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THE IMPACT OF INDIA'S GRAIN REVOLUTION ON THE PULSES AND OILSEEDS

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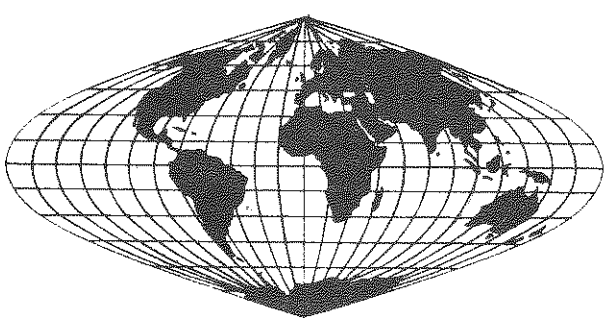

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That the Green Revolution has transformed the food and agricultural situation in India is well known. The production of foodgrains grew from 80 million tons in the early 1960s to over 150 million tons in less than 20 years, permitting India to move from being a major importer to an occasional exporter. Less appreciated is the fact that this achievement has been largely confined to the cereals and that other crops have either been ignored or adversely affected. Chief among the latter are the pulses and oilseeds, both of which loom large in the dietary. Once a major export item, vegetable oils now figure prominantly in the country's import bill; and the prices of most of the traditional pulses have skyrocketed relative to other staple foods.

Such is the context in which the present studies were undertaken.

Mrs. Sharma first examines the consequences of the phenomenal success of the high-yielding wheat varieties, grown during the winter (rabi) season, on the supply of winter pulses. She concludes that, contrary to widespread belief, reduced pulse availability has not led to a decrease in the amount of protein in the diet. Reduced pulse protein has been more than offset by increased cereal protein from wheat and rice. She demonstrates, however, that from a nutritional standpoint the quality of the protein in the average diet has deteriorated.

Her projections indicate that the gap between the demand and supply of pulses will persist; and that, because the main Indian pulses are not heavily traded in the world market, imports do not offer a solution. For the short term she suggests a rationing system akin to the one under which wheat and rice are currently procured and distributed.

For the longer term, Mrs. Sharma advocates promoting the use of new short-duration varieties which can be fitted into the new cereal crop sequences rather than compete with them. In particular the new varieties of greengram and blackgram which can replace the summer fallow in a three-crop rotation show great promise. She anticipates that the rabi pulses, especially gram, will lose their predominant position to these new varieties and also to the kharif (monsoon) pulses grown in the south. Expanded programs of research and extension, she concludes, would expedite these changes.

Ms. Meenakshi focuses on the oilseeds situation, and details the adverse impact of the Green Revolution on the three major annual crops: groundnut, rapeseed-mustard, and sesame. Her analysis indicates that their prospects are limited and that the demand-supply deficit is likely to get larger.

Turning to the perennial tree crops--coconut and oil palm--she finds a somewhat different picture. Because these crops yield far more heavily in terms of oil per unit land area and figure less in the farmers' year-to-year decision making, their prospects are brighter. However, the scope for increased production is hampered by climatic considerations, and any gains are likely to pale in comparison with needs. India thus seems destined to play an ever more important role in the world vegetable oil market. Since the current superabundance of supplies and low prices are likely to persist, Ms. Meenakshi concludes that India should concern itself less with the inevitability of rising imports than with obtaining the best possible terms.

Ms. Meenakshi collected much of her evidence during a three-month visit to India, made possible by grants from Cornell's Program in International Agriculture and the USDA's Economic Research Service. We are especially grateful to Patrick M. O'Brien, Deputy Administrator of ERS, for arranging the latter. Among the many who offered assistance in India, special thanks are due to Professor P. G. K. Panicker of the Centre for Development Studies, Trivandrum; Messrs. V. K. Abraham, K. T. C. Panicker, V. M. Joseph, and R. Ravindran of Oil Palm India, Limited, Kottayam; the officials of the Directorate of Oilseeds Development, Hyderabad; and the librarians and other staff at the Directorate of Economics and Statistics, New Delhi.

Both authors owe much to Ms. Lillian Thomas, who prepared the manuscripts for publication and whose talent, hard work, and patience are so clearly evident in the text figures.

Professors K. L. Robinson and D. G. Sisler shared with me the pleasure of working with Mrs. Sharma and Ms. Meenakshi. The authors hail from India, and are PhD candidates in Cornell's Department of Agricultural Economics. Mrs. Sharma is an officer in the Indian Administrative Service, and has for most of the past dozen years been involved with rural development in the state of Uttar Pradesh. In 1984 she was given leave from her position as Special Secretary in the Department of Agriculture and awarded a Hubert Humphrey Fellowship for study in the United States. Ms. Meenakshi has also attended Cornell on a fellowship. She received her B.A. in economics from the University of Maryland.

Thomas T. Poleman

PULSES IN THE FOOD ECONOMY OF INDIA

by Rita Sharma

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GLOSSARY

Cereals	In India, cereals refer to paddy, wheat, sorghum, maize and millets, and do not include pulses.
Dal	Split grains of pulses. About 75 percent of pulses in India are consumed in this form.
Foodgrains	Include both cereals and pulses
HYV	High-Yielding Varieties
ICMR	Indian Council of Medical Research
ICRISAT	International Crop Research Institute for the Semi Arid Tropics.
Kharif	Rainy season which begins in June/July and extends up to September/October. Suited for rainfed crops.
Quintal	Measure of weight 1 quintal = 100 kilograms
Rabi	Winter season begins in October/November and extends up to February/March. Suited for crops that can make use of residual moisture.
Rupee	Indian currency. Its exchange rate relative to the dollar is indicated below [28].

Year	Exchange Rate (Rupees per dollar)
1970	7.567
1971	7.524
1972	7.595
1973	7.742
1974	8.102
1975	8.376
1976	8.960
1977	8.739
1978	8.193
1979	8.126
1980	7.863
1981	8.659
1982	9.455
1983	10.099
1984	11.363
1985	12.048[a]

Zaid Dry summer season after harvest of the *rabi* crop.

[a] Exchange rate as of third quarter, 1985.

CHAPTER I
INTRODUCTION

Pulses have played an important role in the Indian diet. Even today, in combination with wheat or rice, pulses describe the average Indian meal. They are a rich source of protein and, as such, complement cereals in the diet. In a country where a significant percentage of the population is vegetarian, pulses are essential in providing the amino acid balance needed for normal growth development and the maintenance of health.

In addition to their importance as a source of protein, pulses are valued for their special characteristics as legume crops. As a group, pulses are able to utilize limited soil moisture and nutrients more efficiently than cereals. Their ability to fix atmospheric nitrogen enhances their significance as crops suited for dry and rainfed areas, and specially for small and subsistence farmers, who can ill afford the cost of inputs needed for high-yielding technology.

Production of pulses in the country has stagnated for over two decades. With increasing population this has resulted in an appreciable decline in their per capita availability, which fell from about 65 grams per day in the early 1960s to about 35 grams in the 1980s. In the same period per capita wheat availability increased from around 80 grams per day to 130 grams [36, p. 141]. The latter was due to the dramatic increase in wheat production as a result of the Green Revolution in the mid-1960s, based on the development of fertilizer-responsive high-yielding varieties. The main contribution of the Green Revolution was to increase total cereal production and make the country self-sufficient in food. Production of foodgrains increased from around 80 million metric tons in the early 1960s to around 150 million metric tons in the 1980s [36, p. 141]. While 85 percent of increased wheat production can be accounted for by rising yields, the remainder came from an increase in the area planted to wheat, part of which was diverted from *rabi* pulses [6, p. 7]. In the 1970s, with the spread of high-yielding varieties, even rice production, which had been sluggish, registered a marked increase [52, p. 5]. There was, however, no similar breakthrough in pulse technology, and yields remained at low levels. Consequently, land that was once sown to pulses shifted in the *rabi* season to wheat and in the *Kharif* season to rice.

Pulse acreage in major wheat producing states showed a significant decline. However, trends in total nutrient availability examined in the pre- and post-Green Revolution eras indicated that overall protein availability had increased as a result of the high-yielding variety cereals, especially wheat [51]. This implied that the reduction in quantity of protein supplied by pulses was more than offset by additional protein which came from increased cereal production.

If quantity of protein were the sole criterion in judging the merits of a diet, it can be argued that the replacement of pulses by cereals in the diet was a desirable trend. Cereals consumed in sufficient quantity could fulfill both the energy and protein requirement of the population, and there would be no further need for pulses. However, it is not only the quantity of protein intake that is important but also its quality which is determined by the amino acid balance in the diet. Pulses and cereals consumed together in the right proportion provide the desirable amino acid balance which is not possible in a diet composed only of cereals.

Pulses must therefore remain a part of the diet. On the other hand, cereal production must continue to increase if the food demand of a growing population is to be met. We seem to have here an apparent conflict between objectives.

It is the purpose of this study to analyze trends in the consumption and production of pulses, and to examine the possibility whereby the production of both cereals and pulses can be simultaneously increased.

The study is organized as follows. Chapter II describes the importance of pulses in the diet and in agriculture from the historical as well as current point of view. It emphasizes the role of legume crops in rainfed agriculture and in the farming systems of small and subsistence cultivators.

Chapter III analyzes past trends and the effect of the Green Revolution on pulse production and acreage. At present more than 90 percent of pulse area is confined to unirrigated lands. It is shown that the bulk of future production will continue to accrue from rainfed areas as irrigated lands are diverted away from pulses into high-yielding cereal crops.

Chapter IV examines the effects of reduced pulse protein on the diet, by defining nutritional norms in terms of quantity and quality of protein. It is argued that a certain proportion of pulse to cereal protein in the diet enhances its protein quality, and is infinitely preferable to a diet without pulses.

Chapter V deals with consumption trends in pulses based upon data obtained from national food balance sheets and food consumption surveys. Demand projections are made for pulses to 1990 and 2000 based on expenditure elasticity and estimates of population and income growth. The levels so obtained are compared to those derived on the basis of nutritional norms.

Chapter VI examines the question of how much of the estimated demand in 2000 can be met from domestic supply if existing trends in production continue. It incorporates the progress in pulse technology made in recent years, together with estimates of expansion in area to project pulse production in 2000.

CHAPTER II
IMPORTANCE OF PULSES IN INDIA

Role of Pulses in the Diet

The two most important groups of crops in world agriculture belong to the plant orders *Gramineae* (cereals and grasses) and *Leguminosae* (peas, beans and the grain, forage and green manure legumes) [68, p.1].

Pulses are the edible seeds of leguminous plants, which belong to the category of *leguminosae*. Although members of the same botanical family, a distinction is made between pulses and oilseeds. Leguminous seeds containing only small amounts of fat, e.g., gram, redgram, greengram, blackgram, peas and lentil, are grouped together as pulses, whereas groundnut and soybean, with a higher fat content and used primarily for oil extraction, are categorized as oilseeds.

Pulses are valued for their high nutritional quality. Although the chemical composition is variable between species, all pulses are characterized by a high protein content--in fact, almost twice that of cereal grains. Their nutritional value is not confined to their usefulness as a source of vegetable protein. Pulses are also the source of vitamins and minerals. Nevertheless it is in their actual and potential value as a source of plant protein for human nutrition that their importance lies. Pulses are also valued for the variety, taste and texture that they add to a diet based on starchy staples.

Historical

While it is true that the nutritional quality of pulses was scientifically proven only in the 19th century, their importance as food was recognized from very early times. Pulses appear to have been among the earlier plants domesticated. Traces of wheat, peas and lentil have been found at archaeological sites in Turkey dating 5500 B.C. [2, p. 1]. Chinese literature records the cultivation of soybean with rice, wheat and barley between 3000 and 2000 B.C. Legumes featured in the cropping systems of the early Egyptian dynasties, and later in the Roman era several writers stressed their value for food and soil improvement [68, p. 2]. American Indians from very early times raised beans among their maize. Vessels containing kidney beans were discovered in pre-Inca tombs in Peru [2]. Pigeonpea, a native plant of South Asia, is believed to be one of the oldest cultivated plants in the world and reference to it is found in ancient Hindu religious literature [10].

An interesting Biblical reference to legumes is found in the fourth chapter of Ezekiel. The bread or cakes to be eaten in limited quantity by Ezekiel during a period of fasting and penitence had to contain--as well as wheat and barley--beans, lentils and vetches [2, p. 8].

It seems that throughout history, across vastly different geographical areas, a combination of a cereal pulse diet, though not regarded as a gourmet's delight, was wholesome and nutritional enough to maintain the health and survival of communities, especially those that depended primarily on plant nutrients for energy and protein.

Pulses as Meat Substitutes

Pulses are still an important component of the diets of many sections of populations in countries around the world. Although the pattern of pulse production and consumption varies with agroclimatic and cultural factors, there appears to be one element in common. The importance of pulses is especially marked in those communities where the supplies of animal protein have been limited. The greatest stimulus to the production and consumption of pulses has been a shortage of animal protein. This may be due to economical or cultural factors, or a combination of both.

In a country such as India, with an ancient civilization and settled conditions over periods of several millenia, population expanded and imposed a high pressure on the productive capacity of the land. This in turn necessitated an efficient use of land in meeting the protein requirements of the population. It is well known that the intermediate processing of plant protein by an animal, which is in turn consumed by humans, is wasteful in terms of energy. Therefore in a society with a high population density the most economical use of land implies a preference for plant over animal protein. Even if animals are reared, they are the kind that scavenge on leftovers and do not compete for land, as pigs and poultry do [59, pp. 82-83].

In India the situation is further aggravated by religious beliefs. The prohibition on the slaughter of cows for beef among all Hindus, and a ban on meat consumption of any kind for orthodox Hindus, accentuate the shortage of animal protein and consequently enhance the importance of pulse intake.

The value of pulses in the average diet is assesed from the fact that compared to most commonly consumed vegetable foods, they contain the highest level of protein per 100 grams of edible portion. Their protein content compares well with that of the meats usually eaten in India. This is evident from Table 2.1.

Poor Man's Meat

It is for the role that they play as meat substitutes, that pulses are often referred to as "poor man's meat." The phrase, however, seems to imply that pulses are considered socially inferior food. And as one progresses up the socio-economic ladder, the meat substitute, namely pulse protein, is replaced by animal protein. In most of the developed

TABLE 2.1: PROTEIN AND ENERGY IN 100 GRAMS OF SELECTED FOOD ITEMS

Edible Portion (%)	Food Item	Protein (gm.)	Energy (kcal)
	Cereals		
100	Wheat	11.8	346
100	Rice	6.8	345
100	Maize	11.1	342
100	Sorghum	10.4	349
	Pulses		
100	Gram	17.1	360
100	Redgram	22.3	335
100	Greengram	24.0	334
100	Lentil	25.1	343
100	Kidneybean	22.9	346
	Roots and Tubers		
85	Potato	1.6	97
92	Yam	1.4	111
97	Tapioca	0.7	157
	Animal Products		
100	Egg	13.3	173
100	Goat Meat	21.4	118
100	Pork	18.7	114
100	Fish	19.2	144

Source: Gopalan C., *et al.*, *Nutritive Value of Indian Foods* (National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, 1978), pp. 60-70.

countries of the world, where religious taboos do not exist, there is a significant inverse relationship between increasing per capita income and the consumption of pulses. However, in India the situation is quite the contrary. Pulses are not considered inferior food. They form an indispensable part of the diet of the highest income groups. In fact, as opposed to the situation in many developed countries, in India, as incomes rise, the per capita consumption of pulses increases.

Pulses provide the cheapest source of protein in the diet. Figure 2.1 indicates that the cost of 100 grams of milk or meat protein has been significantly higher than the cost of pulse protein. In fact until the mid-1970s, pulse protein was even cheaper than wheat protein. However, with increased wheat production due to the spread of high-yielding varieties, the cost of wheat protein has fallen below that of pulse protein.

Methods of Utilization and Consumption

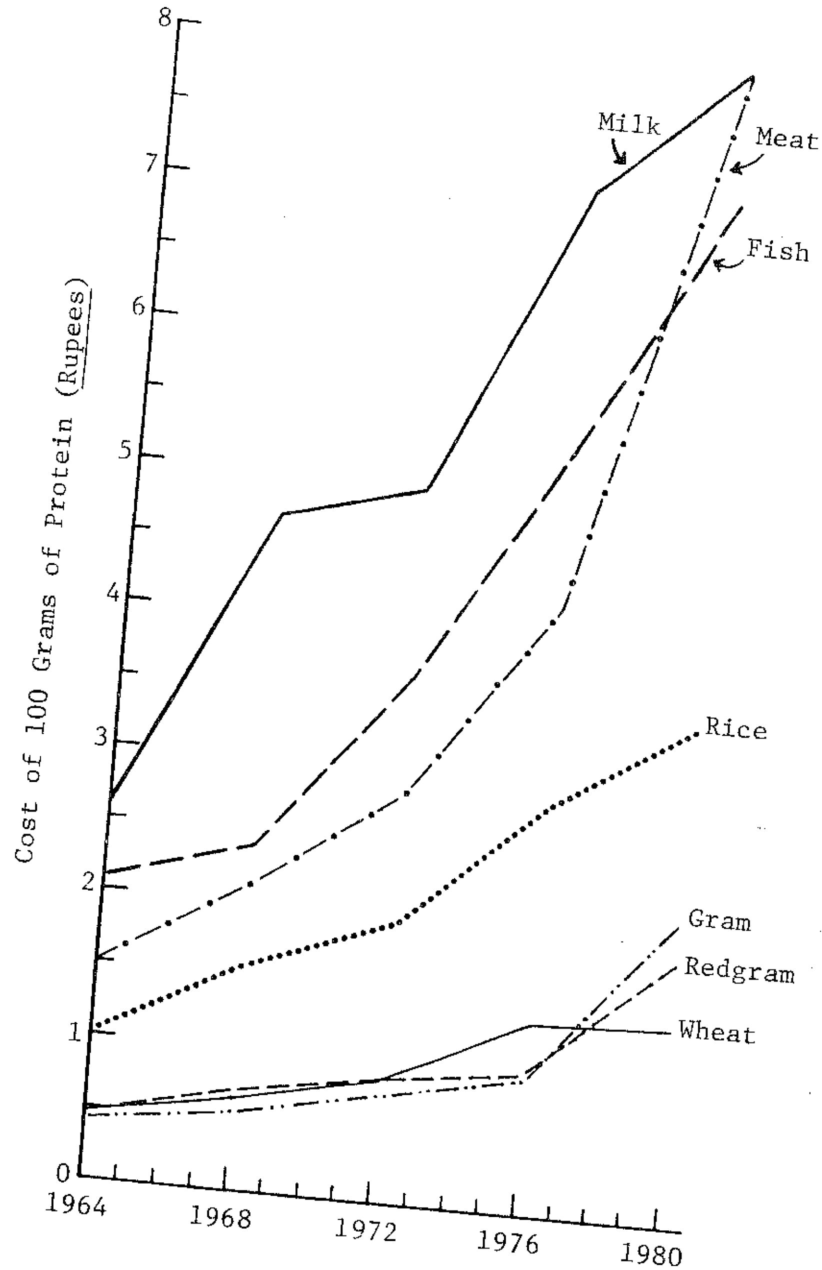
The grain of the leguminous pulse crop can be utilized in a variety of ways and the nutritional value may be influenced significantly by the way in which they are used. The major portion of pulse production is consumed in the form of mature dry seeds. The dried seed is in fact the most economical form of pulse consumption, because dried seeds can be stored and transported easily. Their nutritive value can be maintained for several years.

Pulses which are used as mature dried seeds can also be consumed as fresh seed. The seeds are extracted and cooked in the same way as garden peas. Nutritionally, immature pods have different properties than those of the mature seed; their protein content is lower, but they are relatively rich in vitamins and soluble carbohydrates [59, p. 92].

Decortication and Splitting. In India dry legume seeds are usually split and decorticated. This form of pulse is known as *dal* and is most commonly used. The process does not in any way significantly reduce the nutrient content of pulses. However, since the processing of whole grains into *dal* is usually done in a mill, it makes *dal* more expensive than whole grain pulses. This disadvantage is offset to a large extent by the reduced cooking time for *dal*, which helps save on fuel.

Germination and Fermentation. The practice of utilizing germinated seeds of pulses is also prevalent in many parts of the country. Chickpea is often consumed in this manner. The process involved in germination increases the vitamin C level and also the riboflavin and niacin content [2, pp. 56-58]. Pulses are also fermented to produce pastes and sauces. *Idli*, a common breakfast dish in South India, is prepared by steaming fermented mixed dough of rice and blackgram. Soy sauce is made by fermentation, which improves both the digestibility and palatability of soybean. Soybean products are, however, not as popular in India as they are in other East Asian countries.

FIGURE 2.1. DELHI, INDIA: COST OF 100 GRAMS OF PROTEIN IN SELECTED COMMODITIES, 1964-1980



Source: Appendix Table I.1.

Pulses are usually consumed in combination with cereals. Traditional diets, based on wheat in the North and rice in the South, are supplemented by soups, stews, and curries in which pulses form the main ingredient. Flour made from pulses is mixed with that of cereals for making unleavened bread (*Chappati*). Pulses and rice cooked together (*Khichri*) often form the only course in a poor man's meal. Conventional methods of cooking pulses cause little loss of nutrients; on the other hand, cooking improves taste, texture, digestibility and appearance. Pulses like greengram, when cooked to a soft consistency, are used as traditional weaning foods.

<u>Snacks and Savories</u>. In addition to being a regular part of conventional diets, pulses are widely consumed in the form of snacks and savories. Roasted and puffed gram is eaten in very much the same way as popcorn. There exists a wide variety of sweets, desserts, and snacks made from pulses. This very fact makes it difficult to account for the exact quantity of pulses consumed by a person in the course of a day. Since pulses in the form of extra snacks and sweets might make up almost 10 to 20 percent of an individual's total intake, any household consumer survey which does not take this into consideration would understate pulse consumption. This situation confounds the pulse consumption figures as indicated by the National Sample Survey, as we shall see in Chapter V.

<u>Pulses in Agriculture</u>

Pulses occupy a unique position in Indian agriculture. No other country in the world has as much area under these crops as does India. Pulses occupy nearly 18 percent of the total area under foodgrains in the country. The production of pulses has, however, fluctuated between 9 and 12 million metric tons during the past 30 years, largely as a function of variation in seasonal conditions.

<u>Importance in Dryland Agriculture</u>

In a country like India, where rainfed agriculture constitutes about 70 percent of the total cropped area, the cultivation of pulse crops acquires a special importance. At present more than 90 percent of pulse production comes from unirrigated land. Pulses are grown predominantly in conditions of moisture stress with limited rainfall since they are able to utilize soil moisture and nutrients more efficiently than cereal crops. Pulse crops not only turn out reasonable quantities of foodgrains from marginal lands in the absence of manures and chemical fertilizers, but they go a step further. They restore and improve soil fertility. Leguminous crops have been the mainstay of Indian agriculture. They are included in rotations in almost all farming systems and have helped to keep soils productive through their ability to fix atmospheric nitrogen.

Legumes differ from other food plants in having the property of synthesizing atmospheric nitrogen into plant nutrients. This special ability of leguminous crops to work symbiotically with rhizobia to produce nitrogen is a very important factor in the agriculture of developing countries, for it makes leguminous crops, to a large extent, independent of manures and fertilizers. The nitrogen gained from the atmosphere finds its way into animal and human protein and in a large measure into the soil as an agent of enrichment, leaving the fixed nitrogen in the soil for succeeding crops. Experiments have indicated that pulse crops may add to the soil an equivalent of 20 to 60 kilograms of nitrogen per hectare [46, p. 307]. Since nitrogen is commonly the most limiting element in food production and costly in fertilizer, this special characteristic of pulse crops works to the advantage of the small and marginal cultivators, who can barely afford purchased inputs.

Another important characteristic of legumes is their deep root system which enables them to survive without irrigation even in the dry season, and makes them useful in dryland farming rotations. The roots penetrate the soil to considerable depths and bring up minerals and moisture to enrich the top soil. They also provide a channel for the movement of air and moisture within the soil when they decay. When the green leguminous crop is ploughed back, it provides green manuring and improves the organic matter status of the soil. The leaf drop enriches the soil humus. The thick planting of legumes for green manuring smothers the weeds and therefore loss of nutrients through weeds is also checked. The stems of the redgram shrub provide firewood and are also used for thatching.

Major Pulses Grown in India

A large number of pulse crops are grown in India. The most important of these are gram (chickpea) and redgram (pigeonpea) which taken together account for nearly half of the total area under pulses and for about 60 percent of total production. The next in importance are pulses of the *Phaseolus* group, i.e., greengram, blackgram and *moth*. Table 2.2 lists the commonly cultivated pulses in India, and the seasons in which they are grown.

Three distinct seasons characterize much of India. The rainy or monsoon season, known as *kharif* usually begins in June and extends into October. More than 80 percent of the average annual rainfall occurs during these four months, in which rainfed crops are raised. The post-monsoon winter season, October through March, known as *rabi* is dry and cool and the days are short. During this period crops can be grown on residual moisture, frequently supplemented by a few light showers of the winter rains. The hot, dry summer season from March until rains begin again in June, is known as *zaid*. Any crops grown during this season require irrigation.

TABLE 2.2: MAJOR PULSE CROPS OF INDIA

Botanical Name	Common Name	Indian Name	Percentage Share in Total Pulse Production[a]	Growing Season
Cicer arietinum	gram or chickpea	*chana*	42	*rabi*
Cajanus cajan	redgram or pigeonpea	*arhar* or *tur*	18	*kharif*
Phaseolus mungo	blackgram	*urd*	9	*rabi* & *kharif*
Phaseolus aureus	greengram	*mung*	9	*rabi*, *kharif* & *zaid*
Dolichos biflorus	horsegram	*kulthi*	6	*rabi* & *kharif*
Lathyrus sativus	chickling vetch	*khesari*	5	*rabi*
Lens esculenta	lentil	*masur*	4	*rabi*
Pisum sativum	peas	*matar*	3	*rabi*
Phaseolus aconitifolius	-	*moth*	2	*kharif*

[a]Average of 1980/81 - 1982/83.

Source: India, Indian Council of Agricultural Research, Pulse Crops of India (Delhi, 1970).

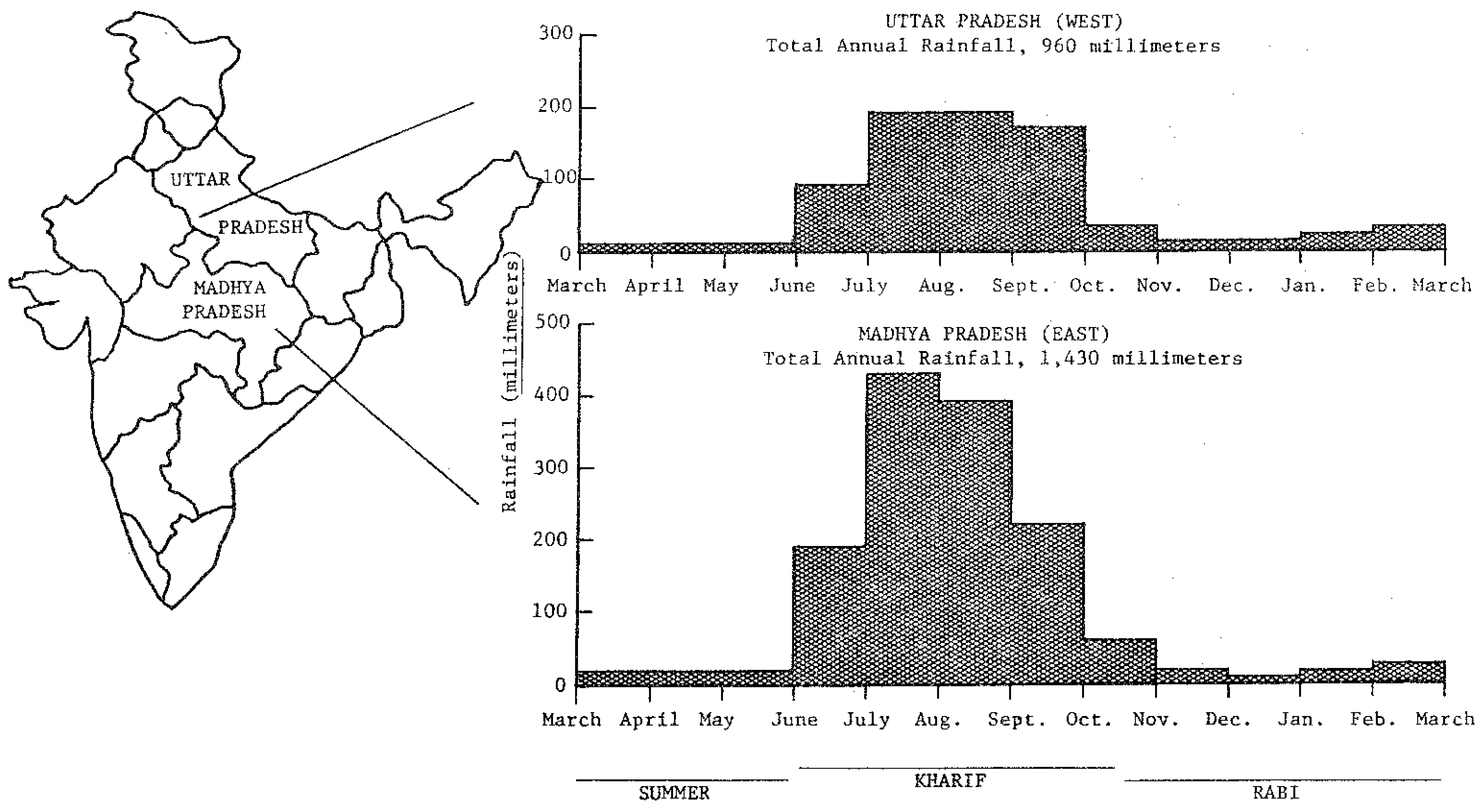
India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India 1981-84 (New Delhi, 1984).

Figure 2.2 shows the normal rainfall pattern in subdivisions of the two largest pulse producing states, Uttar Pradesh and Madhya Pradesh.

Comparison of Area and Yield of Pulses

In the early 1980s the world production of pulses was about 48 million metric tons, of which, 39 million metric tons were in the developing countries [2, p. 81]. India produces almost one third of the total world production of pulses, and about 50 to 80 percent of crops such as gram, redgram, lentil, blackgram and greengram. Grain legumes such as *moth, khesari* and *kulthi* are grown almost exclusively in India. The field bean, or the kidney bean, which is very common in the Americas, and the soybean, cultivated extensively in East Asian countries, do not enjoy the same popularity in India. Figure 2.3 indicates the comparative area and yield of pulses in major producing countries of the world. The average productivity of pulses in India at about 450 kilograms per hectare compares poorly with the high yields in some other countries. Until recently, only those legumes of primary importance in industrialized countries, such as beans (*Phaseolus vulgaris*), peas (*Pisum sativum*), groundnuts and soybeans, received appreciable attention from plant breeders. This accounts for higher yields in countries where these legumes are grown.

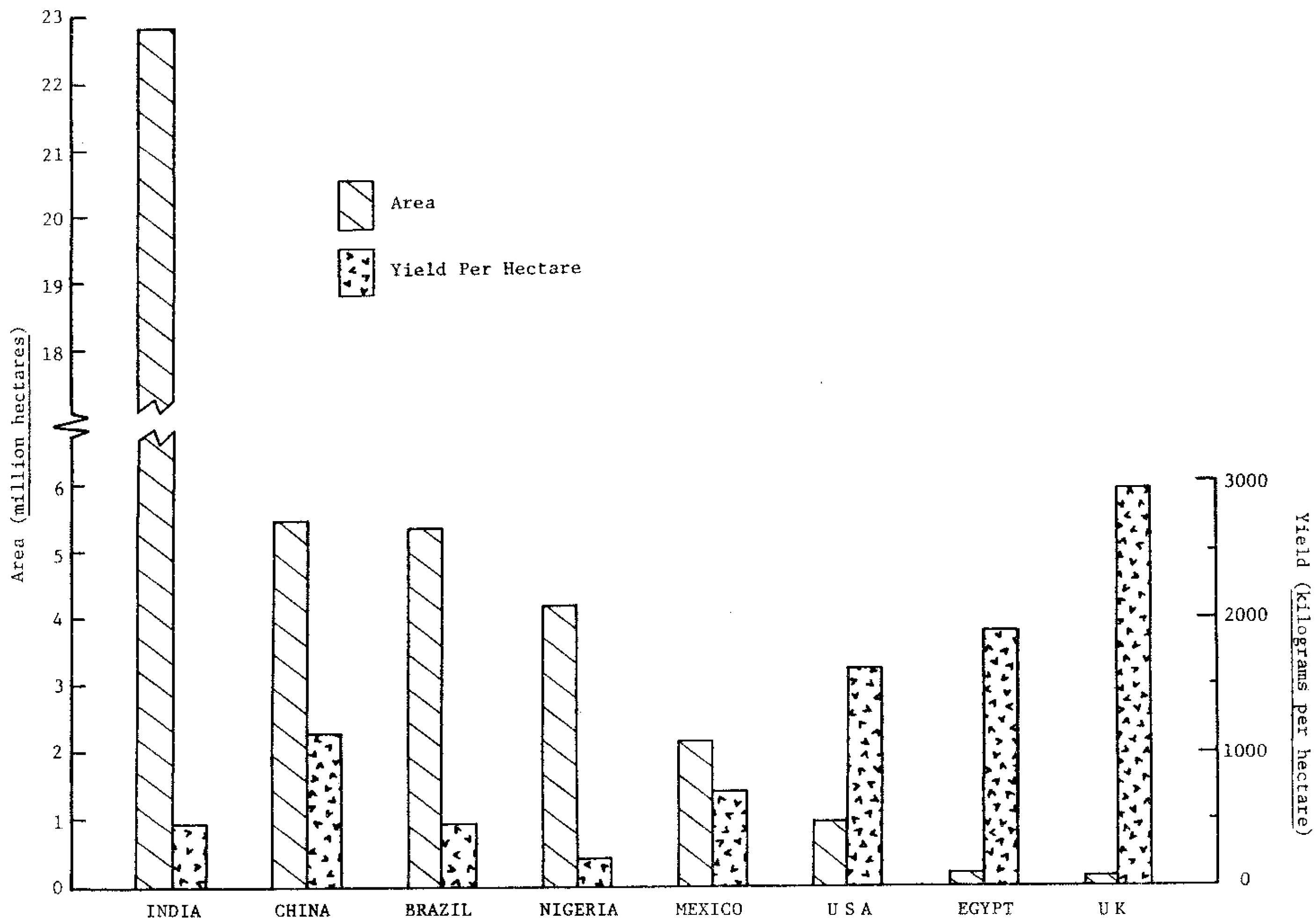
FIGURE 2.2. NORMAL RAINFALL DISTRIBUTION[a/] FOR METEOROLOGICAL SUBDIVISIONS UTTAR PRADESH (WEST) AND MADHYA PRADESH (EAST)



a/ Based on data for 1901-1950.

Source: India, Ministry of Agriculture and Irrigation, Report of the National Commission of Agriculture, Part IV, Climate and Agriculture (New Delhi, 1976), pp. 71-72.

FIGURE 2.3. AREA AND YIELD OF PULSES IN MAJOR PRODUCING COUNTRIES, 1980-82



Source: Appendix Table II.1.

CHAPTER III
IMPACT OF GREEN REVOLUTION ON PULSE PRODUCTION: AN ANALYSIS OF PRODUCTION TRENDS

In the years following the introduction, in the mid-1960s, of the new high-yielding varieties of wheat, area sown to wheat expanded substantially. This breakthrough in food production technology was accompanied by a significant shift in area from pulses to high-yielding varieties of cereals.

Despite the rise in price of pulses, in some cases quite significantly, the area under pulses continued to decline in many states. Other crops which suffered a loss in area were oilseeds and coarse cereals, particularly sorghum, millets and barley.

National Trends in Area, Production and Yield

Production of pulses in India has been stagnant for the last two decades. This is due to the fact that area under pulses has fluctuated between 22 and 24 million hectares, and the yields per hectare have not registered any significant increase. This can be seen in Figure 3.1.

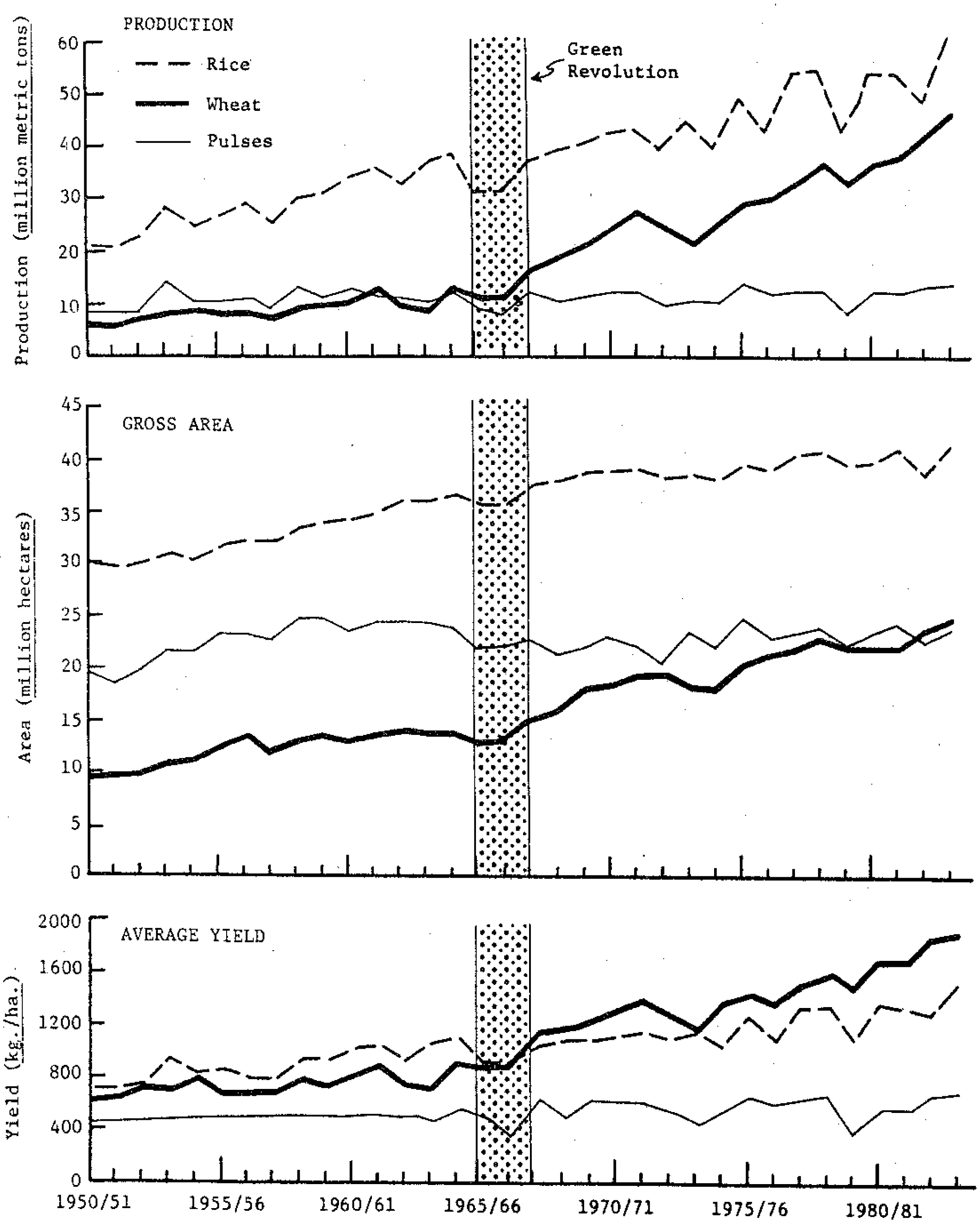
Wheat production, on the other hand, increased from 11 to 45 million metric tons, while rice production rose from 35 to around 60 million metric tons during the same period [36]. The increase in cereal production, especially wheat, has been sharper since the mid-1960s. This came as a result of both increase in area and yield. The latter, due to the introduction of high-yielding varieties, was responsible for about 85 percent of the increased output. The expansion in area of cereals occurred partially at the expense of pulse area.

Production of cereals increased more than two and a half times between the early 1950s and the 1980s. The total production of pulses remained almost the same, with a wide range of fluctuations in between. The fluctuations were the result of variations in weather conditions. Since the bulk of pulse area is rainfed, the production of pulses is more directly and severely affected by abnormal rainfall conditions than cereals like wheat and rice, a sizable percentage of which are grown on irrigated lands.

At the national level the area trend for total pulses remained almost constant. From Figure 3.1 it is difficult to discern any marked increasing or decreasing tendency in the area.

Figure 3.2, however, indicates that the area of gram, peas and beans, and *Khesari* was adversely affected, while redgram, greengram, and blackgram showed a positive trend. We may conclude, therefore,

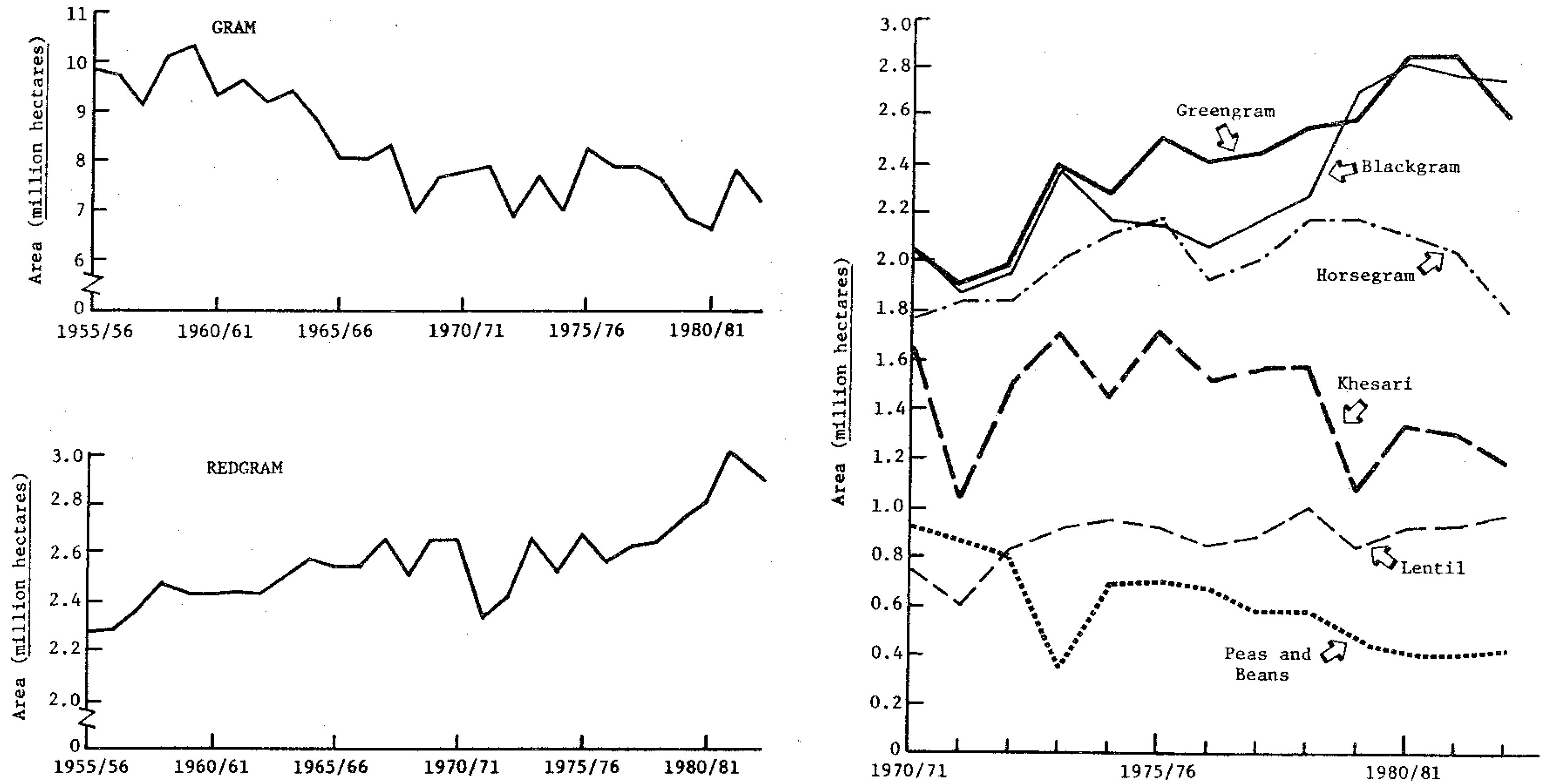
FIGURE 3.1. INDIA: PRODUCTION, AREA, AND YIELD OF WHEAT, RICE, AND PULSES, 1950/51-1983/84a/



a/ Data for 1983/84 are provisional.

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

FIGURE 3.2. INDIA: AREA TREND IN GRAM, REDGRAM (1955/56-1982/83) AND OTHER PULSES (1970/71-1982/83)



Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, <u>Area and Production of Principal Crops in India 1981-84</u> (New Delhi, 1984).

that all pulses were not affected similarly and uniformly due to the introduction of high-yielding variety of cereals. While some pulses were displaced from certain regions as a result of competition from high-yielding cereals, other pulses made positive gains in different regions.

To explain trends in pulse area at the national level, it is necessary to look closely at the impact that the high-yield production technology, introduced in the mid-1960s, had on cropping patterns in different parts of the country.

Green Revolution

The Green Revolution was characterized by high-yielding varieties of seeds together with a package of complementary inputs which were necessary if optimum output was to be achieved. Inputs included recommended doses of fertilizer, timely and assured irrigation, use of plant protection measures, precise agronomic practices and effective management techniques.

At the time that this new technology was introduced, two successive severe droughts in 1965/66 and 1966/67 had ravaged the land and raised doubts about the country's capacity to feed its population. Critics were advocating the application of "triage" and "lifeboat" formulae to food aid [25]. Food imports were at their highest between 1965-67, averaging about 9 million tons on the eve of the Green Revolution. HYVs were seen as the only possible solution to increasing food production. The possibility of the inegalitarian side effects of the Green Revolution, assuming that they could be clearly anticipated at that time, had to be weighed against the more urgent question of food shortages and high prices. The high-yielding technology seemed the only solution to the country's food problem.

Constraints to Adoption of New Technology

Irrigation. Irrigation was one of the essential inputs in high-yielding technology. In the mid-1960s Punjab, Haryana, and Uttar Pradesh had far better irrigation facilities than most other states [37]. Their climate and soil types were suited for wheat production. Coincidentally the first breakthrough in high-yielding varieties was with wheat, and the northern states were quick to adopt the new technology. In states like Madhya Pradesh, Rajasthan, Maharashtra and Orissa, where irrigation facilities were poor and rainfed agriculture predominated, the Green Revolution had only a marginal impact. Even today, more than 70 percent of cultivated area is rainfed and in years of poor monsoon, production in these regions is severely curtailed.

Subsistence Farming Conditions. In addition to the limitation imposed by the absence of assured irrigation was the constraint of small land holdings. About 70 percent of cultivators fall into the category of small and marginal farmers who operate holdings of less than two hectares, accounting for 25 percent of total cultivated area [37]. Returns from such farms are often too low for the farmer to afford high priced inputs such as fertilizers, pesticides, etc., which are essential for high-yielding varieties. There are indications that the small farmers also have greater difficulty in obtaining low cost credit from credit institutions than do owners of medium and large farms. This problem further impedes the small farmers' use of purchased inputs, and consequently the use of HYVs.

Consequences of High Production Technology

Effect on Area and Productivity of Pulses. Farmers who could afford the new technology found it profitable to cultivate their land more intensively. Owner operated farms became more profitable, and the old system of tenancy and share cropping fell out of practice. To make limited land resources more productive, cropping intensity was increased. This was made possible by the short-duration, high-yielding dwarf varieties of cereals, replacing traditional long-duration varieties. Pulses like redgram, with a long maturity period, became less favored in cropping patterns. Pulses like gram, because of their low yields, in competition with wheat, lost out to the higher yielding cereal. There was no breakthrough in the development of high-yielding pulse varieties. Consequently pulses were gradually eliminated from those farms which adopted HYVs and intensive cultivation techniques.

Traditionally the pattern of farming had been one of mixed cropping of cereals and pulses, or cereals and oilseeds. In the northern wheat growing belt, the popular combination was one of wheat and gram or wheat and mustard in the *rabi* season. The new technology, with increasing use of mechanization and intensive agronomic practices demanded that HYVs be planted in monocultures. As a result, the mixed cropping system fell into disuse, and with it a substantial area sown to pulses was lost.

Prime agricultural land was taken from gram and planted to HYVs of wheat in the *rabi* season. However, gram was not eliminated from the cropping pattern altogether. It was cultivated on a smaller scale on newly reclaimed and traditionally fallow areas with low quality soil, and still found favor on unirrigated lands. This resulted in the decline of gram yields.

Gram is an important pulse crop accounting for about 30 percent of area and 40 percent of total output of pulses. The decline in gram area compounded by low yields adversely affected total pulse production. So that any gains made by other pulses were negated by the downward trend of gram production. Declining availability resulted in an increase in the prices of gram as well as of other pulses. The prices of pulses rose much faster than those of coarse cereals which were also grown largely in rainfed conditions. It is quite likely, therefore, that some area sown to coarse grains was diverted to pulses.

Because of nonavailability of data on net returns per hectare from pulses, a comparison is made between gross returns from pulses and competing cereals. Figure 3.3 indicates that the ratio of gross returns per hectare from wheat relative to gram are higher in Punjab and Haryana than in Madhya Pradesh. In the former two states gram has been almost completely replaced by wheat in *rabi*. In Madhya Pradesh, however, it seems that gram is profitably cultivated on unirrigated lands, since area under this crop is expanding in the state. It also appears that the ratio of gross returns from gram and redgram relative to coarse cereals like barley, millet and sorghum is such that these pulses are likely to find greater favor with farmers on unirrigated lands in the future.

Pulses were not competitive with high-yielding wheat and rice varieties on irrigated lands. But compared with coarse cereals in unirrigated conditions they appeared more profitable. So that area under gram shifted away from its native habitat in the Indo-Gangetic plain, as irrigation facilities increased there, into the rainfed regions of the central states like Rajasthan, and Madhya Pradesh.

Meanwhile in the mid-1970s technological breakthrough in pulses came in the form of development of short-duration varieties, especially of redgram, blackgram, and greengram. As a result the area under these pulses registered an appreciable increase in the last 10 years as can be seen from Figure 3.2.

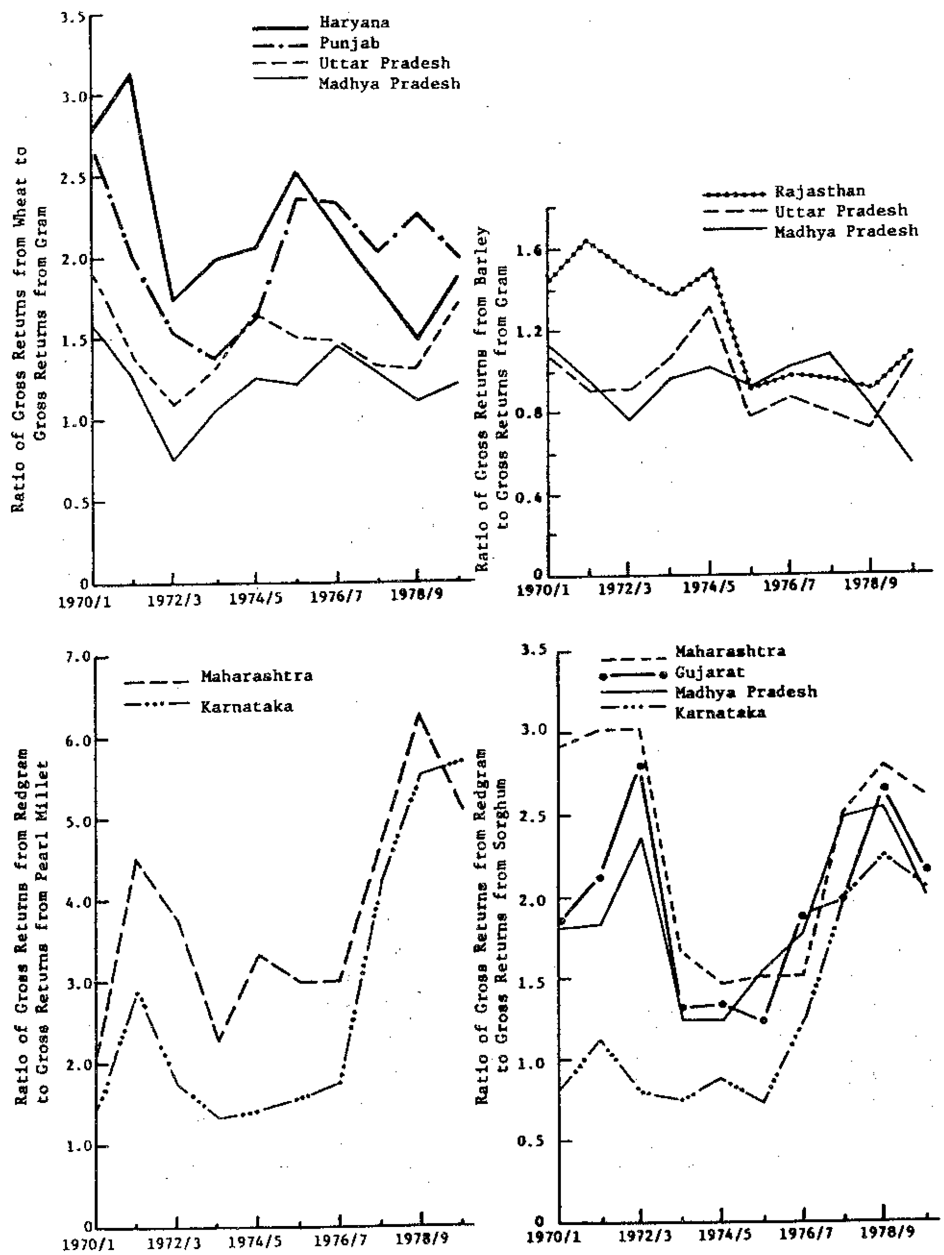
Effect on Cost of Protein

At yield levels obtaining in the mid-1960s, the production of energy from one hectare of wheat was only marginally greater than that from gram, as shown in Figure 3.4. However, by the mid-1970s, the production of energy per hectare from wheat increased appreciably, being more than double that from a hectare of gram. In the early 1980s, the energy contribution from wheat had increased further to almost three times that from a hectare of gram.

Protein production from a hectare of wheat and gram was almost equal in the mid-1960s. As a result of the spread of HYVs of wheat, protein production increased markedly. In the early 1980s the production of protein from a hectare of wheat was more than double that from gram. This shows that the net nutritional impact on the total production of calories and protein improved as a result of the Green Revolution [51].

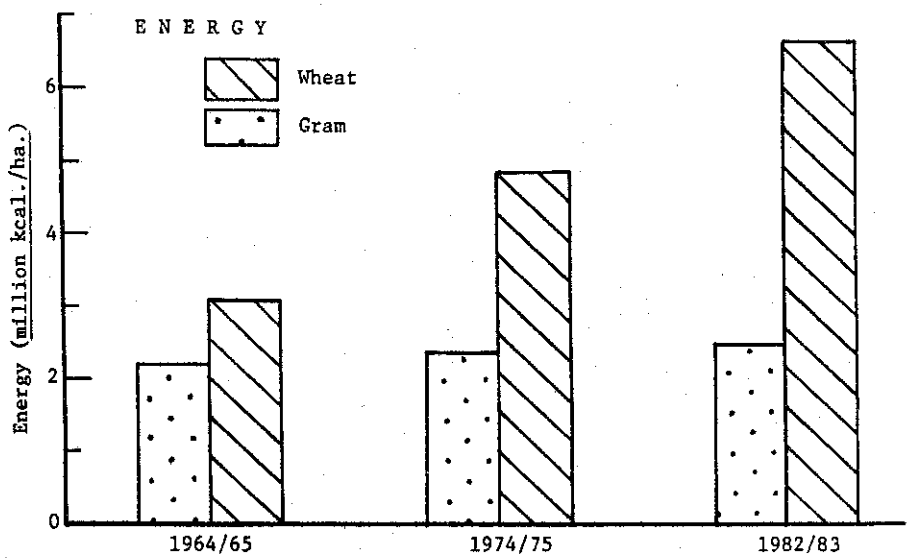
The increased yields had a favorable effect on the cost of protein. Figure 3.5 shows the real and nominal cost of 100 grams of protein during the last 15 years. The cost of protein was calculated from the wholesale prices of gram and wheat prevailing at Hapur Market

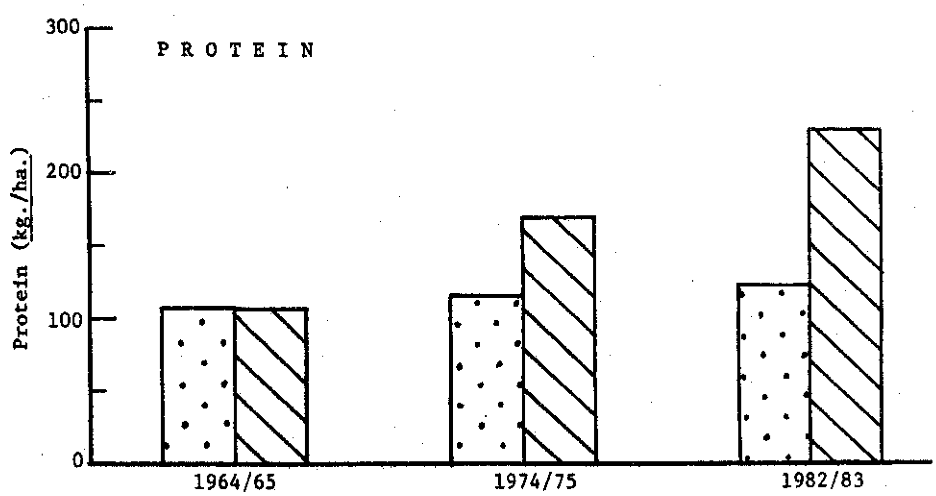
FIGURE 3.3. INDIA: RATIO OF GROSS RETURNS FROM PULSES AND COMPETING CEREALS, 1970/71-1979/80



Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Farm (Harvest) Prices of Principal Crops in India, various issues (New Delhi); India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

FIGURE 3.4. INDIA: PRODUCTION PER HECTARE OF ENERGY AND PROTEIN IN MAJOR WHEAT GROWING STATES[a/], 1964/65, 1974/75, 1982/83

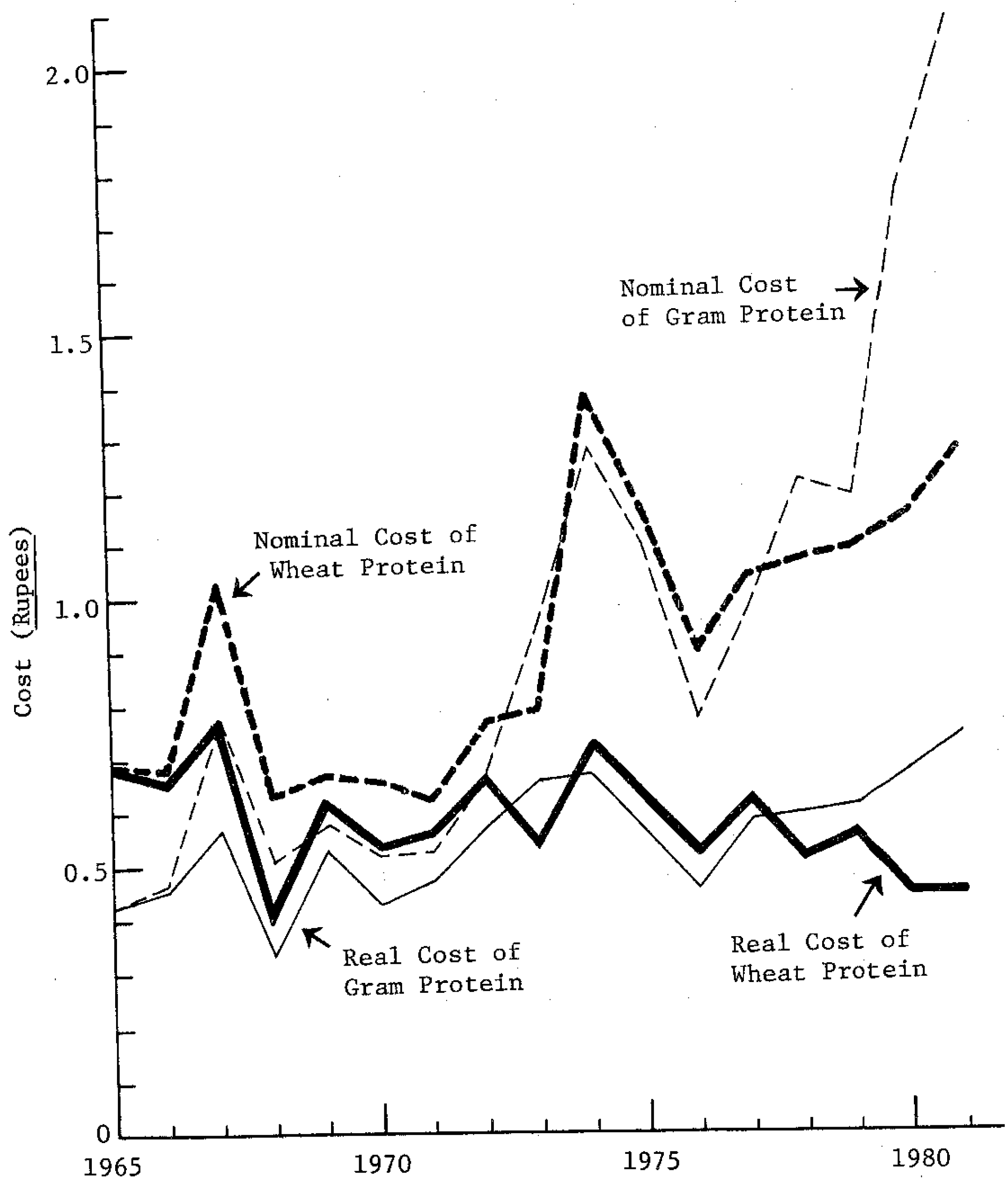




a/ Punjab, Haryana, Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh.

Source: Appendix Table I.2.

FIGURE 3.5. HAPUR, UTTAR PRADESH: REAL[a/] AND NOMINAL COST OF 100 GRAMS OF PROTEIN FROM WHEAT AND GRAM, 1965-1981



a/ Real cost calculated at 1965 prices, using Consumer Price Index for Agricultural Labourers for the State of Uttar Pradesh.

Source: Appendix Table I.3.

in the State of Uttar Pradesh. Hapur Market was chosen on the basis of the assumption that the prices of pulses are most likely to be determined competitively here by the forces of supply and demand. Hapur Market is the largest market for agricultural produce in the State of Uttar Pradesh, which is the largest pulse producing state in the country.

In 1965 gram protein was cheapest at Rs 0.42 per 100 grams. However, in the early 1980s wheat protein claimed this distinction at Rs 0.44.

As a result of the Green Revolution and the spread of HYVs of wheat, it was possible for the real cost of protein in the early 1980s to remain at almost the same level as in the mid-1960s. This is one of the positive contributions of the Green Revolution.

Regional Trends in Pulse Production

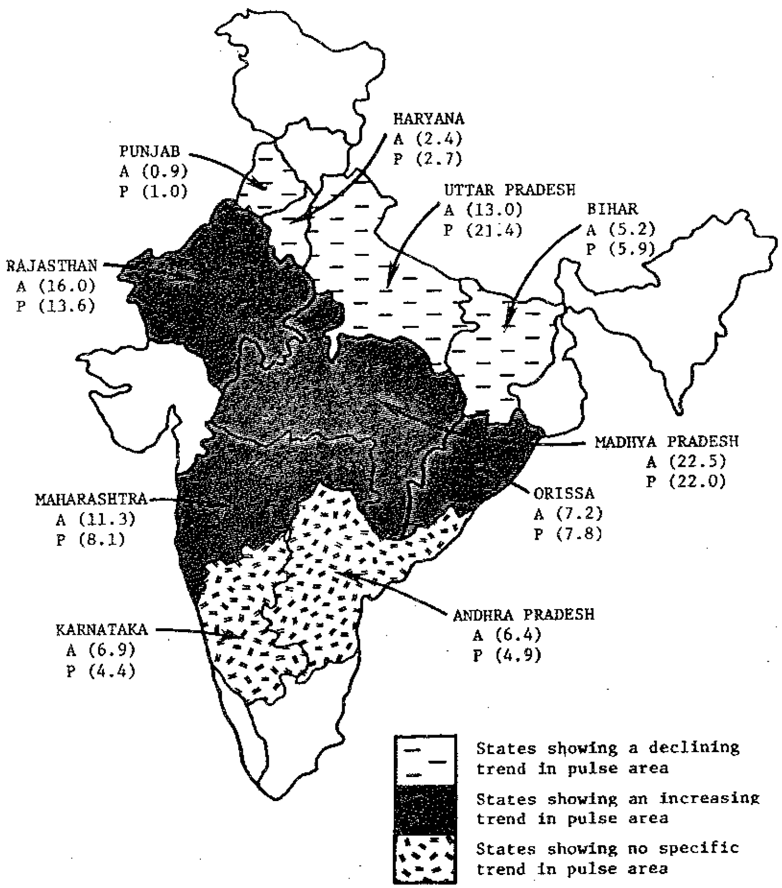
The major pulse producing states in India are shown in Figure 3.6. These 10 states together account for more than 90 percent of production and area under pulses.

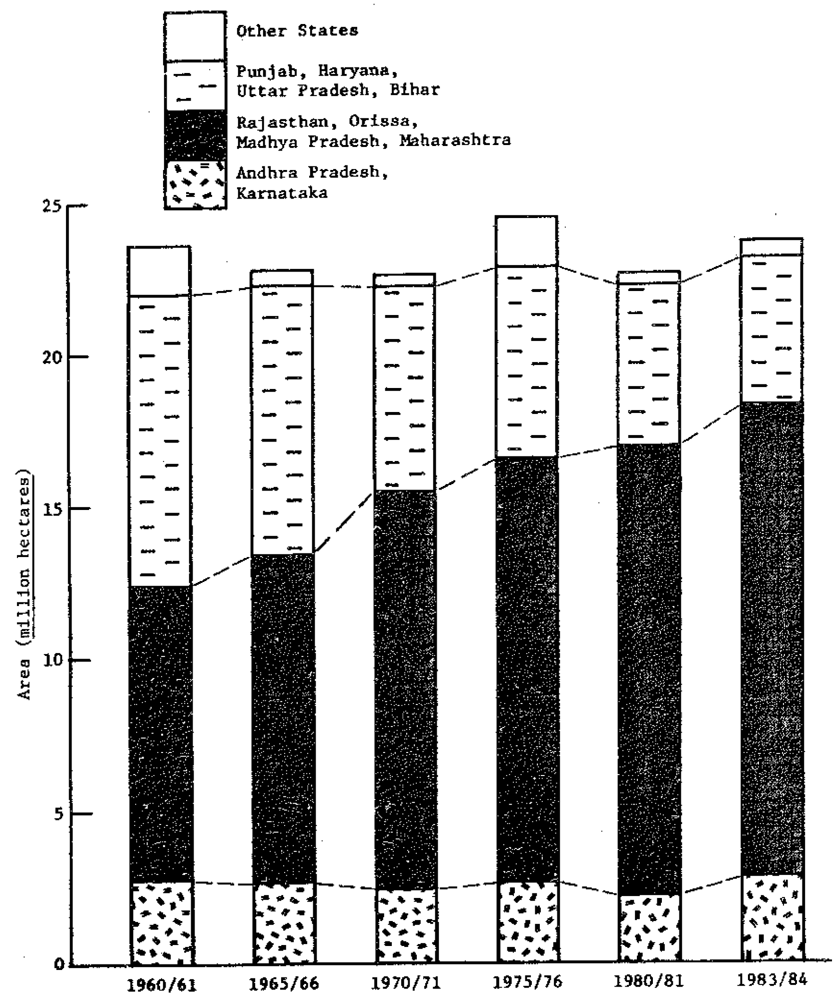
The states of the Indo-Gangetic plain, comprising Punjab, Haryana, Uttar Pradesh and Bihar, which also constitute the wheat belt of the country, indicate a clear declining trend in area sown to pulses. The area in these states has declined from about 9.5 million hectares in the early 1960s to 5 million hectares in the early 1980s. In terms of national pulse area, the percentage share has fallen from about 40 percent to 20 percent.

As we have already seen in the preceding sections, at the national level there does not appear to be any discernible declining trend in pulse area. This is most likely due to the fact that pulse area which was replaced in the Indo-Gangetic plain was gained by the Central Region, comprising states of Rajasthan, Madhya Pradesh, Maharashtra and Orissa. During the period under consideration, area under pulses in these states increased from 9.8 million to 13.3 million hectares, indicating an increase of 35 percent in terms of national pulse acreage.

The Southern Region, comprising states of Andhra Pradesh and Karnataka, did not display any clear trend in acreage, which remained almost constant during the period, accounting for a steady 12 percent of total pulse area [12].

FIGURE 3.6. INDIA: AREA TREND IN PULSES IN MAJOR PRODUCING STATES





NOTE: Figures in parentheses indicate area (A) and production (P) in the state as percentage of national area and production for 1982/83. 1983/84 figures are provisional.

Source: Appendix Tables II.3 and II.4.

Seasonal Trends in Pulse Production

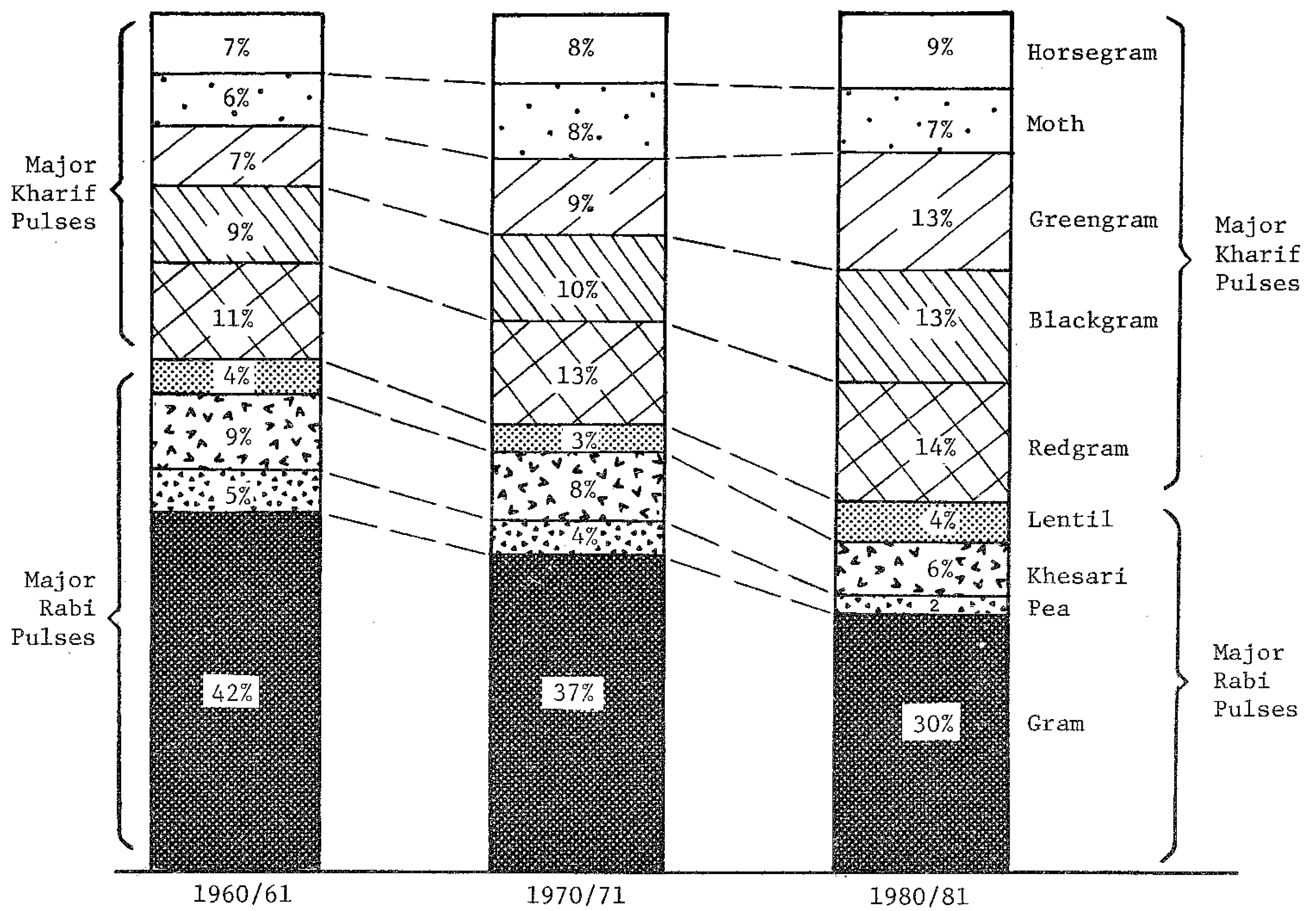
The major pulses are grown either in the *rabi* or *kharif* season. Gram, pea, *Khesari* and lentil constitute the major *rabi* pulses, while redgram, blackgram, greengram, horsegram and *moth* comprise the important *kharif* pulses. The percentage share of various pulses is shown in Figure 3.7 which indicates a declining trend at the national level in *rabi* pulses, and an increasing trend in *kharif* pulses. Pulses which show a declining trend are gram and pea which account for the trend in *rabi* pulses. On the other hand, almost all the *kharif* pulses point to an increasing area trend [12].

The trends are more visible if we look at *kharif* and *rabi* pulses in the two major pulse growing regions. The states of the Indo-Gangetic plain accounted for almost half the area under *rabi* pulses in the early 1970s, as shown in Figure 3.8. However, during the next 10 years, as a result of changes in cropping patterns and greater emphasis on cereals, this region began to lose its importance as the major *rabi* pulse producer. Within a decade the contribution of the Indo-Gangetic plain to the winter pulse area declined from half to less than a third. The central states, on the other hand, because of their dependence on rainfed agriculture had emerged as the main contributor towards *kharif* pulse area. Their share was more than four times that of the northern states. In the decade of the 1970s, however, in addition to maintaining their predominance in *kharif* pulse area, they displayed significant gains in *rabi* pulse area as well. It appears almost as though the area replaced in the Indo-Gangetic plain was compensated by a corresponding increase in the central region. No significant trend in *rabi* pulse area was reflected at the national level, as is evident from Figure 3.9. However, considerable annual fluctuations indicated the impact of changes in weather conditions. It is interesting to note that *rabi* pulse area recorded wider variations relative to *kharif* pulse area, and that *rabi* pulse production seems to be subject to greater variability than *kharif* pulses.

At the national level, *kharif* pulse area registered a small but perceptible increase. On closer examination it appears that the last 8 to 10 years have witnessed a more decisive change in area trend than the previous decade. This seems to be a logical outcome of the impact of improved and short-duration varieties of *kharif* pulses which have only recently begun to make their impact on the field.

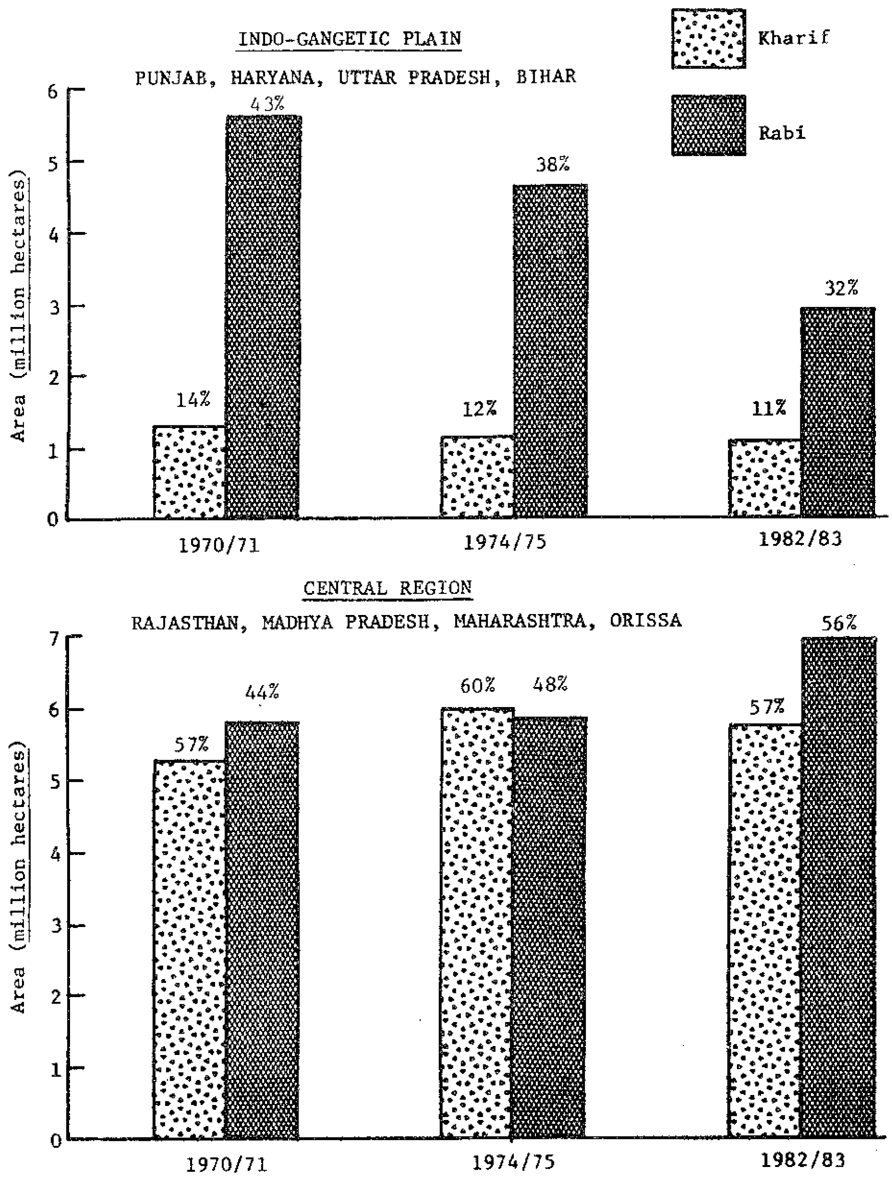
It needs to be emphasized here that although the central states have now taken the lead in both *rabi* and *kharif* pulse area, the average productivity in the region leaves much to be desired. In the early 1980s the states of the Indo-Gangetic plain accounted for around 10 percent of *kharif* pulse area and more than 20 percent of total production. In the central states, on the other hand, production lagged behind, accounting for only 48 percent of the total despite a 57 percent share in acreage.

FIGURE 3.7. INDIA: PERCENTAGE SHARE OF VARIOUS PULSES IN TOTAL PULSE AREA, 1960/61-1980/81



Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, various issues.

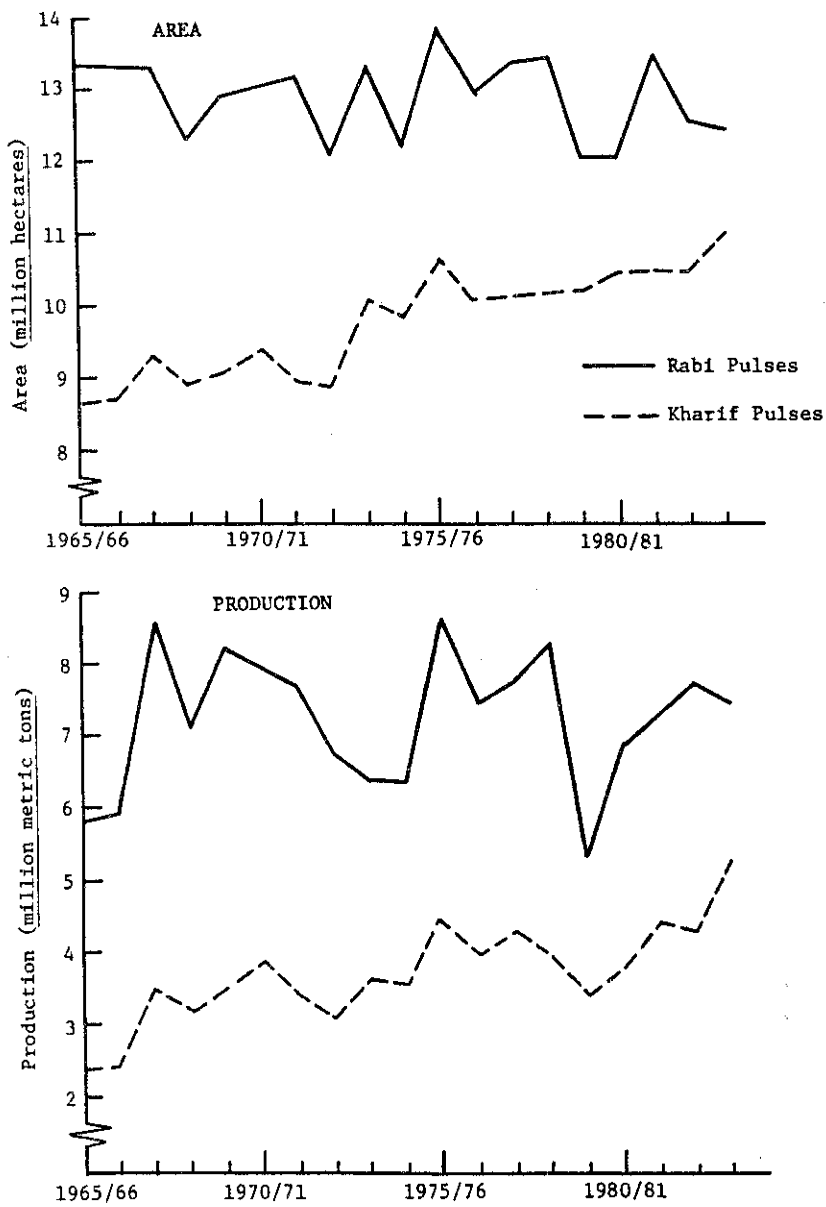
FIGURE 3.8. INDIA: AREA TREND UNDER KHARIF AND RABI PULSES IN MAJOR PRODUCING STATES, 1970/71, 1974/75, AND 1982/83



NOTE: Percentages indicate percent of area and production of *kharif* and *rabi* pulses relative to national area and production under *kharif* and *rabi* pulses.

Source: Appendix Table II.5.

FIGURE 3. 9 . INDIA: AREA AND PRODUCTION OF KHARIF AND RABI PULSES, 1965/66-1983/84



Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Use of Inputs and Area Trends

Irrigation is one of the major inputs which has influenced cropping patterns over the last two decades. In fact there is a positive correlation between increase in irrigated area, and the use of high-yielding varieties. Table 3.1 indicates that in states where the percentage of total irrigated area to total cropped area is high, the use of HYVs and the consumption of fertilizer is greater. In states like Punjab, Haryana and Uttar Pradesh the cropping intensity is also higher relative to the central states.

Figure 3.10 demonstrates, in the case of Uttar Pradesh, that as percentage of irrigated area increased the share of pulse area correspondingly declined. The relationship between increase in irrigated area and replacement of pulse acreage by HYV cereals is very significant [12].

Since more than 70 percent of area cultivated in India is still rainfed, the major portion of pulse production in the future will continue to come from unirrigated areas. However, with the introduction of short-duration varieties, which can be cultivated as catch crops between the two major seasons, and with assured irrigation facilities, there will be a significant increase in pulse area in regions where short-duration varieties can be fitted into cropping patterns. This will be discussed in greater detail in later chapters.

TABLE 3.1: AVAILABILITY/USE OF INPUTS BY STATE

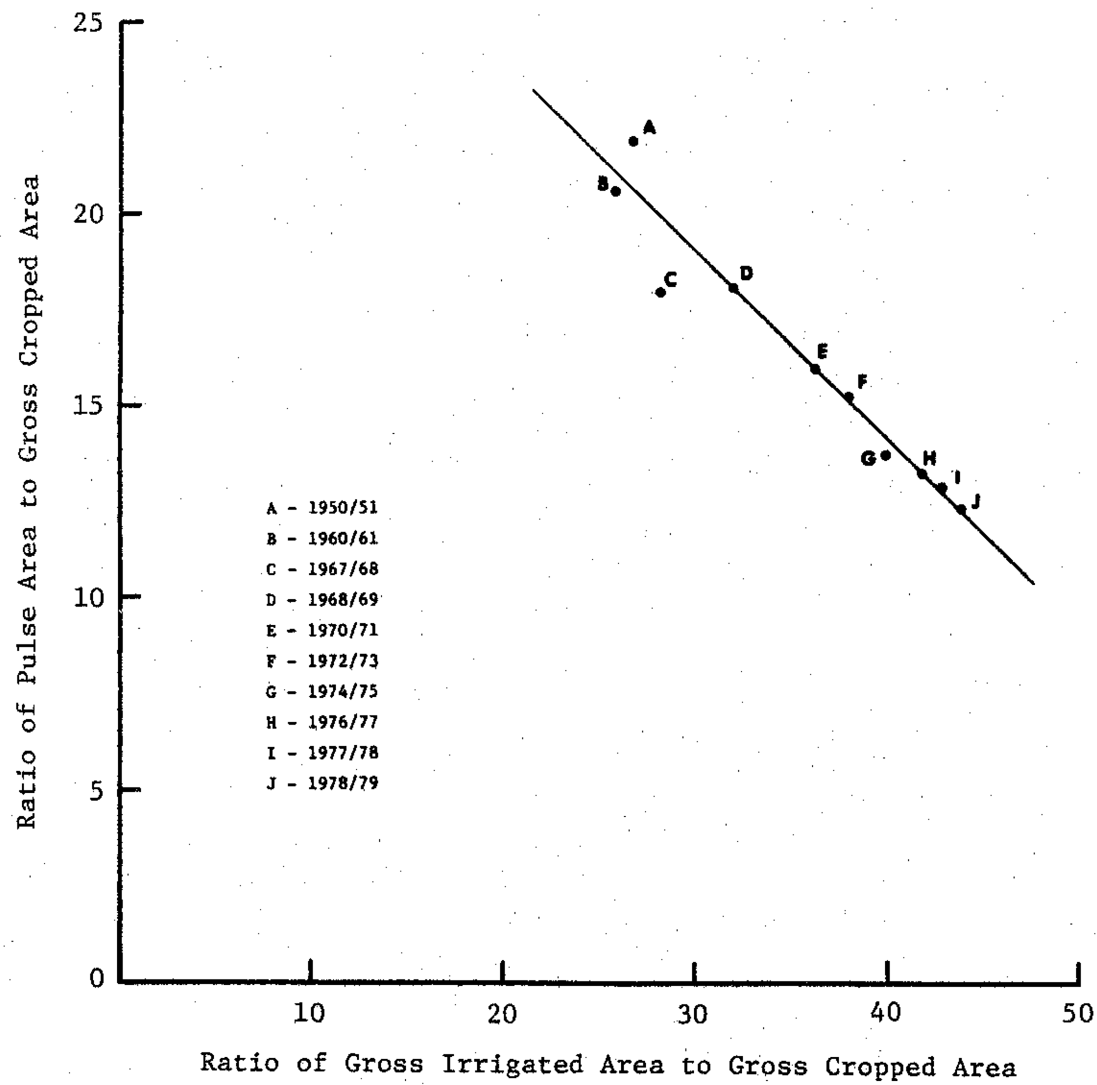
	Percentage of gross irrigated area to gross sown area	Percentage of area under HYVs	Per hectare consumption of fertilizer (kgs/ha)	Cropping Intensity (percent)	Average yield of foodgrains per hectare (kgs/ha)
	(1980/81) a/	(1982/83)	(1982/83)	(1978/79) a/	(1982/83)
Indo-Gangetic Plain					
Punjab	86	68	149	162	2,837
Haryana	61	52	59	152	1,657
Uttar Pradesh	46	38	68	143	1,422
Bihar	33	37	27	134	1,062
Central States					
Madhya Pradesh	12	19	15	114	840
Maharashtra	12	24	32	111	752
Orissa	20	26	13	143	985
Rajasthan	22	19	12	114	763
National	29	30	45	124	1,162

a/ Latest figures available.

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India 1981-84 (New Delhi, 1984).

India, The Fertilizer Association of India, Fertilizer Statistics 1983-84 (New Delhi, 1984), p. I-103.

FIGURE 3.10. UTTAR PRADESH: CHANGES IN PULSE AREA RELATIVE TO IRRIGATED AREA, 1950/51-1978/79



Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume 1, various issues (New Delhi).

CHAPTER IV
CONSEQUENCES OF REDUCED PULSE AVAILABILITY ON THE DIET

It was seen in the last chapter that as a consequence of the Green Revolution a significant area under *rabi* pulses shifted to wheat. This resulted in an overall reduction of per capita availability of pulses. In this chapter we examine the effects of reduced pulse availability on the quantity and quality of protein in the diet. The current per capita protein availability is compared to the Recommended Dietary Allowance (RDA) to give an idea of the nutritional status of the population. Similarly, the existing cereal-pulse protein ratio in the diet is measured against optimum values to determine the quality of protein.

The average Indian diet consists of a cereal staple, e.g., rice, wheat, sorghum or millets, together with a small amount of pulses and vegetables. Irrespective of the nature of the cereal, such a diet can meet the protein needs of the individual, provided sufficient quantity is consumed to satisfy energy requirements [64].

Quantity of Protein

Recommended Dietary Allowances (RDAs)

Individual food needs are determined by age, sex, body composition, level of activity, climate and state of health. RDAs serve as guideposts only for groups of people and are not meant to establish precise individual requirements for which they are often mistakenly used.

The recommended allowances for both energy and protein have been periodically modified. The trend of modification suggests that the recommended intakes have been overstated in the past [49]. The RDAs have consciously erred on the side of caution, both to incorporate a comfortable safety margin and to ensure that substantial variations in food needs among individuals will be covered. They are therefore not to be taken as minimum needs.

FAO RDAs for Energy

The energy requirement is defined by the FAO/WHO Joint Ad Hoc Expert Committee on Energy and Protein Requirements (1971) as "the energy intake that is considered adequate to meet the energy needs of the average healthy person in a specified age/sex category" [20, p. 10]. The energy requirement is conventionally estimated on the basis of an arbitrarily defined "Reference Man and Woman," and depends largely on four interdependent variables: 1) physical activity, 2) body size and composition, 3) age, and 4) climate and other ecological factors. Therefore adjustments in energy requirements need to be made for differences in these variables. Additional energy is needed for growth in childhood and adolescence as well as among women during pregnancy and lactation [20, p. 22].

The energy requirement varies significantly between activities. A classification of activities into light, moderate, very active and exceptionally active has been proposed simply as a guide by the committee, and in the absence of better information the adult population has been assumed to be, on average, moderately active.

The average energy requirement for a reference man of body weight 65 kilograms engaged in light activity is around 2700 kilocalories per day, whereas for exceptionally active work, it can be as high as 4000 kilocalories. Energy requirement is also a function of body weight. For an average male in light activity with a body weight of 50 kilograms, the per day energy requirement is only 2100 kilocalories, which increases to 3360 kilocalories for someone with body weight of 80 kilograms [20, p. 31].

For obvious reasons these recommendations are only broad approximations. A great deal more needs to be learnt about body metabolisms before accurate predictions can be made about energy requirements, and why some people can live on half the calories consumed by others and yet remain perfectly efficient. This again demonstrates that the RDAs include a considerable safety margin.

FAO RDAs for Protein

The FAO/WHO Joint Ad Hoc Expert Committee (1971) has defined the "safe level of protein intake" as "the amount of protein considered necessary to meet the physiological needs and maintain the health of nearly all persons in a specified group." This level is the "safe level" and therefore higher than the average minimum requirement for protein.

Protein RDAs are a function of daily nitrogen loss, protein quality of the diet, age and sex. They have been estimated periodically by expert committees of the FAO. The early studies of the FAO indicated concern with malnutrition and insufficient protein availability. The recommendation of the FAO/WHO Joint-Expert Group (1963) for daily protein intake was 0.71 grams per kilogram of body weight and included a safety factor of 20 percent to cover the needs of members of population with higher than average requirements. For the reference man of body weight 65 kilograms this amounted to 46 grams of reference protein.

With increased research and knowledge in the field of nutrition, perceptions about malnutrition and protein requirements underwent considerable change. No longer was protein deficiency treated in isolation, but was considered as part of a larger problem of protein-energy malnutrition. It was emphasized that when a diet is deficient in calories, the apparent adequate protein in the diet is partly diverted from its primary function to the provision of energy.

The FAO/WHO Ad Hoc Expert Committee (1971) stressed this inter-relationship between energy and protein, stating that "adequacy of energy intakes must receive first consideration, so that any additional protein supplied to meet the estimated protein needs will be efficiently utilized for this purpose" [20, p. 19].

The same committee found that the protein requirements determined by the 1963 Expert Group had been incorrectly assessed on two accounts. Firstly, the estimated nitrogen losses on which the protein needs were based had been overestimated by the previous committee and, secondly, the biological variation in nitrogen requirements assessed at 20 percent was found to be an underestimation.

The 1971 expert panel consequently revised the estimates for protein intake, reducing the daily per capita recommendation for adults by almost a third: from 0.71 grams per kilogram of body weight to 0.57 grams for a man and 0.52 grams for a woman, that is, a daily intake of 37 grams for the reference man and 29 grams for the reference woman. The figures of 37 grams and 29 grams included a safety margin of 30 percent to account for individual variability. This is seen in Table 4.1.

RDAs for Energy and Protein in India

The RDA was first formulated in 1944 by the Nutrition Advisory Committee of the Indian Research Fund Association, now Indian Council of Medical Research. With increased information available on the subject, the recommendations for proteins and calories were revised in 1958 and 1968. The latest recommendations for the reference man weighing 55 kilograms and reference woman weighing 45 kilograms are shown in Table 4.2.

The allowance for protein recommended by the Nutrition Expert group of Indian Council of Medical Research for both reference man and woman is about one gram per kilogram of body weight per day and it is assumed that the dietary protein is derived from a mixture of vegetable foods [23, p. 27]. This works out to 55 grams and 45 grams per day for reference man and woman respectively.

Calculated on the basis of FAO standards, the requirements of protein corresponding to safe level intake are 31 grams and 23 grams per day in terms of the ideal protein having a protein score of 100. However the average Indian diet has a protein quality much below ideal.

TABLE 4.1: FAO: RECOMMENDED DAILY ALLOWANCE FOR PROTEIN

Group	Body Weight (kilograms)	Safe Level of Protein Intake[a/]		Adjusted level of proteins of different quality[b/] (grams per person per day)		
		(grams protein per kilogram per day)	(grams protein per person per day)	Score 80	Score 70	Score 60
Reference Man	65	0.57	37	46	53	62
Reference Woman	55	0.52	29	36	41	48
Pregnancy			+ 9	+11	+13	+15
Lactation			+17	+21	+24	+28

a/In terms of egg or milk protein which is given a score of 100.

b/Scores are estimates of the quality of protein usually consumed, relative to that of egg or milk. For protein score of 60%, 70% or 80% of that of egg, correction factors of 1.67, 1.43 or 1.25 are needed to adjust upwards the safe levels of protein.

Source: FAO/WHO Expert Committee, Energy and Protein Requirements (Rome, 1973), p. 74.

TABLE 4.2: COMPARISON OF RDAs OF INDIA AND FAO FOR PROTEIN AND CALORIES

INDIA

Group	Body Weight	Particulars	kcal	Protein (grams) per kilogram per day	Protein (grams) per person per day
Reference Man	55	Sedentary work	2400	1.0	55
		Moderate work	2800		
		Heavy work	3900		
Reference Woman	45	Sedentary work	1900	1.0	45
		Moderate work	2200		
		Heavy work	3000		
		Pregnancy	+300		+10
		Lactation	+700		+20

FAO

Group	Body Weight	Particulars	kcal	Protein (grams) per kilogram per day	Protein (grams) per person per day
Reference Man	55	Sedentary work	2310	0.57	48
		Moderate work	2530		
		Heavy work	2970		
Reference Woman	45	Sedentary work	1620	0.52	36
		Moderate work	1800		
		Heavy work	2120		
		Pregnancy	+280		+14
		Lactation	+550		+22

Sources: India, National Institute of Nutrition, Indian Council of Medical Research, Nutritive Value of Indian Foods (Hyderabad, 1978), p. 27.

Table 4.1.

FAO/WHO Expert Committee Energy and Protein Requirements (Rome, 1973), pp. 31, 36.

In the early 1980s the average per capita daily availability of foodstuffs, and their contribution to protein supply is shown in Table 4.3. The protein quality of single foods and food mixtures, together with various classifications for measuring protein quality, are discussed in detail later in the section on "Quality of Protein." At this point it is sufficient to say that the protein score of a diet such as the one shown in Table 4.3 is about 65 percent.

To allow for this lower protein quality the recommended allowances for protein intake, based on FAO standards, are adjusted upward by a factor of 1.54. As a result the RDAs for protein for Indian reference man and woman in moderate activity are estimated at 48 grams and 36 grams per day, respectively.

Comparison of FAO and Indian Standards

The comparison of the Indian and FAO standards is shown in Table 4.2. It can be seen that the Indian RDAs are about 15 percent higher for the reference man and 25 percent higher for the woman in the case of protein. For energy the Indian standard is about 10 percent higher for the reference man and 20 percent higher for the reference woman.

Per Capita Calorie Availability

Figure 4.1 indicates daily per capita availability of protein and calories and changes in the sources of supply over the last three decades. Foodgrains are the major source of both protein and energy in the average diet. They account for almost 85 percent of protein and 75 to 80 percent of energy intake.

Rice accounted for about 50 percent of total calories available from cereals in the early 1950s. This figure has remained almost constant. The share of calories from coarse grains like sorghum and millets fell from about 30 percent in the 1950s to 22 percent in the late 1970s. Percentage of calories from wheat increased from 17 percent in the early 1950s to 19 percent in the mid-1960s and more sharply after that to 28 percent in the 1980s.

The overall per capita energy availability over the last 30 years has fluctuated around 1900-2000 kilocalories, except during years of abnormal weather conditions. In terms of recommended allowances the per capita availability of energy was about 82 percent of the Indian RDA and 95 percent of FAO standards for adults engaged in moderate activity.

Per Capita Protein Availability

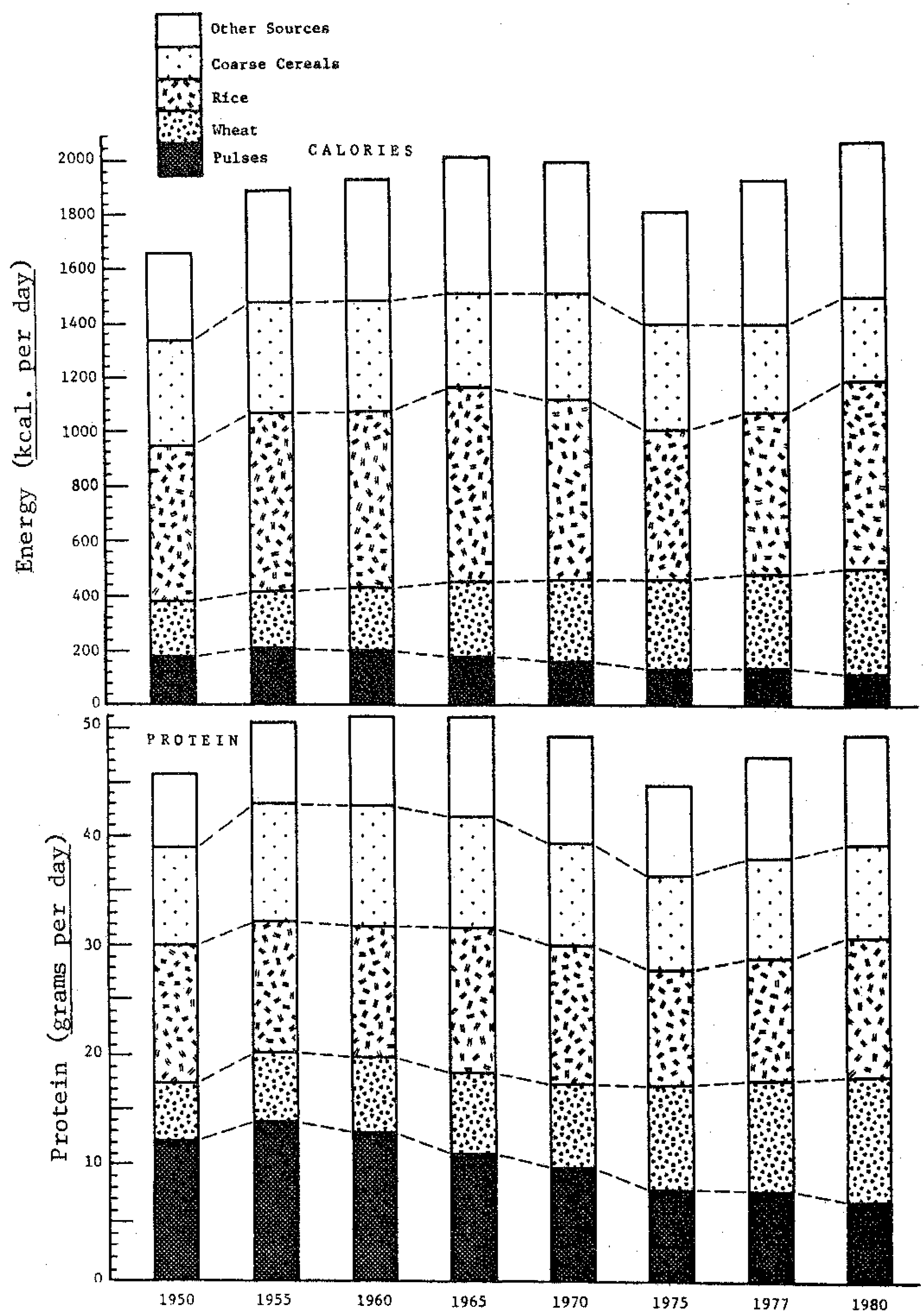
The per capita protein availability as shown in Figure 4.1, indicates that although supply sources have changed, the overall

TABLE 4.3: INDIA: PER CAPITA AVAILABILITY OF FOODSTUFFS, AVERAGE 1979-81

Item	Quantity (grams)	Protein (grams)	Kilo-calories
Vegetable Products			
Cereals	409.0	32.5	1369
Pulses	34.3	7.0	120
Roots and Tubers	53.6	0.6	42
Sugar and Honey	55.3	0.3	186
Nuts and Oilseeds	14.4	0.7	28
Oils and Fats	14.7	-	130
Vegetables	160.4	2.3	37
Fruit	63.4	0.3	29
Spices	3.4	0.4	10
Stimulants	1.5	0.1	1
Total		44.2	1952
Animal Products			
Meat and Offals	3.7	0.5	6
Eggs	2.6	0.3	4
Fish and Seafood	8.4	0.9	5
Milk	104.7	3.8	66
Oils and Fats	2.8	-	23
Total		5.5	104
Grand Total		49.7	2056

Source: FAO, Food Balance Sheet 1979-81 (Rome, 1983), pp. 111-112.

FIGURE 4.1. INDIA: PER CAPITA AVAILABILITY OF CALORIES AND PROTEIN PER DAY FROM VARIOUS SOURCES, 1950 - 1980



Source: Appendix Tables I.4 and I.5.

protein level has remained almost constant at about 50 grams per capita per day. At 50 grams per capita per day the protein supply is well over the FAO recommendation. Even in terms of the Indian RDA, which includes a margin of safety over and above that of FAO standards, the protein availabilities do not appear inadequate.

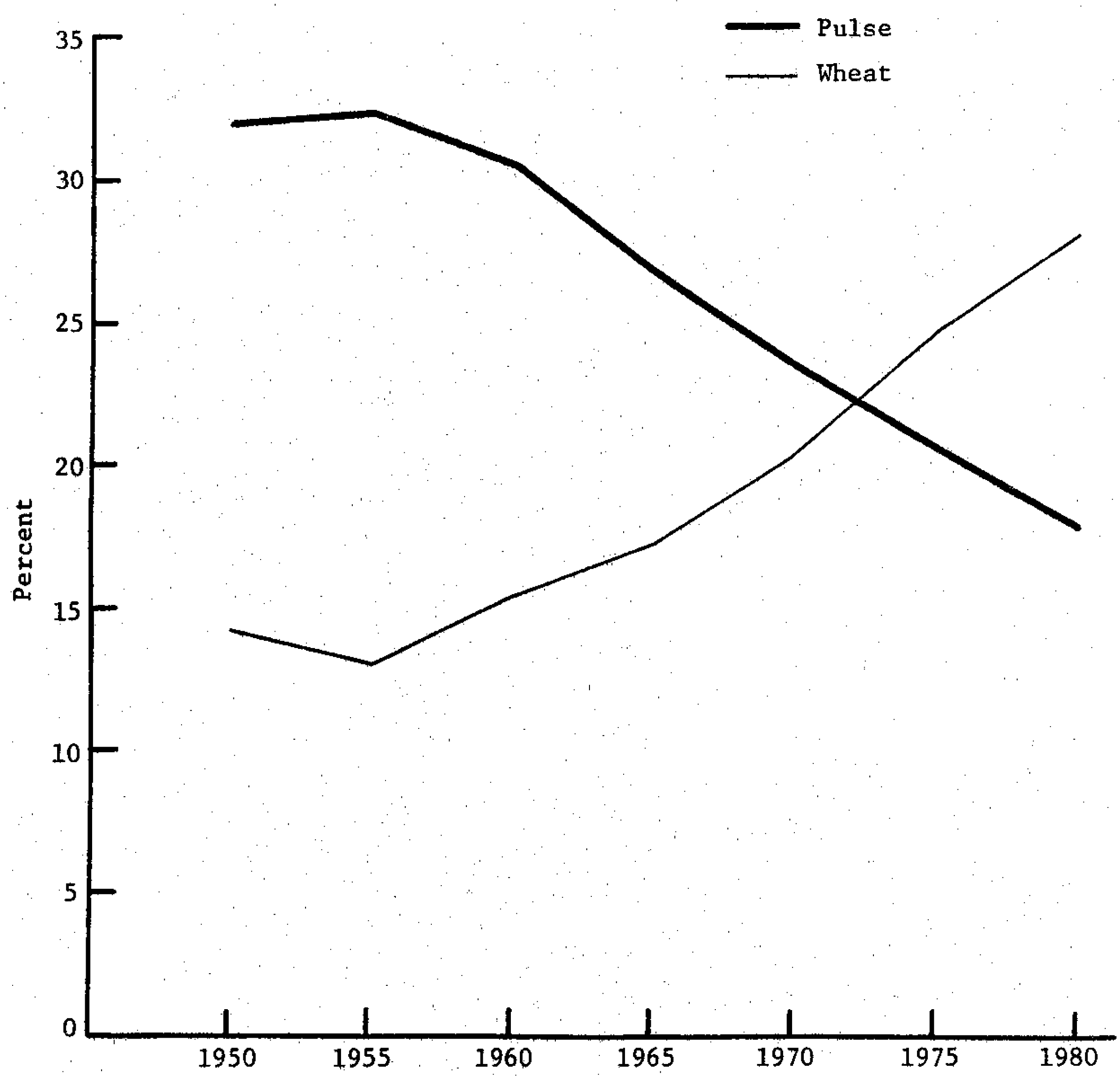
This must, however, be read with the caveat that the data being considered here are average availabilities, determined from food balance sheets, and do not reflect food distribution between income groups or within households.

Figure 4.2 indicates that in the early 1950s pulses were one of the major sources of protein and accounted for over 32 percent of total protein supplied by all foodgrains. This declined to 26 percent in the mid-1960s and fell to an all time low of 18 percent in the early 1980s. During the same period, wheat protein was on the increase. The trend accelerated after the mid-1960s due to the Green Revolution. The protein gap created by reduced pulse availability was compensated by a corresponding increase in wheat protein, which rose from 15 percent to 28 percent. Changes in the share of rice and coarse cereal protein were not as marked as in the case of pulses and wheat, and overall the per capita availability of protein remained almost constant at about 50 grams per day. On the other hand the advantage of enhanced wheat production was an overall increase in the supply of energy as well.

As has been noted earlier, calories are generally the first limiting nutrient in the diet. With increased wheat availability, this constraint was relaxed, enabling the protein being presently consumed to be utilized more fully and effectively.

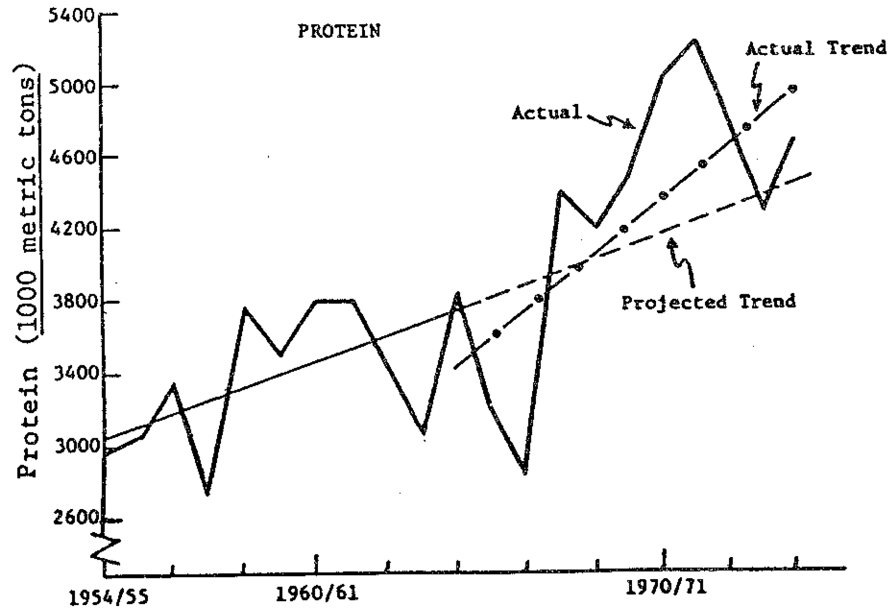
To measure the impact of the high-yielding varieties of wheat on nutrient availability, a study was conducted by Ryan and Asokan [51] based upon data from six major wheat producing states, Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan. A distinction was made between the pre- and post-Green Revolution period of the mid-1960s. Figure 4.3 shows separate linear trend lines fitted to the combined nutrient production figures of all major crops in the six states for these two periods. The pre-Green Revolution lines were projected to indicate the situation if no HYVs of wheat had existed. On comparison of projected trend lines with the actual existing situation, it was found that for both calories and protein, the actual trends were significantly higher than that which would have been produced had the Green Revolution not occurred. In fact in the absence of high-yielding wheat varieties, there would have been a reduction of 10 percent in the annual production of total protein and of 13.5 percent of total calories.

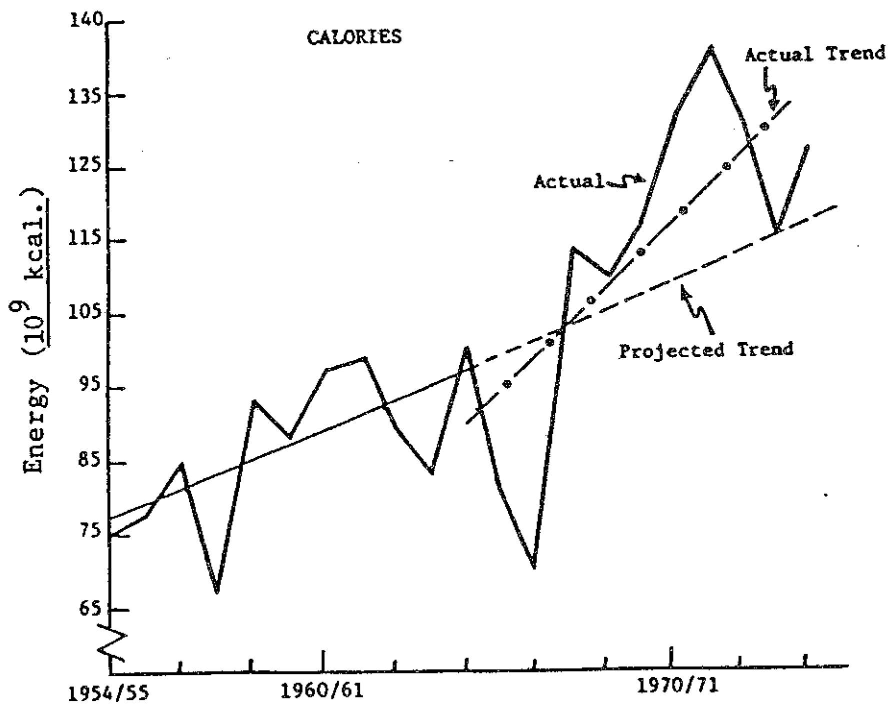
FIGURE 4.2. INDIA: PULSE AND WHEAT PROTEIN AS A PERCENTAGE OF TOTAL PER CAPITA FOODGRAIN PROTEIN, 1950-1980



Source: Appendix Table I.6.

FIGURE 4.3. INDIA: PRODUCTION OF PROTEIN AND ENERGY FROM WHEAT, PULSES, WINTER RICE AND BARLEY IN SIX MAJOR WHEAT-GROWING STATES a/





a/ Punjab, Haryana, Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh.

Source: Ryan, James G. and M. Asokan, Effect of Green Revolution in Wheat on Production of Pulses and Nutrients in India (Economics Program, Occasional Paper 18, ICRISAT, Hyderabad, 1977).

Quality of Protein

We have seen in the previous section that reduced pulse availability has not led to any significant reduction in the quantity of protein in the diet. The only change that has occurred has been the increasing substitution of pulse protein by cereal protein, mainly wheat. Does this in any way alter the quality of protein in the diet, and to what extent? To examine these issues, we first need to look at what is meant by quality of protein, and how it can be measured.

Composition of Proteins

Proteins themselves are a distinct group of compounds. They are composed of carbon, oxygen, hydrogen, nitrogen and some sulphur. The structure of a protein can be described as being a relatively long chain composed of identifiable links called amino acids. The term amino acid is a descriptive chemical name indicating the presence of a nitrogen containing functional group (amino) and a carboxylic acid functional group in each amino acid. There are believed to be 25 different amino acids that link together in innumerable combinations to form the proteins.

Amino acids are classified into groups as being essential or nonessential. The classification "nonessential" simply indicates those amino acids which can be synthesized in sufficient quantities by the species in question, so that none needs be consumed. Essential amino acids are those which must be present in food, because the body is unable to synthesize them. Adult man requires eight essential amino acids [20, p. 53]. Table 4.4 shows the amino acid content of various foods.

Quality of protein is determined by the composition of its amino acid content and its digestibility. Various classifications have been arranged to measure a protein's quality or value. All are based on animal feeding experiments that evaluate a protein in terms of its capacity to support growth. Early it was learnt that whole egg protein ranked above all other proteins in quality. This is true because egg protein is highly digestible and its essential amino acid pattern most closely resembles the essential amino acid content of human protein. Therefore most classifications are arranged to compare all other proteins to egg protein.

Classifications for Comparing Protein Quality

Various classifications for comparing protein quality are shown in Table 4.5.

Biological Value (BV) of a protein represents the percentage of utilizable nitrogen in protein syntheses, and is expressed as:

TABLE 4.4: ESSENTIAL AMINO ACID COMPOSITION OF VARIOUS FOODS

Commodity	Approximate total N g/100 grams	Lysine	Tryptophan	Phenyl -alanine	Methionine
		gram per gram of N			
Cereals					
Wheat	1.89	0.17	0.07	0.28	0.09
Rice	1.09	0.23	0.08	0.28	0.15
Maize	1.78	0.20	0.04	0.29	0.12
Sorghum	1.66	0.15	0.07	0.30	0.10
Pulses					
Gram	2.74	0.44	0.05	0.36	0.08
Redgram	3.57	0.48	0.04	0.46	0.06
Greengram	3.84	0.46	0.06	0.35	0.08
Blackgram	3.84	0.40	0.07	0.31	0.09
Lentil	4.02	0.44	0.06	0.27	0.05
Animal Products					
Fish	2.80	0.56	0.07	0.27	0.19
Egg	2.13	0.44	0.09	0.36	0.21
Meat	2.96	0.51	0.08	0.25	0.15
Milk	0.51	0.50	0.09	0.32	0.16

Commodity	Approximate total N g/100 grams	Threonine	Leucine	Isoleucine	Valine	Cystine
		gram per gram of N				
Cereals						
Wheat	1.89	0.18	0.41	0.22	0.28	0.14
Rice	1.09	0.23	0.50	0.30	0.38	0.09
Maize	1.78	0.28	0.72	0.24	0.30	0.10
Sorghum	1.66	0.21	0.88	0.27	0.34	0.09
Pulses						
Gram	2.74	0.22	0.58	0.32	0.31	0.08
Redgram	3.57	0.20	0.45	0.25	0.26	0.06
Greengram	3.84	0.20	0.51	0.35	0.32	0.06
Blackgram	3.84	0.22	0.50	0.34	0.31	0.08
Lentil	4.02	0.22	0.47	0.27	0.31	0.07
Animal Products						
Fish	2.80	0.24	0.47	0.36	0.35	0.07
Egg	2.13	0.32	0.52	0.41	0.45	0.14
Meat	2.96	0.29	0.48	0.31	0.32	0.08
Milk	0.51	0.28	0.60	0.34	0.40	0.05

Source: Gopalan, C., *et al.*, *Nutritive Value of Indian Foods* (National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, 1978), pp. 139-148.

TABLE 4.5: COMPARISON OF VARIOUS METHODS FOR EVALUATION OF PROTEIN QUALITY

Food	BV	PER	NPU	FAO Protein Score 1973
Cereals				
Wheat	64.7	1.53	40.3	52.6
Rice	64.0	2.18	57.2	66.5
Maize	59.4	1.12	51.1	49.1
Pulses				
Beans	58.0	1.48	38.4	54.1
Peas	63.7	1.57	46.7	57.7
Groundnuts	54.5	1.65	42.7	65.0
Animal Products				
Beef	74.3	2.30	66.9	100.0
Egg	93.7	3.92	93.5	100.0
Fish	76.0	3.55	79.5	100.0
Milk	84.5	3.09	81.6	94.5

Source: Bodwell, C.E., Ed., Evaluation of Proteins for Humans (1977) p. 60.

FAO, Expert Committee, Energy and Protein Requirements (Rome, 1973), p. 63.

FAO (1970) Expert Committee, Amino Acid Content of Foods and Biological Data on Proteins (FAO Nutritional Studies No. 24, Rome, 1970), pp. 36-135.

$$BV = \frac{\text{Retained N}}{\text{Absorbed N}} \times 100$$ [1, p. 72].

Retention of nitrogen expressed as a percentage of the nitrogen in the test diet gives Net Protein Utilization (NPU). NPU = nitrogen absorbed X Biological Value of the protein [1 p. 72].

Protein Efficiency Ratio (PER) is based on the increase in weight of young animals. PERs vary from 0 to 4. Most studies report PER values for legume proteins between 0.5 and 1.5, with the exceptional case of soybean, which is between 1.5 and 2.5. The range for cereal proteins varies between 1.0 to 2.0, while that for meat and egg proteins from 2.5 to 3.5 [1, p. 72]. The value of a protein depends upon the composition of its essential amino acids. The absence of a single essential amino acid reduces the Biological Value of a protein to zero.

The Protein Score is the percentage of the limiting amino acid in the protein set against the percentage in the ideal protein pattern as proposed by the FAO Committee on Protein Requirements [1, p. 73].

We observe from all four classifications that the protein values of legumes come somewhat low down in the scale. This is because legumes are limiting in sulphur containing amino acids, methionine and cystine. On the other hand, as can be seen from Table 4.4, they are rich sources of the amino acid lysine, which is limiting in most cereals.

It is necessary to emphasize here that pulses are generally not consumed as single foods, but in combination with cereals. So that it is not the value of pulse protein by itself, but in combination with cereal protein that is of nutritional importance.

Legume Proteins in Food Mixtures

Pulse proteins supplement cereal proteins because they have a high lysine content and cereals are deficient in lysine. In the same way cereal proteins compensate pulse protein for low levels of sulphur-containing amino acids, methionine and cystine. A pulse and cereal food mixture leads to a higher quality of resultant protein.

Based on the FAO/WHO Report (1971), Beaton and Swiss [4] have distinguished between three categories of diets: 1) diets rich in animal foods with a Protein Score of 80 percent relative to milk or egg protein, 2) mixed cereal legume diets, perhaps with small amounts of animal protein, with a Protein Score of 70 percent, and 3) cereal diets, with few other sources of protein, equivalent to a score of 60 percent.

Optimum Combination of Cereal-Legume Proteins

There are certain proportions of cereal-legume mixtures that maximize the value of combined protein. Figure 4.4 shows the various combinations of maize and beans as well as rice and beans that lead to an optimum value of PER. A mixture of the two components leads to protein quality higher than that of the individual component [8, pp. 27-28].

The results in Figure 4.4 indicate that the maximum protein value is obtained when 50 percent of protein in the diet is derived from legumes and 50 percent from cereals, if the cereal is maize. In the case of rice and legume mixtures the maximum value is obtained when 80 percent of protein comes from rice and 20 percent from beans. Wheat combines in a 73 to 27 percent protein ratio with beans to give the maximum value of protein, which causes an increase in quality of about 50 percent [7, p. 31].

These results suggest the following inferences:

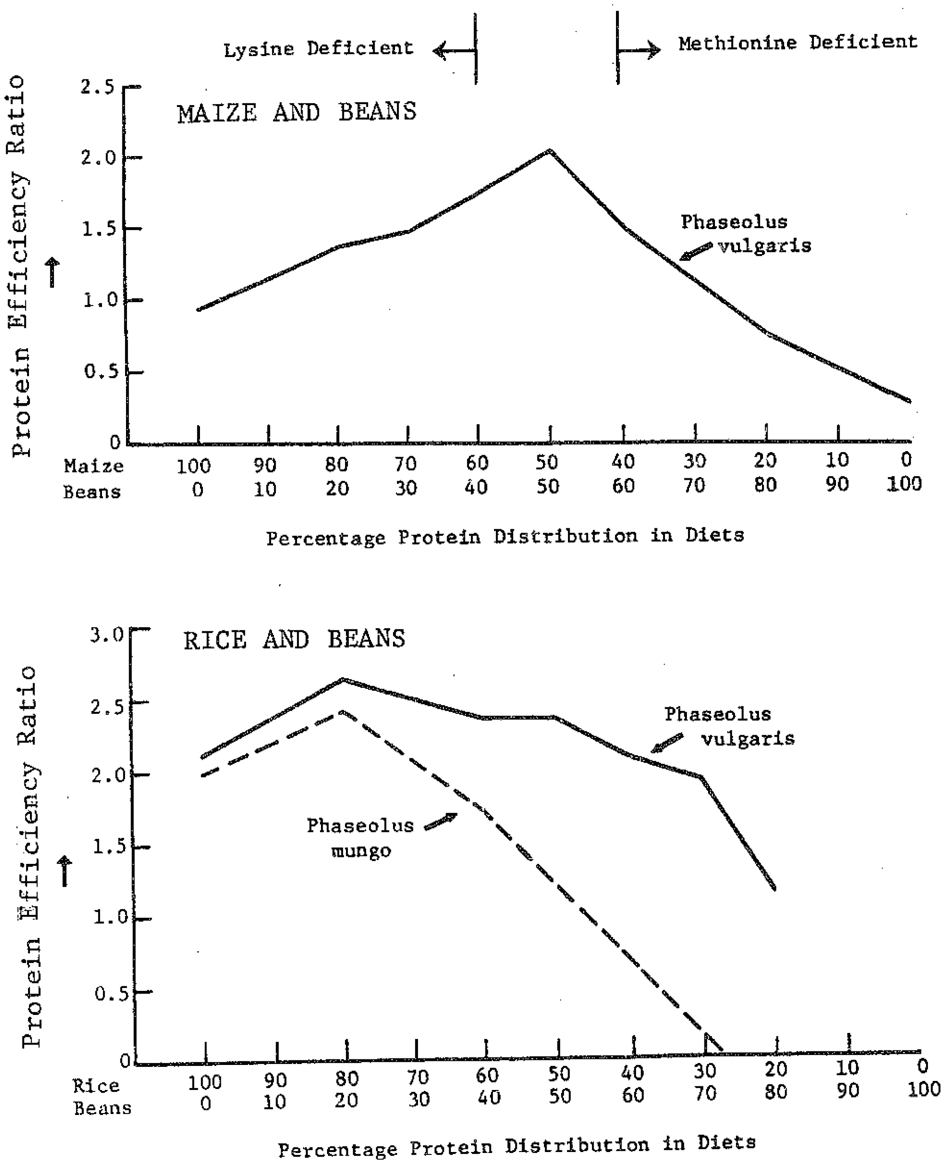
1) The quality of cereal-based diets can be improved by a higher level of legume intake.
2) For diets based on cereals, the poorer the quality of the cereal, the higher the level of legume protein needed to raise the quality of combined protein.
3) Intake of legumes above the optimum quality is likely to lead to a decrease in protein quality.

This last inference could well set the upper limit for per capita pulse consumption. Assuming that pulse production could be increased at will, and that the increased production would stimulate higher intakes, consumption of pulses beyond the optimum or desirable value would add nothing further to protein quality. In strictly nutritional and economical terms it would be wasteful.

Comparison of Actual Cereal-Pulse Protein Ratio With Optimum Values

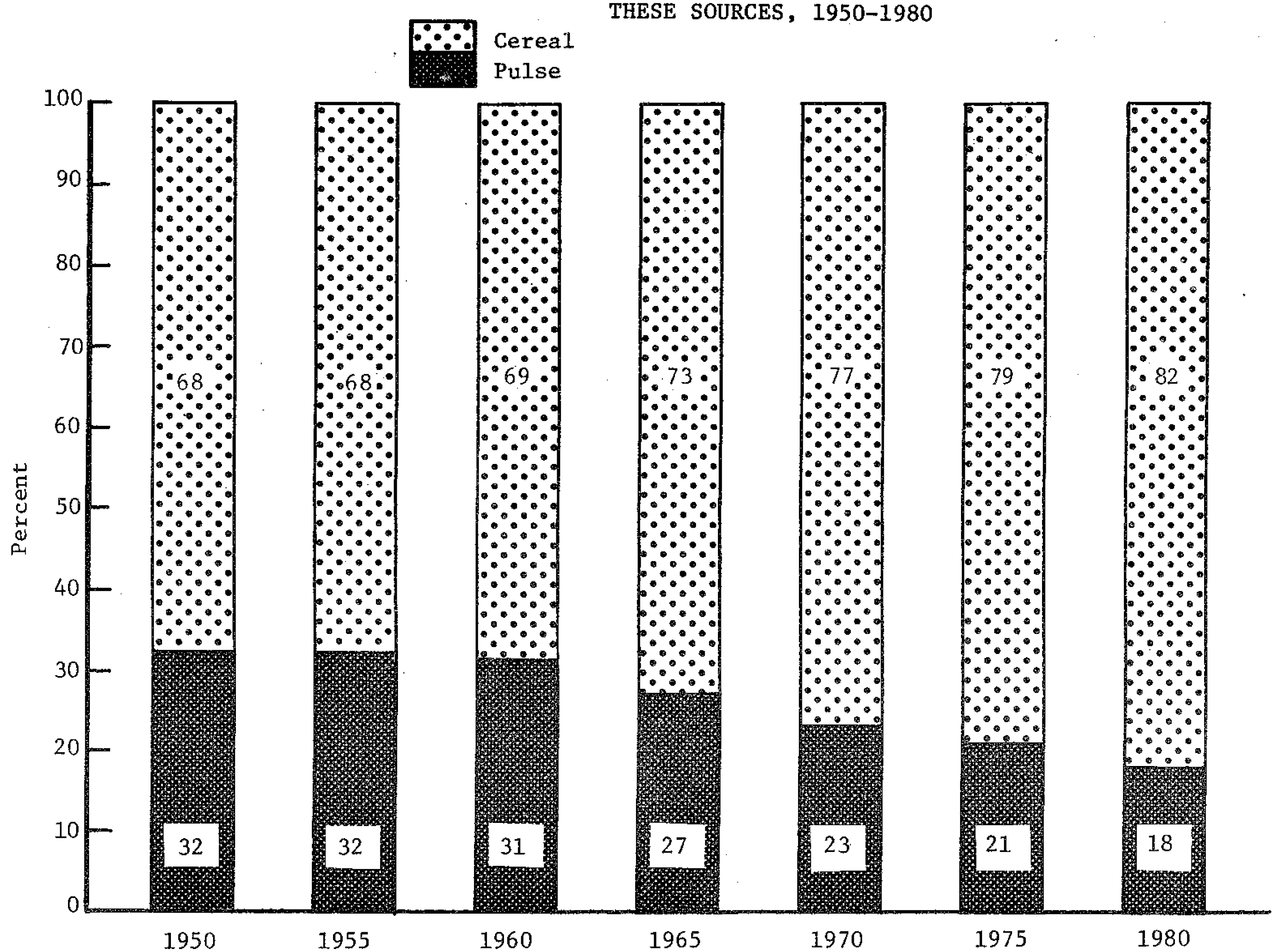
Figure 4.5 shows the actual cereal-pulse protein combination based on per capita availability data [17]. During the 1950s the cerealpulse protein ratio was constant at 68:32. After the mid-1960s, this ratio fell continuously. In the late 1970s and early 1980s the pulse protein share was at an all time low of 82:18. It must be remembered that the cereal protein availability is composed of not just a single cereal protein, but of a combination of rice, wheat, and coarse cereals consisting of maize, sorghum and millets. Similarly pulse protein share is made up of protein from gram, redgram, and other pulses. Therefore the actual cereal-pulse protein ratio cannot be strictly compared to the optimum ratio obtaining for single cereal-pulse combinations as seen in Figure 4.4.

FIGURE 4.4. NUTRITIVE VALUE OF VARIOUS COMBINATIONS OF CEREAL AND LEGUME PROTEINS



Source: Bressani, R. and L. G. Elias, "Improvement of the Nutritional Quality of Food Legumes," Food Nutrition Bulletin, Vol. 1, No. 4, pp. 27-28.

FIGURE 4.5. INDIA: PERCENTAGE CONTRIBUTION OF CEREAL AND PULSES TO PROTEIN DERIVED FROM THESE SOURCES, 1950-1980



Source: Appendix Table I.6.

With this caveat in mind, we look at some of the broad trends. In the preceding section we have seen that if all cereal protein were to come from rice, the desired cereal-legume protein combination would be about 80:20. For a large section of the population the staple diet is rice, and therefore it can be presumed that the source for cereal protein is rice. In such a case, the actual rice-pulse protein ratio in the 1950s and 1960s was higher than the optimum combination. The ratio fell after the mid-1960s, but even in the early 1980s for a rice-based diet, the protein ratio was still adequate.

If we consider a totally wheat-based diet, the broad trends indicate that up to 1965, the desired cereal-pulse protein ratio of 73:27 was met. However, after the mid-1960s the ratio fell much below the optimum.

In the third case of a diet based on coarse cereals, the desired cereal-pulse protein ratio of 50:50 was never achieved. Even in the early 1950s when pulse availability was relatively comfortable, diets based solely on coarse cereals fell quite short of the desired level of protein quality.

Translated into quantities by weight of cereals and pulses, the desired rice-pulse ratio would be about 90:10, the wheat-pulse ratio 80:20, and the coarse grain-pulse ratio 70:30. As against these ratios, the cereal-pulse ratio by weight was about 85:15 up to the mid-1960s and the average pulse availability was 65 grams per capita, implying that pulse availability was adequate to achieve the desired protein ratio if the cereal staple was either rice or wheat, but not a coarse cereal. After the mid-1960s pulse availability declined and the ratio fell. In fact in the early 1980s the average pulse availability was only 35 grams per capita and the cereal-pulse ratio by weight was 92:8.

We might therefore conclude that to achieve an optimum proportion of cereal-pulse protein, the cereal-pulse ratio by weight should be about 85:15 for diets based on wheat or rice, implying an average per capita pulse availability of about 65 grams per day. This figure, however, overestimates pulse requirement on two accounts. Firstly, as seen in Table 4.3, the average diet based on availabilities contains, in addition to cereals and pulses, other sources of protein including animal products. In fact, protein from other sources makes up about 15 to 20 percent, and animal protein alone about 10 percent of total available protein. Animal protein is high quality protein and the inclusion of animal products in the diet automatically reduces the pulse requirement. Secondly, the protein RDAs in India include an additional safety margin of 20 percent over and above that of FAO standards. This in turn inflates the pulse requirement.

Taking both factors into consideration, it seems not unreasonable to conclude that the figure of 65 grams per capita could be reduced by about 40 percent and the 85:15 by weight cereal-pulse ratio to 90:10, which would still result in the desired protein quality, provided, of course, enough energy was available in the diet to ensure that the protein was efficiently utilized. It needs, however, to be emphasized once again that the present analysis in terms of per capita pulse requirement is for an average person in moderate activity and is based upon availability rather than actual consumption data. It, therefore, has limited relevance and is useful only to the extent that it serves as a broad guideline.

If the per capita availabilities of foodstuffs shown in Table 4.3 could be considered as an average diet, then the required quantity of pulses, based on the above argument, would be about 40 grams per day. Taking into consideration the fact that about 10 to 15 percent of pulses might be consumed in the form of snacks and savories and not in combination with cereals, the average requirement would need to be adjusted upwards by 10 percent to about 45 grams per day. The quantity of pulse intake recommended by the ICMR, on the other hand, is about 70 grams per capita per day [23, pp. 29-30]. In the light of the above discussion this figure would appear to be a substantial overestimation.

We can conclude, therefore, that as a result of the Green Revolution and the decline in the per capita availability of pulses, the quantity of protein has not been adversely affected; the decrease in the supply of pulse protein has been more than offset by the protein from additional cereal production.

There has, however, been a perceptible decline in the quality of protein. We have estimated that for a satisfactory protein quality based on a diet of rice or wheat, a minimum daily intake of about 45 grams of pulses is required, provided enough cereal is consumed to meet energy needs. The pulse availability per capita, since the mid-1960s, has fallen from about 70 grams to less than 40 grams per day.

Further, it must be remembered that availabilities do not indicate actual consumption. With average availabilities as low as 35 to 40 grams per day in the early 1980s, portions of the population in the lower income groups are most probably not able to consume the required minimum quantity of pulses. So the quality of protein in their diet is almost certainly well below the desired level.

CHAPTER V
CONSUMPTION TRENDS AND DEMAND PROJECTIONS

In looking at pulse consumption we shall examine consumption trends over time, consumption by state, by rural and urban categories and by income class. There are two sources of information available for the purpose. Cross-sectional data on actual consumption, assessed directly from household consumption surveys, and time-series data as shown in national food balance sheets. The latter are, of course, disappearance data and do not reflect actual consumption.

Food balance sheet data, which indicate net availabilities, have limited use in the study of consumption trends, since they reflect only aggregates, and provide no distinction between rural and urban or different income classes. Our main data source is, therefore, the household consumption survey. However, these are not without error, as we discover in analyzing consumption trends over time. Food balance sheets can be used to advantage in cross-checking the reliability of household survey data.

The Food Balance Sheet data, henceforth referred to as FBS data, are available in India as time-series. The National Sample Survey data based on periodic household consumption surveys, henceforth referred to as NSS data, are available for a number of years, though not as time-series.

Consumption Trends for Pulses

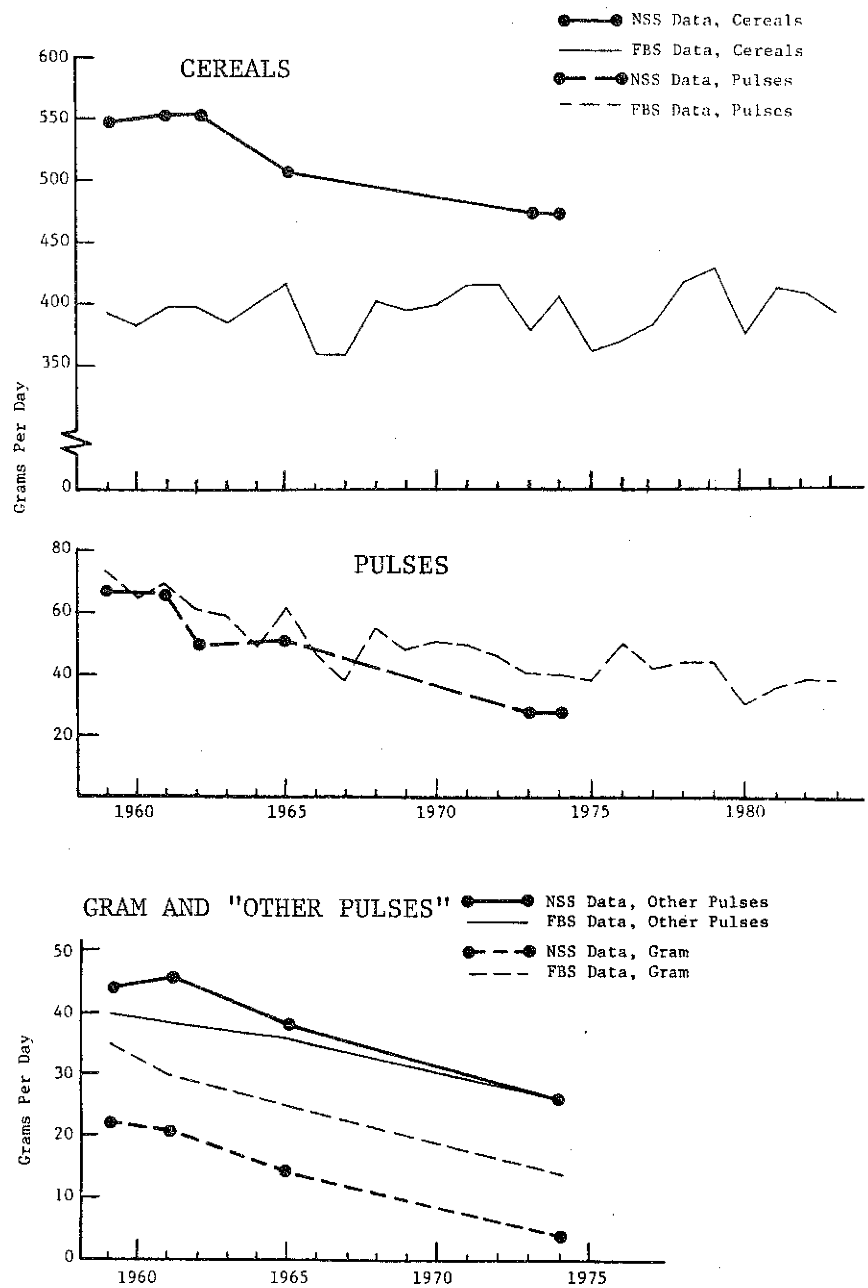
Consumption Trends Over Time

Figure 5.1 shows the data on consumption of pulses and cereals, in quantitative terms, as obtained from the various rounds of the NSS. The latest available data are for 1973/74 (the 28th round). The results for the 1977/78 (the 32nd round) consumption survey are not available as yet. The figure also indicates pulse and cereal availability as obtained from FBS data. The NSS estimate of cereals is 17 percent higher than implied in FBS data in 1973/74. But for pulses, NSS data show a level of consumption that is about 28 percent lower than production estimates.

The trend in pulse consumption, as indicated by the NSS data, shows a decline. This is corroborated by the trend in pulse availability as shown by the FBS data. The pulse consumption trends are in broad agreement, although there is considerable difference between the absolute values.

Weaknesses of the NSS Data. The NSS data on per capita consumption are ascertained on the basis of household consumption surveys. These surveys are based on scientifically selected sample households and are

FIGURE 5.1. INDIA: PER CAPITA CONSUMPTION/AVAILABILITY OF: PULSES AND CEREALS, 1959-1983; GRAM AND OTHER PULSES, 1959-1974



Sources: Appendix Table III.2; India, Cabinet Secretariat, The National Sample Survey: Tables with Notes on Consumer Expenditure (14th, 16th, 17th, 19th, 27th, and 28th Rounds, Delhi, various years).

conducted by trained full-time investigators of the NSS organization. The concepts and definitions used in the questionnaire have been standardized over the last two decades. The data have been used extensively in various studies to estimate food consumption trends, as well as incidence of poverty in the country [3, 53, 60].

Some studies have concluded that consumption of cereals, as indicated by NSS data, is overestimated [52, 66]. It is argued that in households with low incomes some family members eat outside, and consequently their consumption goes unrecorded in the survey. In the high income groups, guests as well as employees of the household, laborers and servants, also share in the food, but are not counted as members [66, p. 134]. This is corroborated by the fact that per capita calorie intake as obtained from the 26th round of the NSS (1971/72) showed a wide variation between the two extreme income groups. The highest group recorded an energy consumption of about 6000 kilocalories per capita per day and protein intake of 180 grams per day. For the lowest income group these figures were about 1500 calories and 46 grams, respectively [52, p. 80]. While the above argument can be applied to cereals to explain the higher bias in the NSS data, it would not be applicable to pulses or other more expensive food items.

Pulse consumption, as is seen from Figure 5.1, tends to be underestimated in the NSS data. There appear to be several reasons for this. First, the argument for a higher bias, as in the case of cereals, would not apply to the case of pulses which are a relatively expensive food item and therefore not as liberally dispensed as cereals, even in the upper income groups. Second, it must be remembered that the NSS data record consumption for households. This eliminates a significant category of establishments which are consumers of both cereals and pulses, such as charities, student hostels, restaurants and eating houses [66, p. 132]. There are certain other sectors which account more for pulses than cereals. These include temples and other places of worship, sweet shops and wayside stalls. Offerings in temples are largely made of sweets whose main ingredient is pulses, particularly gram. There is a strong likelihood that in household consumption surveys a significant portion of pulses consumed in this manner is not accounted for. Third, a sizable amount of pulses, especially gram, are consumed in the form of snacks and savories, often outside the home. With increasing urbanization, and improved mobility, the tradition of eating outside the home has gained considerable ground in the past two decades, as evidenced by the burgeoning of eating establishments in both urban and semi-rural areas. Since consumption surveys are based upon recalling consumption in the past 30 days, it is quite possible that due to memory lapse the quantity of pulses consumed in the form of snacks and savories is underestimated. Since the quantity of pulses consumed is small, being only about 10 to 20 percent by weight of cereals consumed, it is not surprising that a small fraction of this amount consumed outside the home goes unrecorded.

In the absence of studies or surveys that might indicate the percentage of pulses consumed in the nonconventional manner, we must look at the available information in the NSS data. The latter does not provide any breakdown of individual pulses, which are grouped together as one category under "pulses and pulse products." It does, however, record gram as a separate group. This helps to some extent in estimating the degree of bias in the NSS data.

Figure 5.1 indicates the per capita consumption of gram and other pulses, and also their availabilities as determined by the FBS data. It appears likely that there is an underestimation of gram in the NSS data. In the case of other pulses, NSS data seem to be slightly overestimated, but the difference is small and there appears to be a converging trend between the two sets. It may, therefore, be reasonable to presume that gram is the main source of underestimation in the NSS data. The reader must, however, be cautioned that in view of the inadequate data and sketchy information on pulse consumption, any inferences regarding gram and total pulse consumption can at best be reasonable conjecture.

A comparison of NSS and FBS data for gram is seen in Table 5.1. The FBS data indicate that gram accounted for more than 40 percent of total pulse availability in the late 1950s and early 1960s, and that its share has been steadily falling. This appears reasonable in the light of our argument about the effect of HYVs of wheat replacing gram acreage after the mid-1960s. While the same trend is reflected in the NSS data, it can be observed that the percentage of consumption of gram to total pulse consumption is lower than that indicated by the availability data. Up to the mid-1960s the unaccounted gram consumption was about 13 percent. This seems to have increased in the mid-1970s to about 24 percent. One possible reason for the increase might be the fact that with reduced availability of gram and the consequent rise in prices, the average consumer cut down severely on the consumption of gram. However, in business establishments and eating houses consumption was not curtailed to the same extent as in households. This might perhaps explain the widening of the gap between the recorded household consumption and the average availability of gram.

The analysis is constrained by the unavailability of further data in the time-series. However, on the basis of the above discussion we may broadly infer that it is likely that after the mid-1960s the NSS data underestimate pulse consumption by about 15 to 20 percent. Since NSS data stop short in the year 1973/74, the alternative is to ascertain latest apparent consumption from the FBS data. Apart from the fact that FBS data do not reflect actual consumption, they suffer from other weaknesses as well.

<u>Weaknesses of the FBS data</u>. National Food Balance Sheets, published annually, give estimates of foodgrain availability. Separate estimates are available for wheat, rice, coarse cereals, gram and total

TABLE 5.1. COMPARISON OF NSS AND FBS DATA FOR GRAM

(grams per capita per day)

Year	NSS			FBS			
	Gram (1)	Total Pulses (2)	Percentage of gram to Total Pulses (3)	Gram (4)	Total Pulses (5)	Percentage of gram to Total Pulses (6)	Column (6)-(3)
1958/59	22.7	67.0	33.8	35.5	74.9	47.4	13.6
1960/61	21.0	67.0	31.3	30.2	69.0	43.8	12.5
1964/65	14.0	52.0	27.0	25.5	61.6	41.4	14.4
1973/74	3.7	29.3	12.6	14.8	40.8	36.3	23.7

Source: India, Cabinet Secretariat, The National Sample Survey: Tables with Notes on Consumer Expenditure. 14th Round 1958/59, 16th Round 1960/61, 19th Round 1964/65, 28th Round 1973/74 (Delhi, Controller of Publications).

pulses [35]. The equation for net availability can be written as follows:

Net Availability = Gross Production - (Feed, Seed and Wastage, Processing Losses, Industrial Uses) ± Net International Trade ± Changes in Stocks

The FBS data, however, suffer from some shortcomings. The equation shows that net availability depends on gross production. Gross production in the case of pulses may be underestimated, since pulses are usually not grown on prime agricultural land but on marginal lands, and a small percentage of the latter might escape official notice. Redgram, or pigeonpea, has the appearance of a shrub and is often planted on the borders of regular fields to keep out intruders. It is quite likely that the area of redgram sown in this manner might fail to find mention in the official land records.

Another reason why production of pulses may be understated is the fact that pulses have traditionally been planted as mixed crops. Intercropping of pulses with maize, sorghum and sugarcane is still widely practiced. This might also lead to an underestimation in the area and production of pulses. However, in the absence of concrete data any attempt to adjust for underestimation would be arbitrary and lead to greater ambiguity in the official statistics.

Net availability also depends on changes in stocks. However, official records take into account only government stocks. There is no account of stocks privately held. Pulses are marketed almost exclusively by the private trade. It is difficult to collect data from the widespread and diverse range of private foodgrain traders, and no serious effort has been made by the government to collect them.

To account for feed, seed and wastage, the following allowances are made: rice 7.6 percent, wheat 12.1 percent, gram 22.1 percent, total cereals 12.5 percent and total pulses 12.5 percent [35]. The National Commission on Agriculture (NCA) adopted the following breakdown to account for a 12.5 percent allowance: 5.0 percent seed, 5.0 percent livestock feed, and 2.5 percent wastage [33, p. 49].

Since 1976, when the NCA attributed a 5 percent share for feed, the real prices of pulses have risen considerably. As a result there may be a decline in the use of certain pulses as livestock feed. Gram, which was commonly used for feeding horses, finds lesser use for this purpose. On the other hand, with greater emphasis on dairying activities, pulses such as cowpeas and horsegram are being increasingly used. In the absence of more precise information on the changing pattern of pulses for feed use, it appears prudent to accept the 5 percent estimate of the NCA.

On the other hand, because of a 2.5 percent allowance for wastage, it seems that the FBS data overestimate pulse availability. In actual fact losses and wastage in pulses are more than 2.5 percent. One study indicates that nearly 80 percent of the total loss of pulses is caused by insects, rodents and micro-organisms in storage, and pulses are more susceptible to insect damage compared to other foodgrains like wheat, paddy and maize. The estimate attributes losses in storage due to insects as 5 percent for pulses, 2.5 percent for wheat, 2 percent for paddy and 3.5 percent for maize [4, p. 429].

Yet another factor which affects the wastage component is that more than 75 percent of pulses produced are consumed in the form of *dal* [44, p. 405]. Conventional and traditional methods of milling whole grain pulses into *dal* remove anything between 10 and 25 percent of edible portion, and according to one estimate 1.5 million metric tons of pulses are lost annually in the process [43, p. 423].

An Expert Group (1967) set up by the Government estimated the losses for paddy, wheat and pulses at 11, 8 and 9.5 percent, respectively. The losses included post-harvest operations, processing, transporation and storage [43, p. 425]. On the other hand significant advances in technology over the last two decades have led to improved practices in pest and insect control, resulting in the reduction of losses. In the absence of concrete data, it is difficult to formulate a precise estimate of the current level of losses in pulses. Any attempt to alter the official figure of 12.5 percent would be arbitrary and would undermine the validity of the data.

While the NSS data give information about consumption across different expenditure classes, and FBS data provide the latest availabilities, neither of the sources gives any indication of food distribution within households. So that while food consumption or availabilities at the aggregate household level may seem adequate, deficiencies may exist for members within the same family. We have no statistics to determine how these deficiencies within the household may be skewed. It is, however, a well known fact that in traditional rural families the adult males receive the better portion of the meal both in terms of quantity and quality, while the younger members and the women must be satisfied with what remains.

Consumption Trends by State

Pulse consumption data by state in the 1960s and 1970s, in quantitative terms, are not available in published NSS data. Therefore data from an alternative source are examined to see if any useful trends emerge.

Diet Surveys. The National Institute of Nutrition, at Hyderabad, and the Nutrition Sections of the Departments of Public Health in State Governments carry out periodic diet surveys. The data collected by these agencies are compiled and published as the "Report of Nutrition Work done in States." During the period between 1960 and 1969, 575 surveys were conducted, covering a population of about 152,000 persons, in 13 states [22, pp. 26-27].

The average per capita daily consumption of pulses as obtained from these diet surveys is shown in Figure 5.2. The average per capita daily pulse consumption reported was about 34 grams during the period between 1960 and 1969. This is even lower than that obtained from the NSS data. The same surveys also indicate that the per capita consumption of cereals was about 370 grams, lower than the NSS data and also below that reported by FBS data. However, the data are not very useful since they have been averaged over a ten-year period and fail to indicate any trends in consumption.

The data obtained by these diet surveys should be used with a great deal of caution. Absolute values from these data have not been used anywhere in the present study. However, the results from the surveys can be used to suggest the relative trend in pulse consumption by state. This is seen in Figure 5.2.

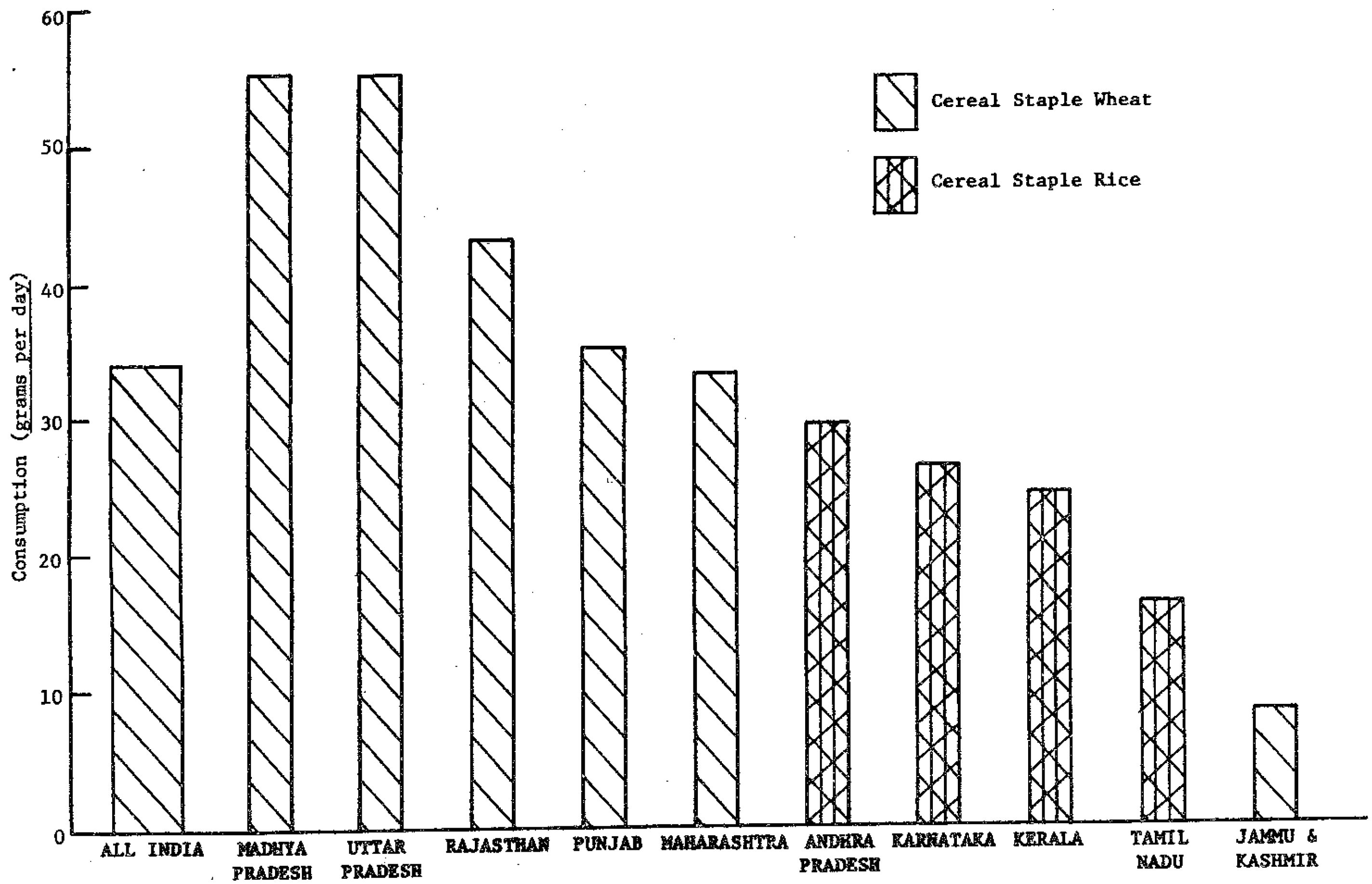
As is to be expected, states which are major producers of pulses also have the higher per capita consumption. The two largest pulse producing states are Uttar Pradesh and Madhya Pradesh; each accounted for about 22 percent of total pulse production in the early 1980s. The diet surveys were conducted between 1960 and 1969. In the 1960s Uttar Pradesh and Madhya Pradesh accounted for about 30 and 15 percent, respectively, of total pulse production. These two states, together with Rajasthan, also had the highest percentage of vegetarian population in the country [22, p. 48], which is another reason for the higher production and consumption of pulses. A third factor is of interest here. The higher pulse consuming states also happen to be the states where the cereal staple is wheat. States where the cereal staple is rice, such as Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, indicate lower pulse consumption. It was seen in Chapter IV that a desirable combination of cereal-pulse protein ratio is 73:27 when the cereal is wheat and 80:20 when the cereal is rice, thereby indicating that protein from rice is superior to that of wheat. Consequently rice requires relatively less pulse protein to supplement it.

It appears therefore that at least at the macro level, pulse production and consumption seem to have been naturally distributed in a nutritionally desirable manner.

Rural-Urban Consumption Trends

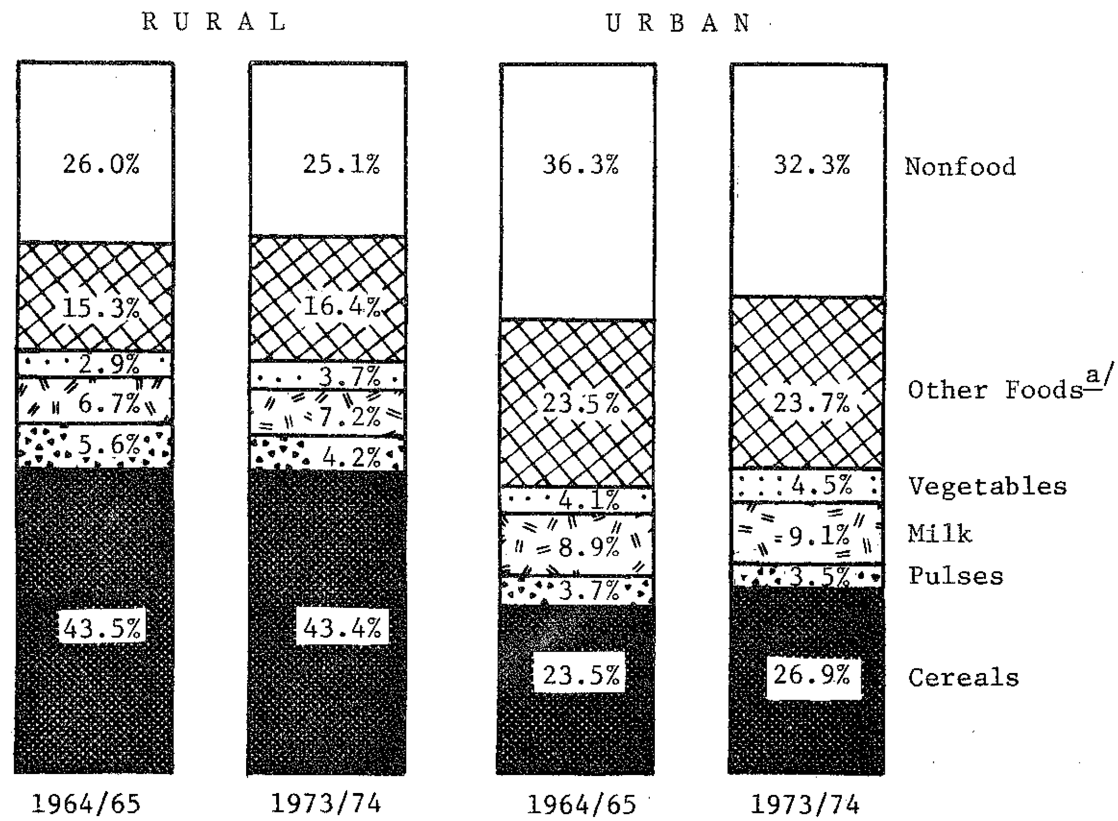
Figure 5.3 shows the average percentage expenditure in rural and urban areas on various food and nonfood items. Rural incomes are on an average 27 percent lower than urban incomes [52, p. 95]. In both rural and urban areas, consumers spend a major share of their income on food. In rural areas expenditure on food items is about 75 percent of total expenditure, while in urban areas it is about 65 percent.

FIGURE 5.2. INDIA: AVERAGE PER CAPITA DAILY CONSUMPTION OF PULSES IN DIFFERENT STATES, 1960-69



Source: Gopalan, et al., Diet Atlas of India (National Institute of Nutrition, ICMR, Hyderabad, 1971), p. 37.

FIGURE 5.3. INDIA: CONSUMER EXPENDITURE ON SELECTED COMMODITIES IN RURAL AND URBAN AREAS AS PERCENTAGE OF TOTAL CONSUMER EXPENDITURE, 1964/65 AND 1973/74



a/ Edible oils, meat, fish, eggs, fruits and nuts, sugar, salt, spices, beverages and refreshment.

Source: India, National Sample Survey: Tables with Notes on Consumer Expenditure (19th and 28th Rounds, No. 192 and 240, Delhi, 1971 and 1978).

Among the food items, cereal expenditure constitutes the largest share, up to 44 percent in rural households and 26 percent in urban households. Pulses have a share of about 4 percent of the expenditure for both rural and urban household budgets. There does not appear to be any marked difference in the share on pulse expenditure between rural and urban groups, unlike in the case of cereals, where the difference is almost double.

Milk products account for about 7 percent of the rural expenditure, and 10 percent of the urban household expenditure. Animal protein is most commonly consumed in the form of milk. The average share of other foods, which includes food items such as edible oils, meat, fish and eggs, vegetables and beverages, is about 17 percent in rural areas and 24 percent in urban areas. In rural areas the choice of food items for low income groups, as with small and marginal farmers and landless agricultural labor, is restricted to what can be cultivated. The urban consumer, on the other hand, is a wage earner and has a greater choice and diversity of food items. This accounts for the significant difference in expenditure between rural and urban areas in this category. However, it may be seen from Figure 5.3 that the difference has narrowed from 12 percent in 1965/66 to 7 percent in 1973/74, which indicates that the rural consumer, especially in the higher income groups, is exercising greater choice in food items.

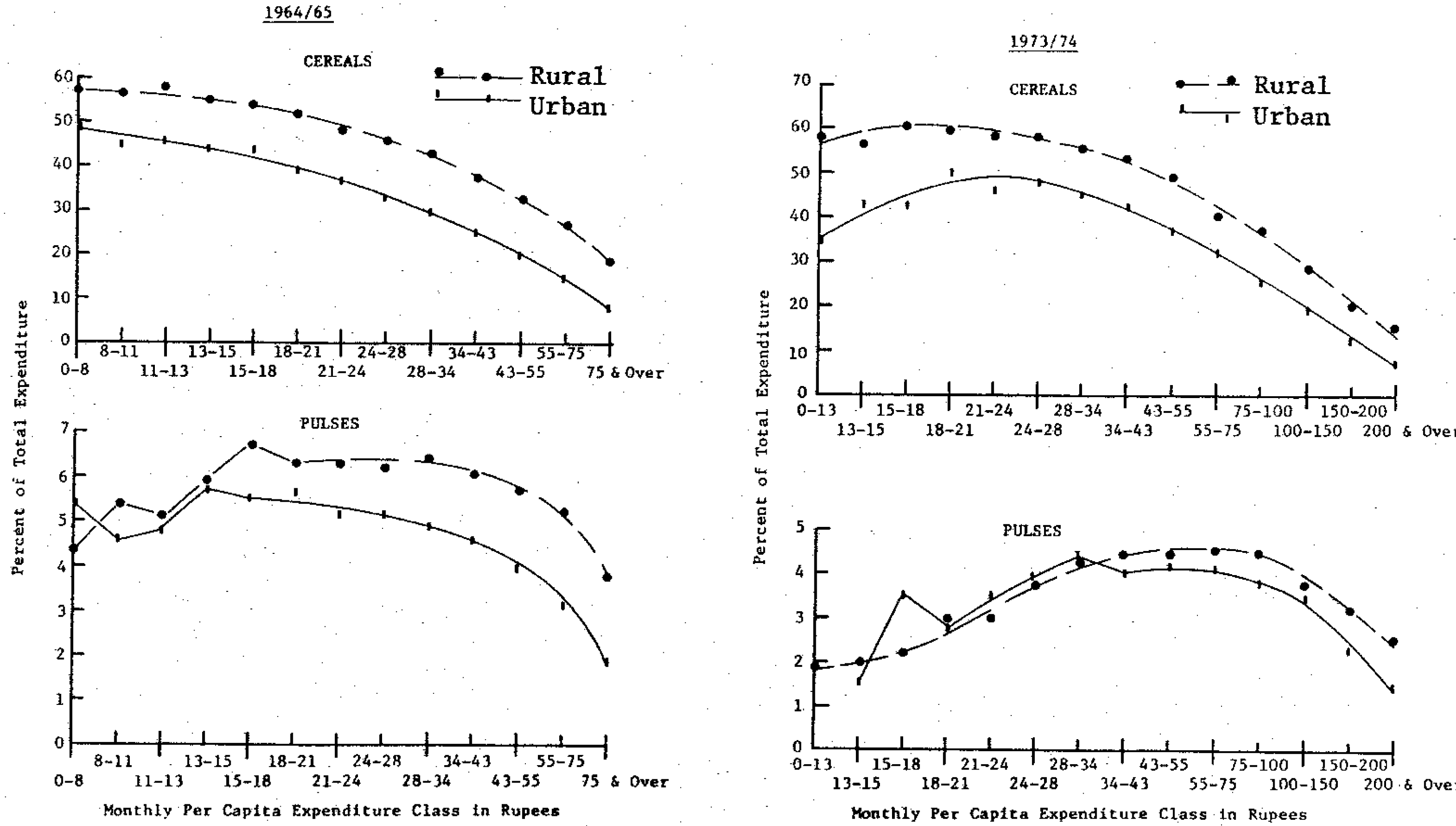
The nonfood group has a 10 percent larger share in the urban budget than in the rural budget. This is as expected, since transportation, housing, etc. form an essential part of the urban consumer's expenditure, whereas the share on these items is relatively lower in rural households.

The most significant difference between rural and urban expenditures appears to be in the categories of cereals, nonfood items and other foods. There are marked trends discernible during the two periods considered. Expenditure on pulses, however, has remained about the same in both rural and urban households during this period.

Consumption by Expenditure Groups

Rural and urban expenditures on food items closely follow Engel's Law, which states that as incomes rise and expenditure increases, the proportion spent on food falls. This is clearly indicated in the case of cereals in Figure 5.4. In 1973/74, for the lowest income group expenditure on food was about 82 percent of total expenditure in both rural and urban areas. Of this, 58 percent was accounted for by cereals in the rural areas, and 35 percent in urban areas. In contrast, the highest income group spent about 45 percent on food in both rural and urban areas. Of this, the share spent on cereals was 15 percent in rural and 8 percent in urban areas.

FIGURE 5.4. INDIA: EXPENDITURE ON CEREAL AND PULSES AS PERCENTAGE OF TOTAL CONSUMER EXPENDITURE, 1964-65 AND 1973/74



Source: Appendix Tables III.4 and IV.1.

Expenditure on pulses varied between 2 and 4.5 percent in both rural and urban areas in 1973/74. However, there appears to have been a significant change between 1964/65 and 1973/74. The gap in expenditure on pulses seems to have narrowed between the rural and urban areas. In percentage terms the expenditure of all classes on pulses appears to have fallen during the period. This is possibly the result of an increase in the relative price of pulses during this period.

Looking at actual per capita consumption instead of expenditure, we find that there has been a decline in the per capita foodgrain consumption between 1964/65 and 1973/74. For cereals, the proportion of decline increases as one moves to a higher income group. The poorest 30 percent of the population experienced practically no change, the middle 40 percent had a 3.9 percent decline, and the wealthiest 30 percent experienced a 12.6 percent decline. This is shown in Figure 5.1 and Table 5.2.

The decline in per capita pulse consumption was more significant. In fact the per capita consumption of pulses fell about 45 percent and was shared almost equally between all income groups. FBS data also indicate that the pulse availability during this period declined. During this period there was on an average a 30 percent increase in the real price of pulses [53, p. 24]. It is quite possible that consumers may have substituted other foods such as vegetables for pulses in the diet.

Table 5.2 also indicates that the percentage expenditure on pulses registered a decline. The percentage of total expenditure on food was higher in 1973/74 than in 1964/65. In 1973/74, the percentage expenditure on other foods also increased. This adds credence to the hypothesis that the consumers may have substituted other food items for pulses [53].

Pulse Consumption and Nutritional Norms

From Table 5.2 it is evident that in the mid-1960s about 70 percent of the population had a per capita pulse consumption greater than 45 grams per day. It may be recalled that in Chapter IV it was estimated that a per capita intake of about 45 grams of pulses together with adequate quantity of cereal consumption to satisfy energy needs fulfilled the requirements of the recommended dietary allowance of protein. This would imply that 30 percent of the population in the lowest income groups could not afford adequate quantities of pulses, although the per capita availability of pulses during this period was more than 60 grams per day.

By the mid-1970s the situation had changed markedly. The per capita availability declined to about 40 grams per day, and the real price of pulses registered an increase of 30 percent. If the NSS data were accepted without adjusting for underestimation, we would conclude that the per capita pulse consumption of the entire population fell

TABLE 5.2. PER CAPITA CONSUMPTION AND PERCENTAGE OF TOTAL EXPENDITURE ALLOCATED TO CEREALS AND PULSES, BY EXPENDITURE GROUP, 1964/65 AND 1973/74

Item/Year	Per Capita Consumption (grams per day)			
	Bottom 30%	Mid 40%	Top 30%	Average
1964/65				
Cereals	374.3	500.0	661.7	510.7
Pulses	29.0	48.0	80.7	44.0
Total Foodgrain	403.3	548.0	742.4	554.7
1973/74				
Cereals	375.3	480.3	578.4	478.3
Pulses	16.0	27.7	44.3	29.3
Total Foodgrain	391.3	508.0	622.7	507.6
	Percent of Total Expenditure			
1964/65				
Cereals	53.7	44.1	28.9	37.7
Pulses	5.8	5.9	4.9	5.4
Total Foodgrain	59.5	50.0	33.8	43.1
1973/74				
Cereals	53.9	46.4	29.9	39.3
Pulses	3.9	4.4	3.8	4.0
Total Foodgrains	57.8	50.8	33.7	43.3
Other Foods				
1964/65	24.1	25.2	29.8	27.4
1973/74	25.1	28.3	31.9	29.6
All Foods				
1964/65	83.6	75.3	63.7	70.5
1973/74	82.9	79.1	65.6	72.9

Source: Sarma, J.S. and Shyamal Roy. Two Analyses of Foodgrain Production and Consumption Data. Research Report No. 12, International Food Policy Research Institute (Washington, D.C. 1979) pp. 36-37.

were accepted without adjusting for underestimation, we would conclude that the per capita pulse consumption of the entire population fell short of the nutritional norms. However, with a 15 percent adjustment for underestimation, the 30 percent of the population in the highest income groups would have had a per capita consumption of more than 45 grams per day. The remaining 70 percent would have had a diet that may have been sufficient in protein quantity but short of the desired protein quality.

In the early 1980s average pulse availability did not increase and was less than 40 grams per capita per day. Consumption data for this period are not available, so that it is not possible to determine the percentage of population unable to consume an adequate quantity of pulses. However, it can be seen that the situation has deteriorated since the mid-1970s. The real price of pulses has increased further. It is likely that income distribution over the last decade has not improved. This assumption is based on available evidence which suggests that there has been little change in the distribution of incomes from the mid-1950s to the mid-1970s [52, pp. 106-107].

With a stagnant availability, no change in income distribution and an increase in the real prices, it appears reasonable to presume that more than 70-80 percent of the population are now unable to consume an adequate quantity of pulses. If the situation is not to worsen any further, efforts must be made to increase the per capita availability.

In the mid-1960s, when the per capita availability was about 60 grams per day, 30 percent of the population in the lower income bracket were unable to consume adequate quantities of pulses. The income distribution did not allow a significant percentage of the lower income groups to afford an adequate pulse intake despite sufficient availability.

We may conclude, therefore, that while planning for pulse production it might be prudent to make allowances for the income distribution factor. The Indian Council of Medical Research has recommended a per capita daily intake of about 70 grams of pulses per day. While this quantity appears considerably inflated from the nutritional point of view, it can be used as the desired availability while targeting pulse production. With an average availability of 70 grams per capita per day it is likely that more than 70-80 percent of the population will be able to consume about 45 grams of pulses per day.

Demand Projection for Pulses

The growth in demand for pulses in general depends upon the following factors: 1) the rate of population growth, 2) the rate of growth of per capita income and, 3) the income elasticity of demand. Changes in the relative price of pulses and the distribution of income are also likely to influence demand.

In deriving demand projections we have assumed constant prices. It is true that it would be more realistic to incorporate in the analysis possible trends of relative prices in the years to come. But in order to be able to make plausible assumptions about price trends, it is necessary to have a firm idea of the emerging supply demand balances. This is not easy. It is more practical to work out demand and supply projections at constant prices, identify the gap therein, and predict price trends using the price elasticity of demand.

Methodology

The method applied in this study for projecting demand is the following:

$$\text{consumption projected} = (\text{base consumption})(\text{demand growth rate})$$
$$\text{demand growth rate} = (1 + p)\ [1 + (y)(e)]$$

where p = proportionate increase in population
y = proportionate increase in per capita income
e = income elasticity of demand.

High and low expected growth rates in population and per capita income, along with high and low estimations of income elasticities, are used to project to 1990 and 2000 a range of demand for pulses.

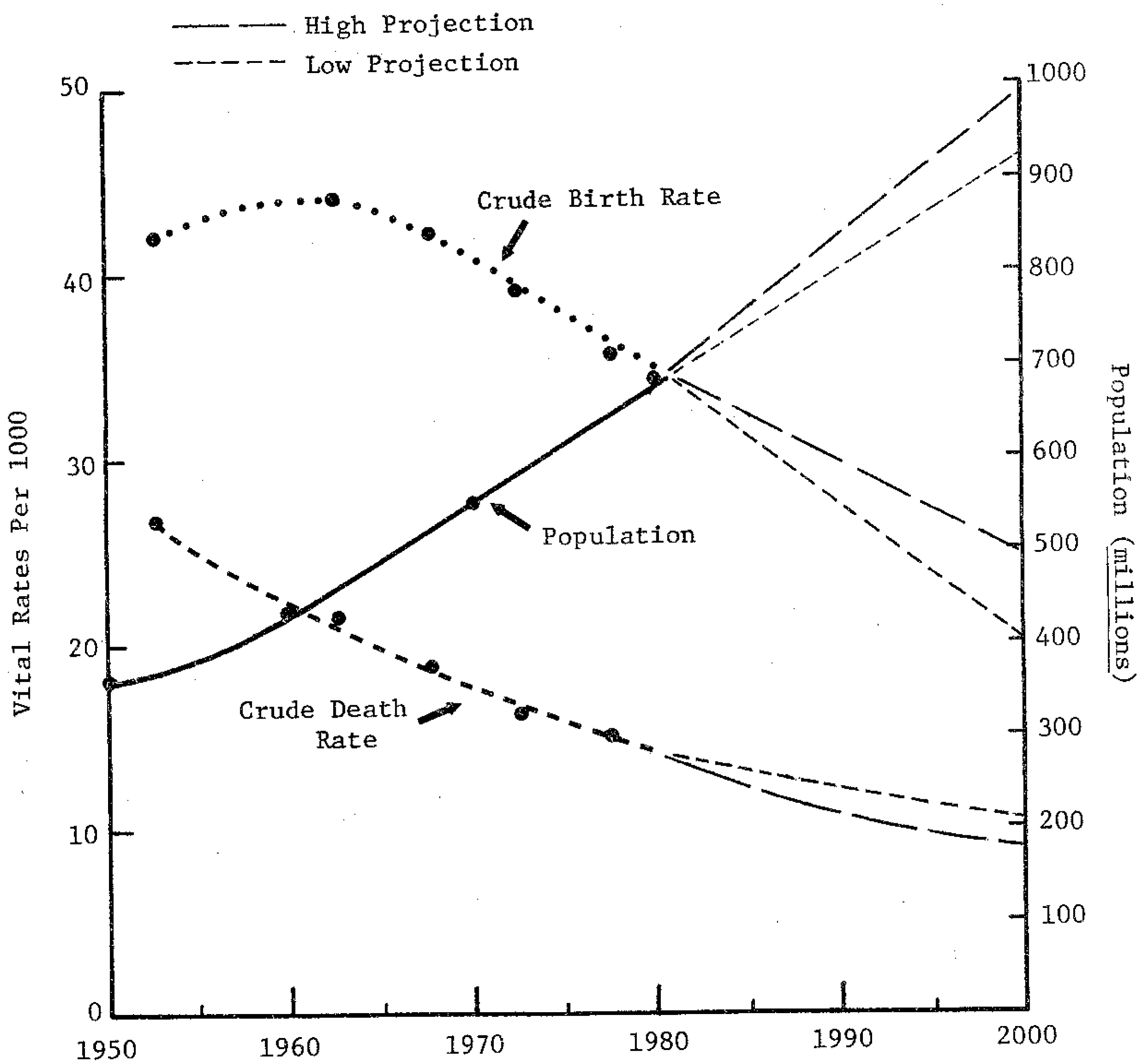
Population Growth Rate

The population of India in 1951 was 361 million, and had grown during the two previous decades at an approximate annual rate of 1.3 percent. The growth rate increased sharply during 1951-61 and 1961-71 to 2.16 percent and 2.48, percent respectively [63, p. 315]. Before the 1950s high birth and death rates kept the population growth rate low; however, during the 1950s, 1960s and 1970s high birth rates coupled with rapidly falling death rates led to increasing rates of growth, as can be seen in Figure 5.5. In Figure 5.5, population growth since 1950 is plotted against its demographic determinants, the crude birth rate (CBR) and crude death rate (CDR).

Demographers hoped that the family planning efforts since the mid-1960s would sharply decelerate the growth of population. Despite the spending of more than 10 billion rupees on family planning measures and the sterilization of more than 20 million people, the population grew by 2.47 percent annually in the 1970s, almost at the same rate as in the 1960s [63, pp. 319-320]. The 1981 census count exceeded the officially projected figures by about 13 million. On March 1, 1981, the population was more than 685 million [48].

However, there is reason to believe that, after rising for most of the past three decades, the population growth rate is over its peak,

FIGURE 5.5. INDIA: POPULATION GROWTH, CRUDE BIRTH RATE AND CRUDE DEATH RATE, 1950-1980, WITH RANGES OF PROJECTIONS TO 2000



Source: United Nations, Demographic Indicators of Countries--Estimates and Projections as Assessed in 1980 (New York, 1982).

because the death rate will not fall as fast as in the past and the birth rate will continue to decline.

The reasons for optimism stem from the rapid expansion of health services in the country. As a result, there has been a significant decrease in infant and child mortality rates. With greater numbers of children surviving there is a strong likelihood that couples will have fewer children, thereby leading to a decline in the birth rate.

Another cause is the rapid rate of urbanization. Between 1961 and 1971, the annual rate of growth of urban population was 3.3 percent, while the rate of growth of total population was 2.4 percent. During the decade of the 1970s, the urban population growth rate increased to 3.7 percent [69, p. 190]. Various demographic studies indicate that fertility rates have been lower in urban areas than in rural areas in recent years [9, p. 140]. Consequently with a continuing rapid rate of urbanization, the birth rate is likely to fall.

There was a decline in the crude birth rate from an average of about 44 per thousand in the 1960s to 35 per thousand in the late 1970s. The death rate during this period fell from 22 per thousand to about 13 per thousand [69, p. 186].

For the purposes of this study, we define the high scenario as one where the birth rate in the 1980s remains almost the same as in the late 1970s implying thereby that the various population control measures have not had any significant impact in reducing the birth rate.

The UN high variant estimates for the first half of the 1980s, shown in Table 5.3, describe such a situation. The CBR at about 34 per thousand is almost the same as in the late 1970s. The UN low variant estimates for CBR are about 30 per thousand, which would reflect a scenario where family planning measures together with improved health facilities and urbanization have a significant impact in reducing the CBR.

It therefore seems justified to use the UN high and low population variants to project a range of demand. The projections for population estimated by the Government of India, in the Seventh Five Year Plan document, also appear to justify the choice, since they lie within this range [37, pp. 11-12].

Income Elasticities

The degree to which changes in income affect the quantity demanded depends upon the income elasticity of the commodity. Income elasticity is defined as the percentage change in quantity corresponding to a one percent change in income, other factors held constant.

TABLE 5.3. INDIA: PROJECTED POPULATION GROWTH RATES

Year	UN (high variant)			UN (low variant)		
	CBR (per thousand)	CDR (per thousand)	annual growth rate (%)	CBR (per thousand)	CDR (per thousand)	annual growth rate (%)
1980-85	33.9	13.2	2.07	30.6	13.5	1.72
1985-90	30.5	11.5	1.90	28.6	12.4	1.62
1990-95	28.6	10.3	1.83	26.8	11.6	1.53
1995-2000	26.1	9.4	1.67	24.1	10.8	1.33

Sources: United Nations, Demographic Indicators of Countries Estimates and Projections as Assessed in 1980 (New York, 1982), p. 302.

In empirical analyses, however, it is usually expenditure elasticities rather than income elasticities, that are estimated. Expenditure elasticity measures the percentage response of expenditure on a particular commodity to a one percent change in total expenditures. Sometimes it is the percentage change in quantity corresponding to a one percent change in total expenditure that is estimated. In the literature this is often also referred to as expenditure elasticity thereby causing some confusion. In the present study a distinction is made between the two, the latter will be called quantity elasticity. To further clarify the situation the following definitions are stated:

1) Income elasticity $E_y = \left(\frac{\Delta Q}{\Delta Y}\right) \frac{Y}{Q}$

2) Expenditure elasticity $E_E = \left(\frac{\Delta E_c}{\Delta E_T}\right) \frac{E_T}{E_c}$

3) Quantity elasticity $E_Q = \left(\frac{\Delta Q}{\Delta E_T}\right) \frac{E_T}{Q}$

where Q = quantity consumed
Y = income
E_T = total expenditure
E_c = expenditure on commodity C

Demand elasticities are estimated either from time-series data or from cross-section data.

There are certain drawbacks in using time-series data, because the only time-series available are those of Food Balance Sheets, which do not indicate consumption but only aggregate availabilities. Even these may be biased due to exclusion of changes in private stocks, the constant allowance for nonfood use and wastage, as well as limitations in the gross production estimates.

The alternative is to use cross-section data as obtained from the NSS. Although not without their drawbacks, the NSS data report actual consumption, but more importantly they can be used to analyze variation in consumption levels according to socio-economic characteristics of the population, which is not possible from the time-series data, which provides only aggregate information.

The NSS data for various survey years are reported not by income but by expenditure groups. In such surveys obtaining data on expenditures rather than incomes is easier and more precise. The income reported by the respondent in a sample survey often overlooks the income of other members [65, p. 49]. Similarly, expenditures on commodities rather than actual physical quantities appear to be more easily recalled by the respondent. Most rounds of the NSS report expenditure on various commodities, thereby providing the basis for estimating expenditure elasticities. However, there are certain years in which actual physical quantities have been reported. Quantity elasticities have been computed using data from these rounds.

Expenditure elasticities are generally higher than income elasticities, since expenditures on a particular commodity may be more responsive than quantities to changes in total expenditure. This is as to be expected, since consumers with higher incomes buy better quality items which are usually higher priced, so that higher expenditures on a particular commodity may not imply a proportional increase in physical quantity consumed. The expenditure response includes a quality as well as a quantity effect [65, p. 49].

Expenditure and quantity elasticities have been estimated in various studies. The estimates for quantity elasticity are shown in Table 5.4. It is evident that the estimates of elasticities vary considerably.

One of the criteria for selecting the quantity elasticities to be used in this study is that they should be based on the latest possible data. This limits the choice to NCA estimates based on 1970/71 data or FAO estimates based on 1973/74 data. However, the latter has estimates only for gram, and not for all pulses. We shall, therefore, use the NCA estimates of 0.85 and 0.66 for rural and urban areas, respectively, in the higher and lower projections for demand. These two figures appear to be reasonable since they are just slightly lower than the World Bank Study (1981) estimates of expenditure elasticities based on 1973/74 cross-section data [26, p. 13].

Per Capita Income Growth Rate

Official Indian statistics report net national product at market prices as well as net national product at factor cost. The latter is taken as a measure of national income. Per capita income growth is determined by subtracting the population growth rate from national income growth.

The annual growth rates of national income and per capita income during the six plan periods are shown in Table 5.5. The national rate of growth has fluctuated from an average of 2.2 percent during the Third Plan to 5.3 percent in the Fifth Plan period. In 1979/80, a year of severe drought the national income registered a negative growth.

Agriculture plays a predominant role in the Indian economy, and the performance of the agriculture sector determines to a large measure the behavior of the national income. The severe drought of 1979/80 had an adverse effect on the agricultural output and this was reflected in the negative growth of national income. The year 1976/77 was a year of record agricultural production, the growth of national income in that year was 9.8 percent [27, p. 91]. This implies that the national income has been subject to wide fluctuations due to variation in weather conditions. However, increased irrigation and improved agricultural practices are likely to reduce yield variability in the future. In fact a notable feature of agricultural production during the Sixth Plan was the limited impact of adverse weather in 1982/83.

TABLE 5.4. INDIA: ESTIMATES OF QUANTITY ELASTICITY FOR PULSES

Study	Quantity Elasticity		
	National	Rural	Urban
NCA[a]		0.85	0.66
FAO[b] Gram		0.97	0.81
FAO[c]	0.50		
Sarma[d] (World Bank Study)	0.68		
Chopra and Swamy[e]	0.58		

[a]India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture, Part III, Demand and Supply (Delhi, 1976). Appendix 10.2. Estimates based on NSS data 25th Round (1970/71).

[b]FAO, Income Elasticities of Demand for Agricultural Products (Rome, 1983). Based on NSS data 28th Round (1973/74).

[c]FAO, Agricultural Commodity Projections, 1970-80 (Rome, 1971).

[d]Sarma, J.S., "Behavior of Foodgrain Production and Consumption in India, 1960-77)" (World Bank Staff Working Paper 339, Washington, D.C., 1979). Estimates based on NSS data 19th Round (1964/65).

[e]Chopra, K. and G. Swamy, Pulses: An Analysis of Demand and Supply in India (1951-71) (Bangalore, 1975). Estimates based on NSS data 14th Round, 1958/59.

TABLE 5.5. INDIA: ANNUAL GROWTH OF NET NATIONAL PRODUCT AT FACTOR COST AND PER CAPITA NET NATIONAL PRODUCT (1951/52 - 1984/85)

(percent)

Plan Period	Annual Growth of Net National Product (1970-71 prices)	Annual Growth of Per Capita Net National Product (1970-71 prices)
First Plan 1951/52-1955/56	3.6	1.7
Second Plan 1956/57-1960/61	4.0	1.9
Third Plan 1961/62-1965/66	2.2	0
Three Annual Plans 1966/67-1968/69	4.0	1.8
Fourth Plan 1969/70-1973/74	3.4	1.1
Fifth Plan 1974/75-1978/79	5.3	2.9
Sixth Plan 1980/81-1984/85	5.2	3.1

Source: India, Ministry of Finance, Economics Division, Economic Survey 1984/85 (Delhi, 1985) p. 91.

India, Planning Commission, Seventh Five Year Plan 1985/90, Vol 1, (New Delhi, 1985), p. 1.

The Seventh Plan has set a target of 5 percent annual growth for the economy during the remaining decade and a half of this century. Taking projected population growth into account, this implies a per capita income growth rate of 3.1 percent during 1985-91, 3.3 percent during 1991-96 and 3.5 percent during 1996-2001 [37].

Projections for per capita income from various other studies are shown in Table 5.6. On the basis of past experience, it appears that a sustained per capita income growth rate of more than 3 percent per annum may be slightly optimistic. Therefore, this has been arbitrarily scaled down to 2.5 percent per annum and set as the upper limit. The average growth rate per capita over the last six plans has been approximately 1.5 percent and this has been chosen as the lower limit for this study.

Base Consumption

The last estimate of actual pulse consumption as determined by the NSS data was 6.2 million metric tons in 1973/74. As discussed in the previous sections, it appears that NSS data underestimate pulse consumption. During the same period the pulse availability accounting to FBS data was 8.7 million metric tons.

There are no estimates of actual consumption available after 1973/74. Pulse availability data are, however, available up to 1983. Taking into account the fact that actual pulse consumption as reported by the NSS data might be underestimated, we use apparent consumption as indicated by availability. It is necessary that the base year, besides being a recent year, should be a normal year from the points of view of production and prices. We therefore take the base annual consumption as the pulse availability from the FBS data averaged over the years 1982-84. This works out to 10.5 million metric tons, or 39 grams per capita per day.

Projected Demand for Pulses

Table 5.7 summarizes the projections made for the high and low growth scenarios, as discussed in the preceding sections. Projected high demand for pulses in 1990 and 2000 are 16.42 and 23.76 million metric tons, respectively. Projected demand for the low scenario are 14.72 and 18.61 million metric tons. Table 5.8 shows the demand projection for pulses estimated in various other studies.

The demand projections made in the present study appear to be in line with the estimates of the World Bank Study. The slightly higher bias in the latter could be due to the fact that expenditure elasticities rather than quantity elasticities have been used to project demand. Even so the difference is not very significant.

TABLE 5.6. INDIA: PROJECTIONS FOR ANNUAL PER CAPITA INCOME GROWTH RATE

(percent)

Study	1990	2000
Sanderson and Roy [a] (1975-)		
High	3.0	3.5
Low	1.4	1.6
FAO[a] (1975-)	1.6	1.9
IFPRI[b] (1975-)		
High	1.5	--
Low	1.1	--
Hitchings[c] (1979/80-)		
High	3.1	3.1
Low	1.6	1.6
NCA[d]		
High	2.0	2.0
Low	1.0	1.0
Kannan & Chakraborty[e] (1981-)		
High	4.25	4.5
Low	4.00	4.5
Planning Commission[f] (Government of India)		
1986-1990	3.1	3.4
1990-2000		

a/Sanderson, Fred M. and Shyamal Roy, Food Trends and Prospects in India Washington, D.C., Brookings Institution 1979, p. 136.

b/International Food Policy Research Institute, "Food Needs of Developing Countries: Projections of Production and Consumption to 1990." Research Report 3, (Washington, D.C. 1979), p. 147.

c/Hitchings, Jon, A. "India: Demand and Supply Prospects for Agriculture." World Bank Staff Working Paper No. 500 (Washington, D.C., 1981), p. 20. (Per capita expenditure growth rate is used.)

d/India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture, Part III Demand and Supply (New Delhi, 1976), p. 13. (Per capita consumption expenditure growth is used.)

e/Kannan, R. and T. K. Chakraborty, T.K., Economic and Political Weekly (December 1983), p. A141. (Per capita consumption expenditure growth is used.)

f/India, Planning Commission, Government of India, Seventh Five Year Plan 1985-90. Vol. 1, (New Delhi, 1985), pp. 11-13.

TABLE 5.7. INDIA: DEMAND FOR PULSES PROJECTED TO 1990 AND 2000

Year	Base Consumption (million M.T.)	Per Capita Base Consumption (grams per day)	Total Consumer Demand (million M.T.)	Consumer Demand Per Capita (grams per day)	Total[a] Demand (million M.T.)	Requirement based on 70 grams per capita per day (million M.T.)
Average of 1982-84	10.50	39				
1990						
High			14.37	47	16.42	24.45
Low			12.88	44	14.72	23.47
2000						
High			20.79	57	23.76	29.12
Low			16.29	48	18.61	27.07

[a] Total demand includes 12.5 percent for feed, seed, and wastage.

Sources: Table 5.3, Table 5.4, Appendix Table III.2.

TABLE 5.8. COMPARISON OF DEMAND PROJECTIONS, 1990 and 2000

(million metric tons)

	Demand Projections			
	1990		2000	
Study	High	Low	High	Low
NCA[a]	--	--	28.23	23.66
Kannan and Chakraborty[b]	19.49	19.10	28.47	27.75
Hitchings[c] (World Bank Study)	16.89	15.26	24.29	20.25
Present Study	16.42	14.72	23.76	18.61

a/India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture, Part III, Demand and Supply (New Delhi, 1976), p. 15.

b/Kannan, R. and T.K. Chakraborty, "Demand Projections for Selected Food Items in India, 1985-86 to 2000-01," Economic and Political Weekly (December 1983), p. A141.

c/Hitchings, Jon A., "India: Demand and Supply Prospects for Agriculture," World Bank Staff Working Paper No. 500 (Washington, D.C., 1981), p. 16.

Compared to the present study, the demand projections made by Kannan and Chakraborty appear to be overestimated. The projected rates of income growth used in the study by Kannan and Chakraborty appear to be very optimistic and perhaps account for the overestimation of demand projections.

While interpreting the results of this study, the limitations of the data and the methodology need to be borne in mind. First, because of the dated and imprecise nature of actual consumption statistics, estimates of disappearance have been used as baseline consumption. This may not reflect actual consumption.

Second, to the extent that changes in income distribution might take place, demand would be affected according to marginal propensities to consume at various income levels. No account of this has been taken.

Third, the absence of prices in the analysis is an obvious limitation to projections based on cross-sectional data. Relative prices are assumed to be constant, whereas they would respond to changing consumption patterns and production levels. The technology of the future may influence the relative prices of pulses, cereals, vegetables and animal products, and to the degree that dietary patterns are affected by these changes (which will depend upon the price elasticities of the different commodities), actual consumption levels will differ from the projections obtained in this study.

Other factors--such as future government policies regarding price supports, procurement, levies on producers or millers, and imposition of rationing--will also influence production and, ultimately, consumer demand. All have been ignored in this study.

Nonetheless, the study does provide a broad idea of the magnitude of the demand for pulses by the end of the century. The present availability of pulses is of the order of 11 million metric tons. With an estimated demand of about 24 million metric tons, based on the high scenario, production will have to more than double if the projected demand is to be met.

If the production trends of the past two decades are any indication, meeting the future demand for pulses is indeed a formidable task that challenges agricultural scientists and administrators alike.

CHAPTER VI
ESTIMATING PULSE PRODUCTION IN 1990 AND 2000

The probable demand for pulses in 1990 and 2000 having been estimated, we now examine the potential for pulse production and the extent of the gap between demand and supply.

It was seen in Chapter III that one of the consequences of the Green Revolution was to shift acreage away from pulses to high-yielding variety cereals in irrigated areas where the response of the HYVs was greatest. In the northern wheat belt, where irrigation and HYVs spread faster than in any other part of the country, pulse acreage was most adversely affected. As a result, after the mid-1960s there was a shifting away of pulse area from the irrigated northern region into the predominantly rainfed areas of central and peninsular states.

The last seven to eight years, however, have witnessed a small but perceptible change in the situation, as the new pulse technology in the form of short-duration varieties is spreading, and has begun to make an impact on the farmers' fields. This augurs well for the future of pulse production in the country. While the bulk of production will continue to come from rainfed areas, it is expected that production from irrigated areas will play an increasingly important role.

New Technology for Pulses: Potential for Increase in Area

Short-Duration Varieties

The breakthrough in pulse technology, unlike in the case of wheat and rice, has not come in the form of high-yielding varieties, but in the development of short-duration varieties. These short-duration varieties have made it possible for double cropping to take place in areas where only a single crop was previously cultivated. The short-duration varieties have been developed mainly for redgram, greengram and blackgram, which has made it possible for these pulses to fit into crop rotations which were not possible before. Pulses which previously competed with cereals for the same land have now begun to be sown during the season where the land would ordinarily be left fallow, leading to the possibility of double and triple cropping intensity.

Gram. It is by far the most important of pulse crops. Although a number of improved varieties have been developed, they respond to improved agricultural practices and a package of inputs. Gram continues to be a *rabi* crop and as such competes for land with other *rabi* cereals particularly high-yielding varieties of wheat. No major breakthrough has yet been achieved in evolving gram varieties which could be fitted in crop rotations to avoid competition with *rabi* cereals.

Redgram. The traditional varieties of redgram were almost perennial crops having a maturity period of 8 to 10 months. With the development of short-duration varieties, which mature after 5 to 6 months, redgram has become a seasonal crop, which can be fitted into annual rotations. The short-duration varieties have opened up vistas for double cropping as well as crop sequences which were not possible with the traditional varieties.

Varieties of redgram which mature in less than 150 days have made feasible a wheat-redgram rotation in the irrigated northern wheat growing region. It has been estimated that the production of redgram could be increased an additional 1.5 million tons from an expanded area of 1 million hectares by the early 1990s, in the states of Punjab, Haryana, western Uttar Pradesh and Rajasthan alone, by the adoption of the wheat-redgram rotation [40, pp. 18-19]. The yield potential of these varieties is 1500 to 2000 kilograms per hectare [11, p. 32]. In Punjab the area under redgram increased almost six-fold during the years 1976/77 to 1982/83 [36, p. 135]. However, the cultivation of short-duration redgram varieties in Punjab is still in its infancy, and in absolute terms the increased production has not made a significant contribution to overall production. Its importance lies in its scope for the future.

Greengram. It is the new varieties of greengram which offer the largest potential for a major breakthrough in production in the next two decades. Short-duration varieties of greengram mature in less than 70 days. This very short period of maturity gives the crop a unique advantage in cropping patterns. It need not compete with cereals in the traditional *rabi* and *kharif* seasons, but can be cultivated during the summer fallows, after the *rabi* crop has been harvested and before the *kharif* crop is sown. The fields are usually left vacant during this time. Since these are the hot, dry summer months, this kind of crop rotation requires irrigated land for short-duration greengram varieties.

With the spread of short-duration greengram varieties, there has been a marked expansion in area in the states of Uttar Pradesh, Orissa and Bihar. This can be seen from Figure 6.4. More importantly, farmers in irrigated areas are no longer restricted to double cropping, but can think in terms of triple cropping systems. It is now possible to practice a three crop rotation such as wheat-greengram-rice, wheat-greengram-maize or wheat-greengram-sorghum in the irrigated areas of the northern states [40]. This is a major change for Indian agriculture.

Intercropping of Pulses with Other Crops

Another method of increasing area under pulses is through intercropping of legumes with cereals and other crops which result in bonus yields of pulses without significantly affecting the yield of the main crop.

While the short-duration varieties are more suited to the irrigated areas, in rainfed regions long- and mid-duration varieties are being used in suitable intercrop combinations with cereals and other crops to increase the effective area under pulses. In fact, the traditional redgram varieties have seldom been cultivated as pure stands. Redgram is usually intercropped with sorghum, millets, or maize. This is one of the reasons why agricultural scientists believe that redgram production is grossly underestimated [56, p. 19].

The ability of redgram to tolerate drought has made it a favored crop in low rainfall areas suitable for mixed cropping. In combination with sorghum, the long duration redgram crop allows the former unrestricted growth for the first four months. By the time the sorghum is ready for harvest, the redgram crop has sent its roots deep into the soil, using the residual moisture to thrive for the next four or five months, making a more complete use of the land than would have been possible through an alternate cropping pattern. It has been observed that such a crop combination makes the redgram less susceptible than a pure stand to wilt disease [46]. Long- and mid-duration redgram will continue to be an important crop in regions which are rainfed. With improved agronomic and cultural practices, the yields in intercropping systems can be increased further.

Studies in Andhra Pradesh have indicated that medium-duration redgram varieties can be grown successfully as intercrops with short-duration pulses such as greengram and blackgram. Advantage is taken of the initial slow growth characteristic of the redgram crop. The greengram or blackgram crop yields about 400 to 600 kilograms per hectare in about 65 days, before redgram picks up growth. This not only results in an increase of pulse production per unit area, but also increases the income of the farmer [21].

In the state of Gujarat, where the area under redgram has increased significantly, the intercropping and relay cropping of redgram with millets, sorghum, other pulses and groundnut is opening up the possibilities of further expansion in area. Other pulses such as greengram, blackgram and cowpea have been tried in suitable combinations with cotton, sugarcane and fruit crops [55].

In rainfed regions the potential for expansion in area is likely to come, on the one hand, from increase in cropping intensity, and, on the other, with the cultivation of improved pulse varieties in suitable mixed and intercropping systems with cereals, commercial and plantation crops [45].

In irrigated areas, the short-duration varieties which can be fit into a third cropping season are likely to gain popularity since they would not compete with cereals. The technology developed for summer greengram has already attained wide acceptability in many irrigated regions of the north. In addition to increasing pulse production, the summer pulse technology has created a significant employment potential during the lean period at an estimated 59 mandays per hectare during the life cycle of the crop [11, p. 34]. With the continued increase in irrigated area, it is estimated by Chandra that summer pulse area might rise to about 5 million hectares by 2000 [11, p. 34]. This appears to be an unduly optimistic estimate. Since the current area under greengram and blackgram cultivated during both *rabi* and *kharif* seasons is about 5.3 million hectares, it does not appear likely that acreage under the summer cultivation alone would increase by 5 million hectares.

Chandra [11] has identified an additional 9 million hectares of land that could be brought under pulse cultivation using the various technologies discussed above. These are described in Table 6.1. Considering that the current area under pulses is about 22 million hectares, this implies an increase of about 40 percent. It also suggests that of the increased area 67 percent is expected to come from irrigated lands, and that summer greengram and blackgram are likely to play an increasingly important role in the future.

Current Pulse Technology: Potential for Increase in Yield

Present pulse technology consists of a number of improved varieties of various pulses. With use of improved varieties and the recommended cultural practices, significant increase in the productivity of pulses has been achieved in national demonstrations on farmers' fields; however, such increases are not comparable to those achieved for wheat or rice.

With improved agronomic and cultural practices, the yields of gram have been known to increase from 2500 to 3000 kilograms per hectare, compared to a national average of about 700 kilograms per hectare [40, p.19]. For pigeonpea, yields of 2100 kilograms per hectare are possible, as against the present average of 700 kilograms per hectare [41, p. 291]. Other pulses have also responded significantly to improved management techniques [41, p. 291].

The recommended package of practices consists of [11]:

1) providing a minimum of one but preferably two irrigations whenever possible and moisture conservation practices on drylands,
2) use of seed inoculation with appropriate rhizobial culture,
3) application of phosphatic fertilizer,
4) timely weed control through pre-emergence weedicides or manual weeding, and
5) providing plant protection cover.

Greengram and blackgram are mainly cultivated during the *kharif* season when they are highly susceptible to yellow mosaic virus (YMV) disease. Various estimates have shown that yields of these pulses can be reduced from 30 to 70 percent due to the incidence of YMV. This is one of the reasons why the yields of greengram and blackgram are among

TABLE 6.1. INDIA: CURRENT AND POTENTIAL AREA FOR PULSE CULTIVATION

(million hectares)

	CURRENT AREA[a]	
A.	Irrigated Area	2.0
B.	Rainfed Area	20.5
	ADDITIONAL AREA	
A.	Irrigated Area	
	1. Full season crop of redgram in redgram-wheat rotation, in redgram-mustard rotation and *rabi* redgram (northern plains)	1
	2. Summer/spring crop of greengram or blackgram (Northern plains)	3
	3. Additional crop of pulses in Jute-rice or cereal-sweet potato systems (all over the country)	1
	4. Intercropping of short-duration pulses in sugarcane and soybean (all over the country)	1
		6
B.	Rainfed Area	
	1. Pulses in receding moisture conditions under rainfed area (eastern U.P. Bihar and M.P.)	1
	2. Pulses in rice fallows in eastern and central India	1
	3. Pulses in rice fallows in southern India	1
		3

[a]/Current Area refers to 1980/81.

Sources: Chandra, S., "Increasing Pulse Production In India: Constraints and Opportunities" in Srivastava, H.C., et al., Eds., Pulse Production: Constraints and Opportunities (New Delhi, 1984), p. 35.

India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India 1981-84 (New Delhi, 1984), pp. 191, 346.

the lowest of the pulses, with an average of 400 kilograms per hectare. With the introduction of YMV-resistant varieties, there is a potential for increasing yields to 1500 kilograms per hectare, and increasing stability in production [11, p. 33].

The current pulse technology therefore has the potential to increase yields of pulses. However, in spite of the existing technology, productivity of pulses continues to remain at levels much below those obtained on national demonstration trials on farmers' fields. This is because the new technology requires intensive agronomic practices and superior management, and is often rejected by the farmer as beyond his means. This is evident from the fact that pulses continue to be grown on marginal lands, with low allocations of irrigation and fertilizer, despite evidence from experimental and on-farm trials about the positive response of these crops to modern inputs. If the impact of the technology is to be realized in the field, a greater effort is needed in the future to increase availability of improved varieties of seeds and other inputs, and to strengthen the extension system.

Estimating Pulse Production in 1990 and 2000

Methodology

Projections of supply raise more complex problems than those of demand. To estimate the latter, there are a number of studies that provide reasonably good estimates of income and expenditure elasticities. Official statistics are available on population and income growth which can be used together with income elasticities to project future demand.

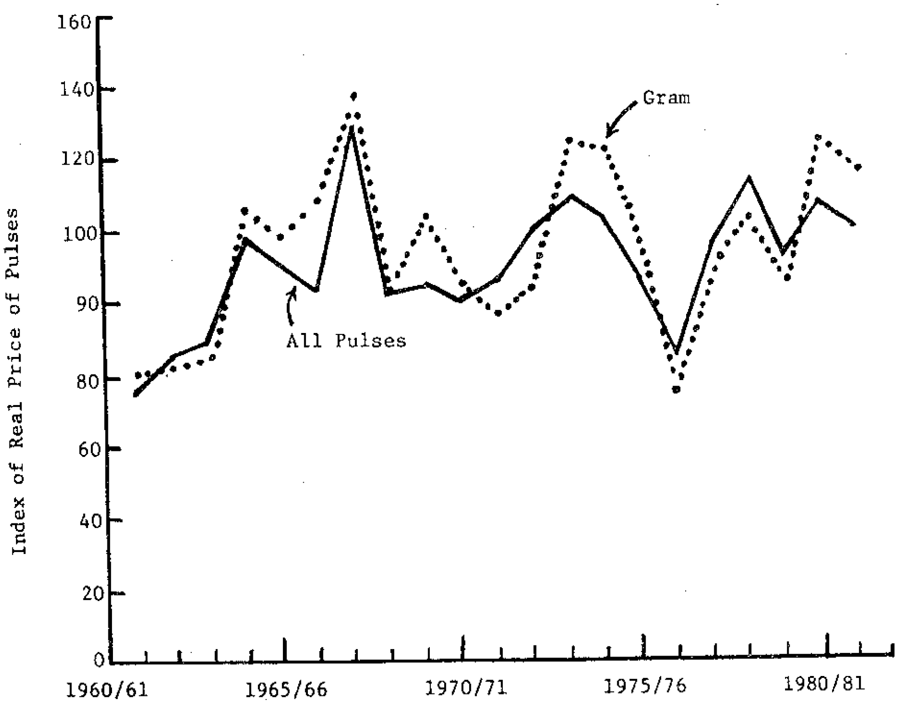
Compared to this, the limitations of the available knowledge of the production function, the problem of predicting the movement of prices and the lack of reliable information on price elasticities of supply, make it difficult to estimate pulse production possibilities over time with a sufficient degree of confidence.

If relative prices are to be used as an instrument to determine the future production of pulses, we need reliable empirical data on the extent of responsiveness of supply to price movements. For instance, if the price elasticity of supply for pulses was both positive and significant, an increasing trend in the relative price of pulses would imply a positive supply response and greater production. Figure 6.1 indicates what has happened to the relative price of pulses over the last two decades. The price fluctuations as evidenced in Figure 6.1 are so wide as to obscure any strong trend.

Also, reliable information on supply elasticities is not available. The problem is further complicated by the fact that supply responsiveness is not uniform, but varies for different pulses, regions and time periods.

FIGURE 6.1. INDIA: INDEX OF REAL PRICE[a/] OF PULSES, 1960/61-1981/82

(1970/71 = 100)



a/ Index of wholesale prices of pulses divided by index of wholesale prices of all commodities.

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Bulletin on Food Statistics, 1981/82 (New Delhi, 1982), p. 22.

Several studies have been conducted on the acreage, rather than output, response of various crops to relative price movements. However, most of them have concentrated on cereals and cash crops [61, pp. 73-74]. Pulses have not merited enough attention, and sufficient information on price elasticities of acreage for pulses is not available.

However, on the basis of existing studies, it was found that supply elasticities, though positive, were of low magnitude for most of the major foodgrain crops of India. Gram was one of the crops included. This would imply that price by itself as a tool for increasing pulse production would not be very effective [42, p. 24], unless yields could also be increased.

In spite of these limitations, it is necessary to provide some quantitative idea of the magnitudes of likely availabilities of pulses relative to demand in the projected period. This would serve as the basis for the formulation of long-term policies and programs.

A simple approach is therefore adopted for estimating pulse production. The magnitude of the projected supply is determined as a product of the projected area and the projected yield of pulses.

In using this approach the following assumptions are made:

1) that normal weather will prevail during the projected year,
2) that relative prices will remain essentially constant, although in reality relative prices will change, shifting both supply and demand to offset persistent large imbalances, and
3) that no major breakthrough in technology will occur resulting in dramatic increases in yield.

Area and yield projections are made for individual major pulses in different states, and then totaled to obtain the national estimates. This procedure is adopted since area trends for various pulses are different in the major producing states, and the levels of yields also vary considerably.

Projections of supply are made on the basis of estimated compound growth rates of area under pulses during the period 1970/71 to 1982/83. The areas in 1990 and 2000 are projected by a simple extrapolation of past trends. Production is then estimated on two different assumptions regarding yields, giving high and low projections. There appears to be considerable year to year variation in the yield of various pulses in different states, and it is difficult in most cases to identify any clear trends in yields. Consequently, it is not possible to follow the method of extrapolation employed for area. Therefore, the following procedure has been adopted. The low scenario yield has been obtained by taking the average of the last five years, i.e., 1978/79 to 1982/83. The highest average yield achieved in any year in the state during the period 1970/71 to 1982/83 is set as the higher level. For example,

Figure 6.3 shows that the yield of redgram in the state of Uttar Pradesh has varied between 588 kilograms in 1973/74 to 1540 kilograms per hectare in 1972/73. The latter was the highest yield achieved and has therefore been set as the upper level. In the case of Karnataka the yield has ranged from 331 kilograms per hectare in 1971/72 to a maximum of 695 in 1977/78. The high projection in the case of Karnataka has, therefore, been taken as 695 kilograms per hectare.

True, this procedure is arbitrary, but in the absence of any clear trends it is difficult to employ any other approach. Estimation is made more difficult by the fact that more than 90 percent of pulse area is rainfed and the yield of pulses in these areas will continue to fluctuate with variations in weather.

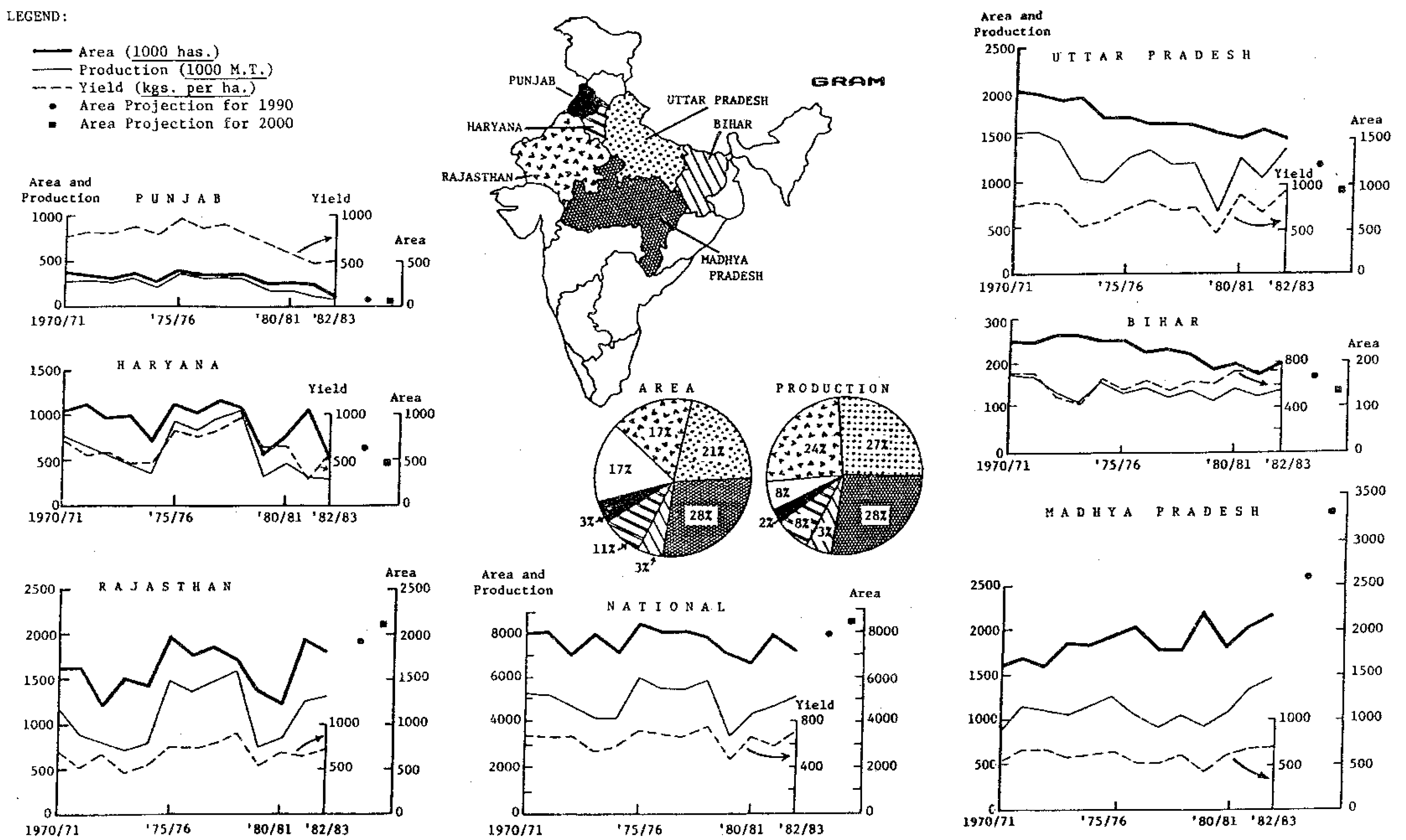
A second source of uncertainty in yields is the susceptibility of these crops to diseases and insects. While efforts are being made to ensure plant protection through the use of chemicals, the prohibitive cost of inputs for such measures has prevented any significant impact on the farmers' fields. This is likely to continue for some time in the future.

While double and triple yields have been obtained with the use of improved varieties and the recommended package of practices, these have been limited to demonstration plots and a very small percentage of farms. The yields in traditional farming systems have stagnated almost at the same level for the last three decades. The main reason for this is the fact that pulses are grown on marginal lands as low priority crops with little or no inputs. Unless a deliberate effort is made to change this attitude through extension and an improved supply of inputs, there is not much likelihood of a significant increase in yield. However, if there is a breakthrough in pulse technology resulting in high-yielding varieties, or a change in the attitude of cultivators towards using greater inputs for pulses, the yields of pulses might be higher than those projected in this study. But if trends of the past 10 years are any indication, this does not appear very likely.

Projections for Individual Pulses

Gram (Cicer arietinum). Gram is cultivated as a *rabi* crop. It is raised with the help of residual moisture, generally after a *kharif* crop, and requires cool, dry weather conditions for optimum growth. The northern plains of India, including the states of Punjab, Haryana, Bihar, Uttar Pradesh, Madhya Pradesh and Rajasthan are best suited for gram production. Figure 6.2 shows the major gram producing states which together account for about 83 percent of area and 92 percent of production of gram. In the states of peninsular India it is a crop of minor importance, mainly because the winter season is shorter and milder, and horsegram fits better in crop rotations. The cultivation of gram also declines in the extreme eastern and western regions of the country.

FIGURE 6.2. GRAM: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources: Table 6.2 and Appendix Table IV.1.

The gram crop remains in the field from 4 to 6 months depending on the length of the cold season and the varieties grown. Gram is susceptible to frost but is fairly tolerant to drought because of its deep root system. This characteristic is made use of in various crop mixtures. Wheat grown on unirrigated land is often mixed with gram during seeding. In the event of weather conditions proving too dry for wheat, the gram crop compensates for loss in wheat yields. The wheat-gram mixture acts to some extent as an insurance against adverse weather. Gram is cultivated predominantly as a rainfed crop, only 20 percent of area under this crop being irrigated [36, p. 347].

Table 6.2 indicates the projected area and production of gram by state. Production in 2000 is expected to rise by 20 percent based on the assumptions of the high scenario. It will increase from an average of 4.7 million tons during 1981-83 to 6 million tons in 2000.

At the national level the area under gram is likely to expand by 17 percent increasing from an average of 7.2 million hectares during 1981-83 to 8.5 million hectares in 2000. Gram acreage in Punjab, Haryana, Uttar Pradesh and Bihar is projected to decline, while in Madhya Pradesh and Rajasthan is expected to increase. In the future Madhya Pradesh and Rajasthan are likely to emerge by far the largest producers of gram. It appears that cultivation of gram will shift from its native habitat in the Gangetic plain to the central states.

Redgram (Cajanus cajan). Redgram is the second most widely grown pulse crop. It accounts for about 13 percent of total pulse area and contributes 19 percent to total production. India produces over 80 percent of the world's total production of redgram [12, p. 81].

The crop is adaptable to a fairly wide range of climate and soils and is cultivated almost all over the country except in regions with excessive rainfall and waterlogging or in areas which are affected by severe frost. Its deep root system enables it to withstand moisture stress conditions; consequently it is widely grown in the semi-arid agricultural regions of the central and peninsular part of the country. The major redgram producing states are shown in Figure 6.3. They account for about 91 percent of total area under the crop and 89 percent of production.

The traditional redgram was a *kharif* crop and had a maturity period of eight to ten months. Development of short- and medium-duration varieties have made it possible to fit redgram into double cropping systems with wheat in areas of assured irrigation, such as the canal irrigated areas of Rajasthan, Punjab, western Uttar Pradesh, northern Madhya Pradesh and Haryana. These varieties planted in June-July with the onset of monsoon can be harvested in late October or early November, vacating the field in time for the wheat crop in *rabi* [47].

Short-duration varieties have made it possible to cultivate redgram in nontraditional areas as well as in nontraditional season.

TABLE 6.2. GRAM: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a] Area	Current[a] Production	Yield Alternatives High	Yield Alternatives Low	1990 Projection Area	1990 Projection Production High	1990 Projection Production Low	2000 Projection Area	2000 Projection Production High	2000 Projection Production Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Punjab	208	109	986	500	61	60	30	25	25	12
Haryana	765	352	982	607	621	610	377	497	488	301
Uttar Pradesh	1525	1247	922	730	1216	1121	888	928	855	677
Bihar	187	134	718	676	165	119	112	137	98	92
Rajasthan	1654	1144	909	706	1937	1761	1367	2120	1927	1496
Madhya Pradesh	1998	1293	682	590	2612	1781	1541	3320	2264	1959
Total	6337	4279			6615	5454	4317	7028	5659	4540
National	7726	4687			7970[b]	5928[c]	4692[c]	8468[b]	6151[c]	4935[c]

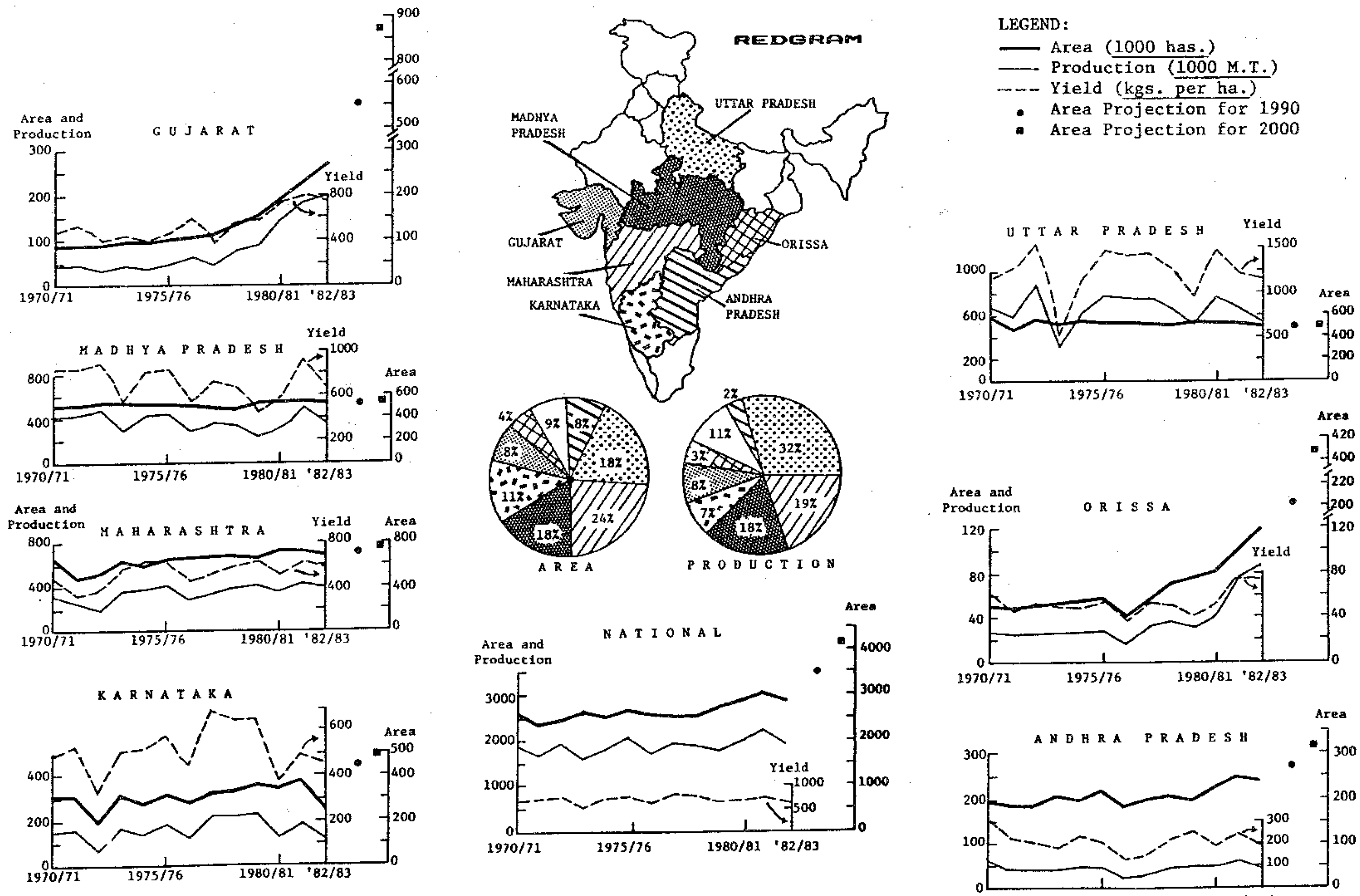
[a] Current Area and Production figures are for the triennium average 1980/81 - 1982/83

[b] Projected national area includes 17 percent of area in other states

[c] Projected national production includes 8 percent production in other states

Source: Appendix Table IV.1.

FIGURE 6.3. REDGRAM: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources: Table 6.3 and Appendix Table IV.2.

Redgram can be profitably grown in the *rabi* season in fields vacated by maize, early paddy and minor millets in areas where the winter temperatures are mild. Coastal regions of Orissa, parts of Madhya Pradesh, rice growing areas of Karnataka, Tamil Nadu and coastal Andhra Pradesh, where fields are often left fallow, are areas where redgram can be cultivated as a second crop. To make use of the residual moisture, the crop must be sown early in September [58].

The development of improved varieties of redgram suitable for intercropping with sorghum, millets, groundnut, cotton and other pulses, together with fitting short-duration varieties in new cropping patterns, has led to an increase in area of redgram in states like Gujarat, Orissa, Karnataka and Andhra Pradesh. This can be seen in Figure 6.3.

Table 6.3 indicates the projected area and production of redgram by state. Production in 2000 is estimated to rise by about 85 percent, increasing from an average of 2.0 million metric tons during 1981-83 to 3.5 million metric tons in 2000.

At the national level the area under redgram is projected to expand by about 50 percent, increasing from 2.9 million hectares to 4.2 million hectares. Uttar Pradesh, the largest producer at present, is expected to maintain its lead in 2000. However, Gujarat and Orissa are also likely to emerge as major producers. Of the 2.3 million hectare increase in area under this crop, Orissa, Gujarat and Karnataka are expected to account for more than 50 percent.

It was mentioned earlier that according to one estimate [40] the redgram acreage could be expanded by 1 million hectares in the states of Punjab, Haryana, Uttar Pradesh and Rajasthan. However, the increase in acreage in these states has not yet shown up in the trends indicated by the official statistics. It appears that production of redgram is likely to increase largely in the unirrigated rainfed areas of the central and peninsular states, and to a smaller extent in the irrigated command areas of the northern plains.

Greengram (Phaseolus aureus) and Blackgram (Phaseolus mungo). Greengram and blackgram each account for around 12 percent of total area and 9 percent of production. They are warm weather crops and are more widely and thinly spread than redgram. In the northern states, they are generally cultivated as *kharif* crops, while in the southern and central states they are grown in both the *kharif* and *rabi* seasons. Figures 6.4 and 6.5 show the major greengram and blackgram producing states.

The development of short-duration varieties of these two pulses probably offers the greatest potential for increase in production in the future. These short-duration varieties, which can be harvested in less than 70 days, can be fitted in double and triple cropping as well as intercropping sequences in nontraditional seasons without disturbing

TABLE 6.3. REDGRAM: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a] Area	Current[a] Production	Yield Alternatives High	Yield Alternatives Low	1990 Projection Area	1990 Projection Production High	1990 Projection Production Low	2000 Projection Area	2000 Projection Production High	2000 Projection Production Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Uttar Pradesh	509	644	1540	1214	489	753	594	489	753	594
Madhya Pradesh	523	376	903	1214	520	469	340	530	478	346
Orissa	101	83	739	581	205	151	119	409	302	237
Andhra Pradesh	238	50	313	219	272	85	60	320	100	70
Gujarat	226	172	790	686	551	436	378	873	690	599
Maharashtra	697	395	634	583	709	449	413	747	473	435
Karnataka	323	142	695	529	459	319	243	499	347	264
Total	2617	1862			3205	2662	2147	3867	3143	2545
National	2897	2038			3523[b]	2992[c]	2412[c]	4248[b]	3532[c]	2861[c]

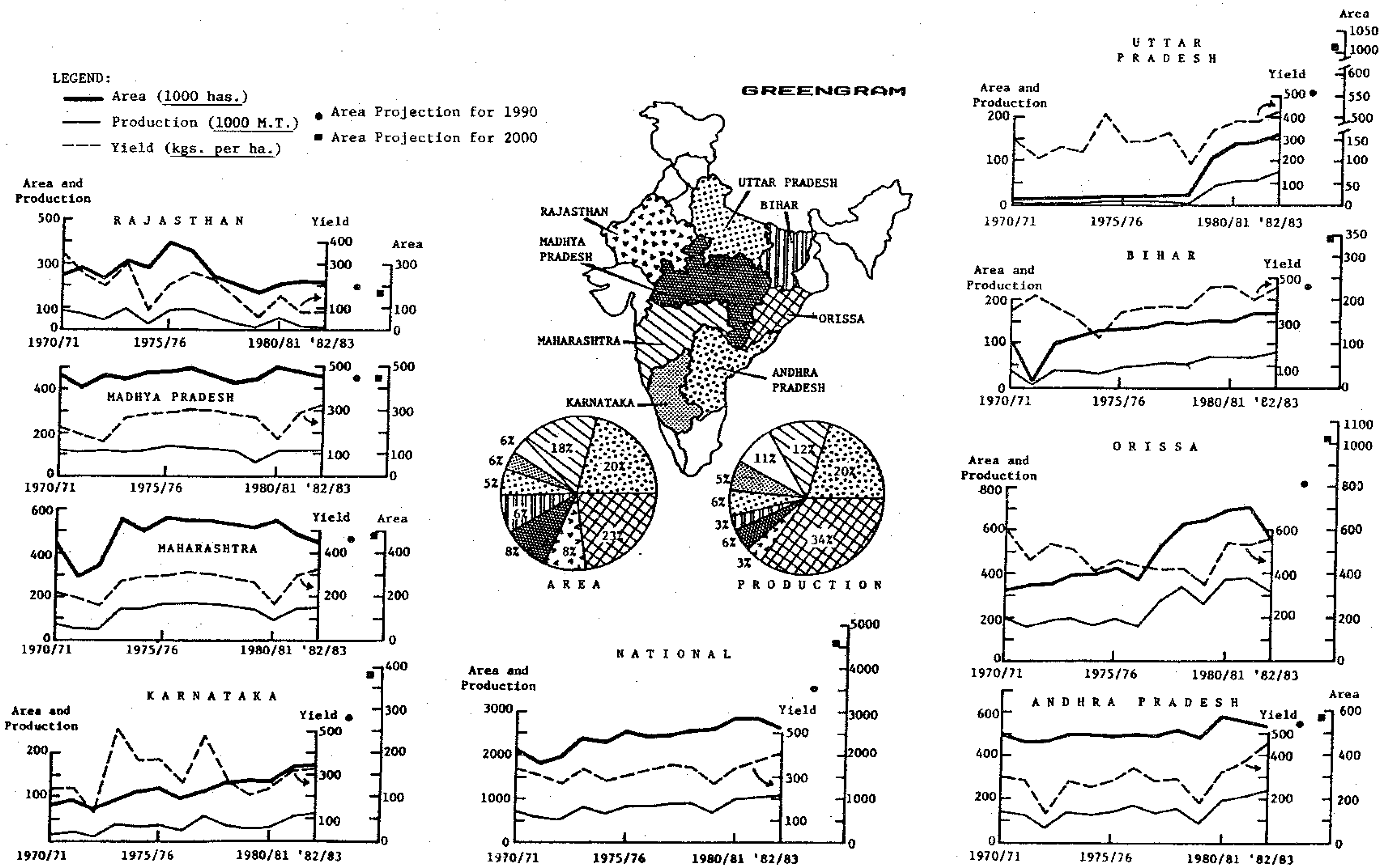
[a] Current Area and Production figures are for the triennium average 1980/81 - 1982/83

[b] Projected national area includes 9 percent of area in other states

[c] Projected national production includes 11 percent production in other states

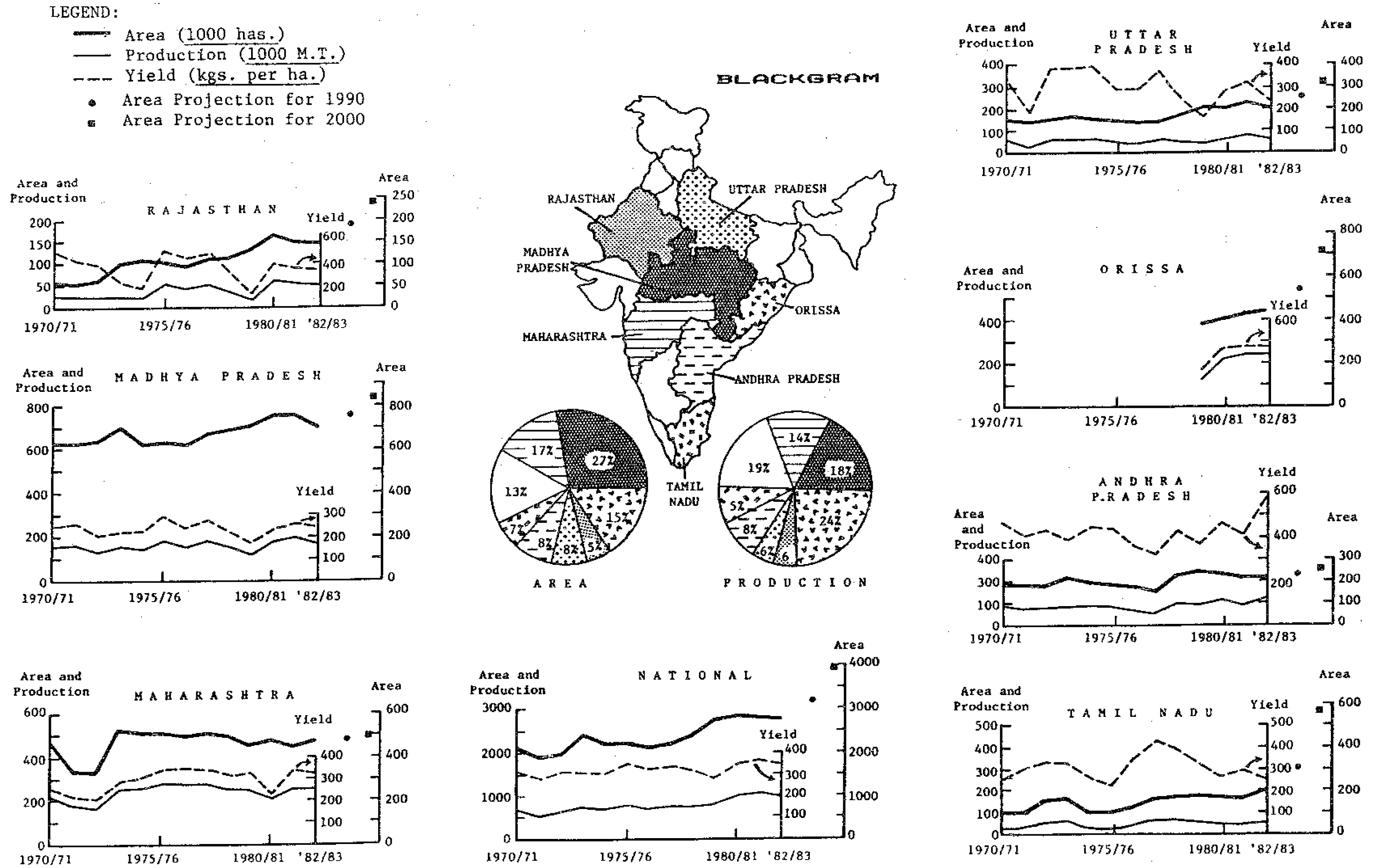
Source: Appendix Table IV.2.

FIGURE 6.4. GREENGRAM: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources: Table 6.4 and Appendix Table IV.2.

FIGURE 6.5. BLACKGRAM: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources; Table 6.5 and Appendix Table IV.4.

the existing crop preferences of the farmer for remunerative cereal and cash crops.

In the irrigated areas of the northern states, summer greengram is being cultivated as a third crop. Area under greengram in Uttar Pradesh has increased significantly in the last five to six years with the spread of these varieties. In the rainfed areas of the central and southern states, fields traditionally left fallow after taking either a *kharif* or *rabi* crop are now being sown to short-duration greengram or blackgram. Due to double cropping there has been an increasing area trend in both pulses in almost all the states.

Tables 6.4 and 6.5 indicate that the area and production of greengram and blackgram are expected to increase significantly in the future. The estimated production of greengram in 2000 is likely to be more than double the present production, based on the assumptions of the high scenario. It will increase from an average of about 1 million tons during 1981-83 to 2.2 million tons in 2000. The acreage at the national level is expected to rise about 75 percent by the end of the century, increasing from an average of 2.8 million hectares during 1981-83 to 4.6 million hectares in 2000.

At present the major producers of greengram are Orissa, Andhra Pradesh and Maharashtra. In the future, Orissa is expected to maintain its lead; however, Uttar Pradesh is likely to emerge as the next major producer of greengram. Of the 1.8 million hectares increase in greengram acreage, almost 70 percent is likely to come from Orissa and Uttar Pradesh. In the latter the short-duration summer greengram varieties sown on irrigated land are projected to become the major contributers.

In the case of blackgram, too, production is expected to double by 2000, increasing from an average of about 1.0 million tons between 1981-83 to 1.8 million tons in 2000. The blackgram acreage at the national level could increase by as much as 45 percent, expanding from 2.8 million hectares between 1981-83 to 3.9 million hectares in 2000. Orissa, Maharashtra, Andhra Pradesh and Madhya Pradesh are the major blackgram producers at present. In the future, Orissa and Madhya Pradesh are likely to maintain their relative importance. In addition, Tamil Nadu will emerge as a major producer. These three states together are expected to account for about 70 percent of the increase in area under this pulse crop.

<u>Horsegram (Dolichos biflorus)</u>. Horsegram is a crop primarily of peninsular India and is suited to cultivation during both *rabi* and *kharif* in dry regions and upland areas. This pulse crop accounts for about 8 percent of total area under pulses and 6 percent of production. The pulse is used for cattle feed as well as human consumption in the low income groups.

TABLE 6.4. GREENGRAM: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a] Area	Current[a] Production	Yield Alternatives High	Yield Alternatives Low	1990 Projection Area	1990 Projection Production High	1990 Projection Production Low	2000 Projection Area	2000 Projection Production High	2000 Projection Production Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Bihar	141	72	466	433	231	108	100	342	160	148
Uttar Pradesh	149	61	442	347	555	245	193	1118	494	388
Rajasthan	215	29	363	126	194	71	25	172	62	22
Madhya Pradesh	234	59	310	234	225	70	53	225	70	53
Orissa	562	356	597	504	811	484	409	1021	609	514
Andhra Pradesh	554	209	449	322	543	244	175	568	255	183
Maharashtra	497	129	325	269	468	152	126	486	158	131
Karnataka	158	49	510	272	284	145	77	387	196	105
Total	2600	964			3313	1519	1158	4319	2004	1544
National	2775	1033			3524[b]	1706[c]	1300[c]	4595[b]	2252[c]	1735[c]

[a]Current Area and Production figures are for the triennium average 1980/81 - 1982/83

[b]Projected national area includes 6 percent of area in other states

[c]Projected national production includes 11 percent production in other states

Source: Appendix Table IV.3.

TABLE 6.5. BLACKGRAM: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a/] Area	Current[a/] Production	Yield Alternatives High	Yield Alternatives Low	1990 Projection Area	1990 Projection Production High	1990 Projection Production Low	2000 Projection Area	2000 Projection Production High	2000 Projection Production Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Tamil Nadu	174	48	421	308	316	133	97	571	240	176
Uttar Pradesh	209	59	379	249	244	92	61	310	118	77
Madhya Pradesh	737	182	259	225	761	197	171	837	217	188
Rajasthan	151	55	515	305	187	96	57	243	125	74
Orissa	427	231	547	488	543	297	265	712	389	347
Andhra Pradesh	221	160	751	485	228	171	140	250	188	121
Maharashtra	464	136	349	305	482	168	147	494	172	151
Total	2383	817			2761	1154	938	3417	1449	1134
National	2773	978			3174[b/]	1427[c/]	1158[c/]	3929[b/]	1790[c/]	1401[c/]

[a/] Current Area and Production figures are for the triennium average 1980/81 - 1982/83

[b/] Projected national area includes 13 percent of area in other states

[c/] Projected national production includes 19 percent production in other states

Source: Appendix Table IV.4.

Figure 6.6 shows the major horsegram producing states. While area under this crop appears to be declining in Madhya Pradesh, Andhra Pradesh and Tamil Nadu, it shows an increasing trend in Karnataka and Orissa. Horsegram is generally sown in rice fallows in the southern states.

Since horsegram is not one of the major pulses, relatively less importance has been assigned to this crop in terms of research and development. In some states it is being replaced by the more remunerative cowpea.

Table 6.6 shows that there is likely to be a significant increase in area under this pulse in the states of Karnataka and Orissa. Area at the national level will increase by 12 percent in 1990 and 37 percent in 2000. Production is also estimated to double by the year 2000.

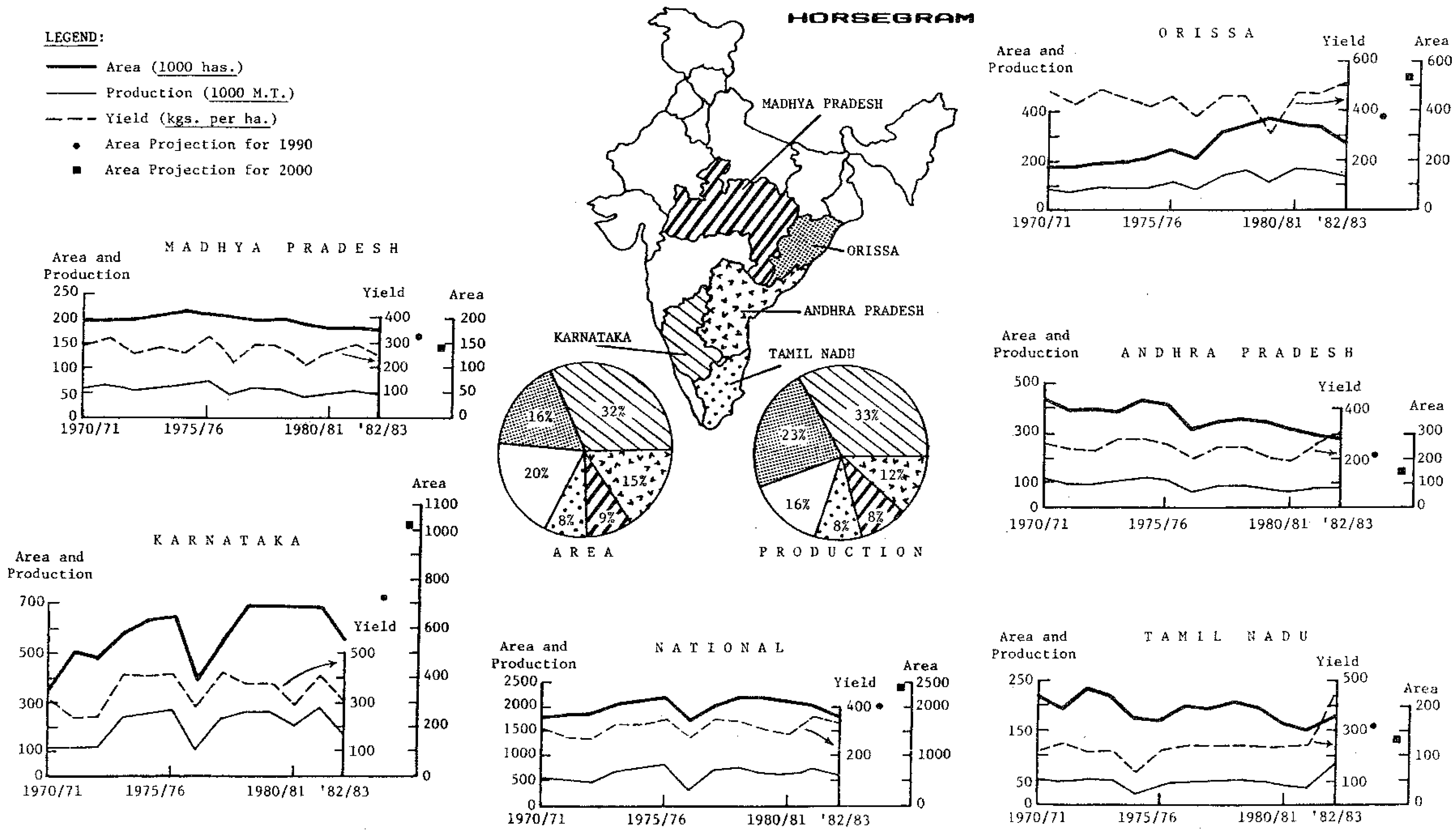
Lentil (Lens esculenta) and Khesari (Lathyrus sativus). Lentil and *khesari* are both *rabi* pulses, and together account for about 9 percent of total area and 8 percent of production. The major lentil and *khesari* growing states are shown in Figures 6.7 and 6.8, respectively. Madhya Pradesh and Bihar are common to both.

Lentil, with a shorter maturity period than gram, is confined almost exclusively to areas with cold winters of the north Indian plains and the foothills of the Himalayas. It is usually grown as a sole crop under unirrigated conditions and is a suitable substitute for gram in areas that may be too dry for the latter. In the event of winter rainfall being too heavy, lentil growing on heavy soils of rice fallows is likely to suffer from poor soil aeration, and the yields are adversely affected.

Khesari is also grown in rice fallows in unirrigated areas. Its advantage over gram and lentil is that it can be sown much later, and requires very little cultivation. The seed is usually sown broadcast without any preparatory tillage. It is a hardy crop with the ability to withstand drought, which is one of the reasons it is popular with the small and marginal farmers. However, the pulse is known to contain certain poisonous alkaloid nemotoxins which cause paralysis of the lower limbs if the pulse is consumed in large quantities and without adequate amount of soaking. Efforts are being made to replace *khesari* with improved varieties of lentil which can survive severe moisture stress like *khesari*.

Figures 6.7 and 6.8 show that the area under lentil is increasing while that under *khesari* is on the decline. Tables 6.7 and 6.8 indicate that in future the production of lentil is likely to increase while that of *khesari* is expected to decline. The area and production of lentil in 2000 is estimated to more than double. The major share of the increase is likely to be in the state of Uttar Pradesh. In Bihar and Madhya Pradesh the area is also projected to increase, although not significantly.

FIGURE 6.6. HORSEGRAM: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources: Table 6.6 and Appendix Table IV.5.

TABLE 6.6. HORSEGRAM: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a] Area	Current[a] Production	Yield Alternatives		1990 Projection			2000 Projection		
						Production			Production	
			High	Low	Area	High	Low	Area	High	Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Madhya Pradesh	179	48	324	260	164	53	43	146	47	38
Orissa	316	151	503	440	368	185	162	533	268	235
Andhra Pradesh	299	75	438	244	212	93	52	148	65	36
Karnataka	639	216	416	353	720	300	252	1012	420	357
Tamil Nadu	162	50	434	276	155	67	43	133	58	37
Total	1595	540			1619	698	552	1972	858	703
National	1989	649			2024[b]	831[c]	656[c]	2465[b]	1022[c]	836[c]

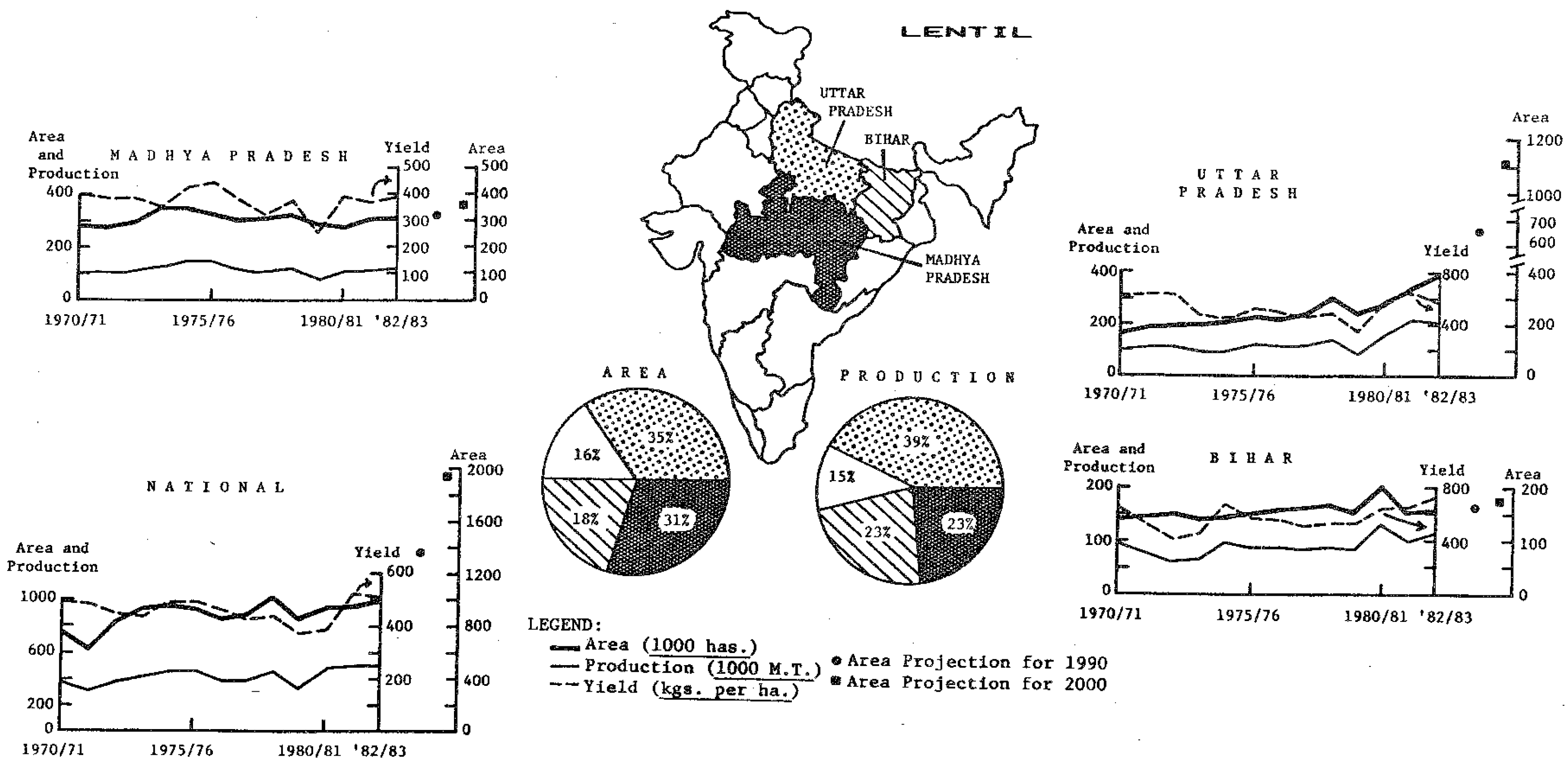
[a] Current Area and Production figures are for the triennium average 1980/81 - 1982/83

[b] Projected national area includes 20 percent of area in other states

[c] Projected national production includes 16 percent production in other states

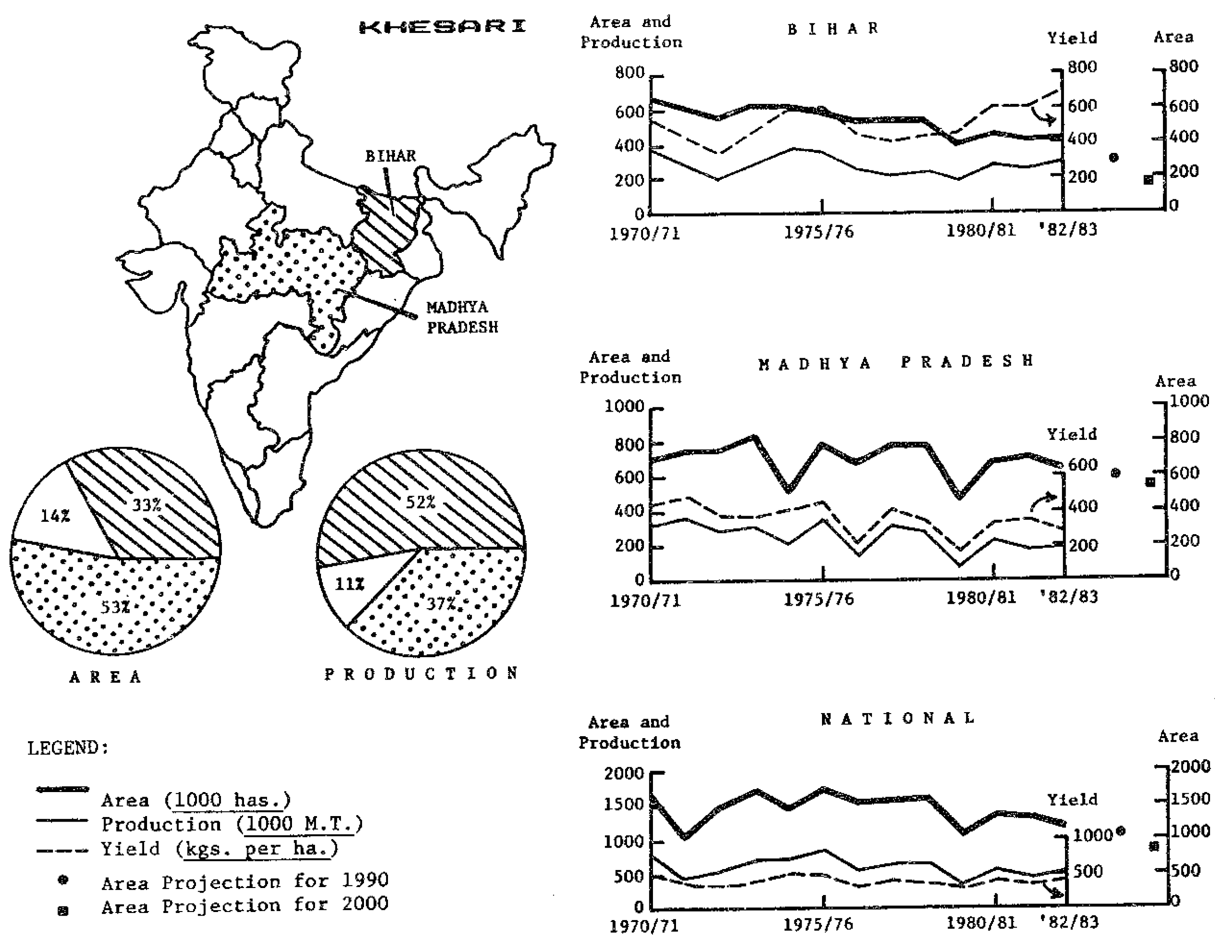
Source: Appendix Table IV.5.

FIGURE 6.7. LENTIL: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources: Table 6.7 and Appendix Table IV.6.

FIGURE 6.8. KHESARI: TRENDS IN AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES, 1970/71-1982/83, WITH PROJECTIONS TO 1990 AND 2000



Sources: Table 6.8 and Appendix Table IV.7.

TABLE 6.7. LENTIL: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a/] Area	Current[a/] Production	Yield Alternatives High	Yield Alternatives Low	1990 Projection Area	1990 Projection Production High	1990 Projection Production Low	2000 Projection Area	2000 Projection Production High	2000 Projection Production Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Uttar Pradesh	333	192	640	516	664	425	343	1118	715	577
Bihar	169	114	736	619	162	119	100	173	127	107
Madhya Pradesh	292	113	441	358	323	142	116	352	997	810
Total	794	419			1149	686	558	1643	997	810
National	954	487			1368[b/]	808[c/]	657[c/]	1955[b/]	1174[c/]	953[c/]

[a/] Current Area and Production figures are for the triennium average 1980/81 - 1982/83

[b/] Projected national area includes 16 percent of area in other states

[c/] Projected national production includes 15 percent production in other states

Source: Appendix Table IV.6.

TABLE 6.8. KHESARI: AREA, PRODUCTION AND YIELD IN MAJOR PRODUCING STATES PROJECTED TO 1990 AND 2000

States	Current[a/] Area	Current[a/] Production	Yield Alternatives High	Yield Alternatives Low	1990 Projection Area	1990 Projection Production High	1990 Projection Production Low	2000 Projection Area	2000 Projection Production High	2000 Projection Production Low
	(1000 ha.)	(1000 M.T.)	(kg./ha.)		(1000 ha.)	(1000 M.T.)		(1000 ha.)	(1000 M.T.)	
Bihar	423	275	708	574	295	209	170	196	139	113
Madhya Pradesh	677	193	487	273	606	295	165	561	273	153
Total	1100	468			901	504	335	757	412	266
National	1284	526			1048[b/]	567[c/]	376[c/]	880[b/]	463[c/]	299[c/]

[a/]Current Area and Production Figures are for the triennium average 1980/81 - 1982/83

[b/]Projected national area includes 14 percent of area in other states

[c/]Projected national production includes 11 percent production in other states

Source: Appendix Table IV.7.

Production of *Khesari*, on the other hand, is likely to decrease by 10 percent in 2000, and the area is expected to register a decline of about 25 percent during this period.

Effect of Development of Livestock Sector

The production of pulses in the future will also be affected by the development of the livestock sector. This will influence cropping patterns in the fields of farmers involved in dairy activities. Dual purpose pulse crops such as cowpea (which is presently not extensively grown) and *guar* bean (*cyamopsis tetragonoloba*), which provide fodder as well as grain, are likely to gain importance [46].

Short-duration variety pulses, which are rapidly gaining popularity in irrigated areas, are likely to come into competition with green fodder legumes, where farmers are engaged in dairy activities. With increase in the number of crossbred cattle, this is likely to increase. For agricultural activities near urban centers, where there is a ready market for dairy products, the summer pulses will have to compete with green fodder as well as summer vegetables. This could result in some decline of pulse acreage. However, in the absence of data it is difficult to surmise to what extent pulse production would be affected.

Changing Share of Major Pulses in Total Area and Production

Projected pulse area and production is summarized in Table 6.9. Pulse production in the past has been dominated by gram, which accounts for about 32 percent of area and 44 percent of production. On the basis of high estimates, the position is likely to change in the future. The percentage share of gram in total area is likely to decline slightly from 32 percent to 30 percent in 2000; the share in production, however, is expected to decrease significantly from 44 to 34 percent. This can be seen from Figure 6.9. The major *kharif* pulses, on the other hand, are expected to increase in both area and production. Redgram, greengram and blackgram together are projected to account for 45 percent of total area in 2000, compared to 38 percent in 1981/82. Their share in production is likely to increase from 34 to 43 percent.

The future will see greater diversification in the production of pulses. While gram will continue to account for a significant share of production, it is the *kharif* pulses such as redgram, greengram and blackgram that are likely to play an increasingly important role in the pulse economy.

Comparison of Supply Projections

Table 6.10 summarizes the estimates for pulse production in 2000, made in various studies.

TABLE 6.9. INDIA: PROJECTED PULSE AREA AND PRODUCTION IN 1990 AND 2000

Pulse Crop	Area (1000 hectares)			Production (1000 metric tons)				
	Current[a]	Projected 1990	Projected 2000	Current[a]	Projected 1990 High	Projected 1990 Low	Projected 2000 High	Projected 2000 Low
Gram	7,226	7,970	8,468	4,687	5,929	4,693	6,152	4,936
Redgram	2,897	3,523	4,248	2,038	2,993	2,412	3,532	2,861
Greengram	2,775	3,524	4,595	1,033	1,706	1,200	2,252	1,735
Blackgram	2,773	3,174	3,929	978	1,427	1,158	1,790	1,401
Horsegram	1,989	2,024	2,465	649	831	656	1,022	836
Lentil	954	1,368	1,955	487	807	657	1,174	953
Khesari	1,284	1,048	880	526	567	376	463	299
Total	19,898	22,630	26,541	10,398	14,260	11,252	16,384	13,020
All Pulses	22,896	24,598[b]	27,937[c]	11,234	15,500[d]	12,231[d]	17,809[d]	14,152[d]

[a] Current refers to average of 1980/81 - 1982/83

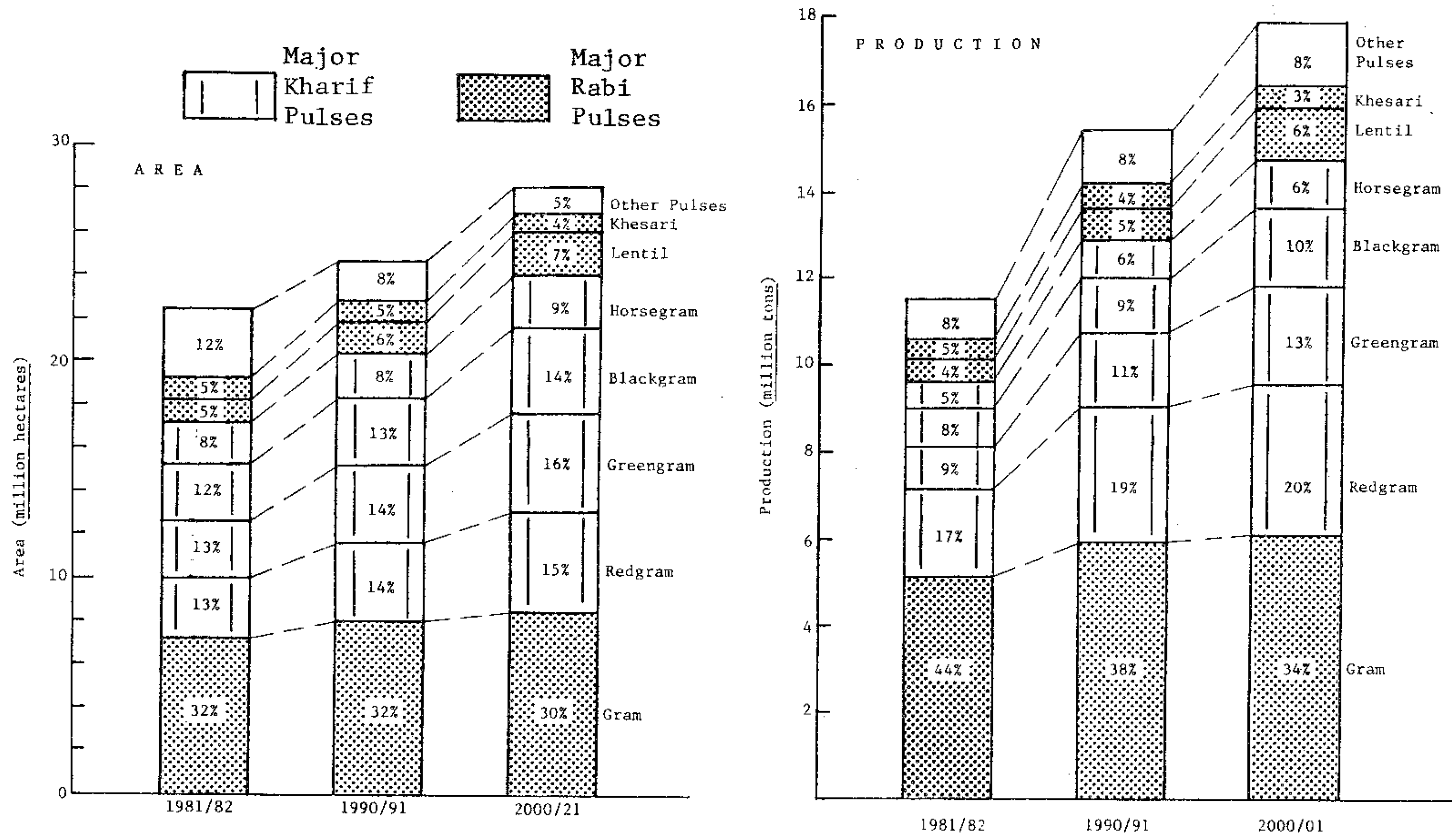
[b] Includes 8 percent area sown to other pulses

[c] Includes 5 percent area sown to other pulses

[d] Includes 8 percent share of other pulses

Sources: Tables 6.2 through 6.8

FIGURE 6.9. INDIA: SHARE OF MAJOR PULSES IN TOTAL PULSE AREA AND PRODUCTION, 1981/82, 1990/91, AND 2000/2001



Sources: Tables 6.2 through 6.8.

TABLE 6.10. COMPARISON OF SUPPLY PROJECTIONS FOR PULSES FOR 2000.

Study	Area (million hectares)	Yield (kilograms per hectare)	Production (million Metric tons)
N C A[a]	25.0	1400	35.0
Sanderson and Roy[b]	27.7	928	25.7
Present Study			
High	27.9	638	17.8
Low	27.9	505	14.1

[a] NCA - Report of the National Commission on Agriculture, Part III, Demand and Supply (New Delhi, 1976), Table 11.6, Table 11.15.

[b] Sanderson, Fred H. and Shyamal Roy, Food Trends and Prospects in India (Brookings Institution, Washington, D.C., 1979).

The NCA supply projections appear to be unrealistically high. It is unlikely that average yields (which were 490 kilograms per hectare in the triennium 1981-83) will increase to 1400 kilograms per hectare in 2000, unless there is a dramatic breakthrough in pulse technology on lines similar to that of wheat. Based upon past trends it does not appear likely that yields will triple in the next decade and a half. The NCA in their report of 1976 estimated that pulse production in 1985 would have reached 22 million tons, with average yields of the order of 900 kilograms per hectare. According to the latest official estimates available, albeit provisional, the pulse production in 1983/84 was only 12.6 million tons and the average yield 541 kilograms per hectare. The projection for production at 35 million tons in 2000 appears to be quite unrealistic.

The projection for the year 2000 in Sanderson and Roy's study (1979) for pulse acreage is quite similar to that in the present study. However, projected yields per hectare are about 45 percent higher. We have seen that the major impact of the new pulse technology lies in its ability to reduce the growing period of the crop, so that pulses can be fitted into cropping patterns which would ordinarily allow for the field to remain fallow. This would enable the cultivator to reap an additional harvest with minimum of inputs. It must be remembered that the bulk of pulses are still grown on marginal lands and do not receive as high a priority as cereals. Farmers are not willing to invest in the required inputs for pulses, which are necessary if yields are to be increased.

This implies that increased production is likely to come about as a result of increase in area, especially in regions where the pulse crop does not compete for land with high-yielding cereals, rather than through any dramatic increase in yields which are predicated on purchased inputs.

Another point to be noted is that the average yield of pulses is relatively higher in the northern states than in the central and southern states. The area trends indicate that pulse production is shifting away from the Gangetic plains into the central and peninsular regions. This would imply a negative effect on the overall productivity of pulses.

In light of this, the estimated average pulse yield of 928 kilograms per hectare by Sanderson and Roy appears to be unduly optimistic.

The target for pulse area and production for 1990 set by the Government of India in the Seventh Five Year Plan (1985-90) is consistent with the estimates made in the present study for 1990, based on the high scenario. The estimated area for 1990 in the present study is 24.5 million hectares, whereas the targeted area in the Seventh Plan is 25.7 million hectares. The estimated pulse production is 15.5 million tons. The target for production is set at 16 million tons [37, p. 6].

This implies an average yield of about 620 kilograms per hectare, which is almost in agreement with that of the present study.

Demand Supply Balances

Supply Prospects

The demand and supply projections for all pulses are summarized in Table 6.11 and illustrated in Figure 6.10. Under the low assumption scenario, production in 2000 is estimated to be 14.2 million metric tons, whereas for the high scenario it is 17.8 million metric tons. In both cases the supply is projected to fall short of the demand: by 4 million tons for the low scenario and 6 million tons for the high scenario. Compared to the requirements based on nutritional norms this gap will be wider still: by 3 and 11 million tons for the low and high scenario, respectively.

Effect of Relative Prices

One of the assumptions made while projecting pulse production was that the relative prices will remain constant. However, this is an unrealistic asssumption. Figure 6.10 indicates what has happened to the relative price of pulses over the last two decades. Although no trend is evident, pulse prices have fluctuated greatly from one year to another.

The prices of pulses vary more widely than many other crops because pulses are grown mainly in rainfed conditions and accordingly their production is prone to greater variation as a result of varying weather conditions. In years of short harvest prices rise rapidly and have the effect of choking back demand to ration the available supply.

If projected demand in 1990 and 2000 is to be met, prices will have to rise to encourage increased production; alternatively the price rise could have the effect of dampening demand. Since price elasticities of supply for pulses are not available, it is not possible to predict the additional production which would result from a sustained increase in the relative price of pulses. However, estimates of price elasticity of demand for pulses are available. These are of the order of -0.6 [13]. We can, therefore, estimate the increase in the price of pulses which will be needed to close the demand-supply gap if the supply projections remained unchanged.

For the year 1990, the projected consumer demand for the high scenario is 16.4 million tons, whereas the available supply is 15.5 million tons. If demand is to be reduced to meet the available supply, prices would have to rise at the rate of about 1 percent per annum from 1982/83 to 1990. For the year 2000, when the gap between projected demand and supply is wider still, the needed price increase would be greater: in fact, about 4 percent per annum from 1990 to 2000.

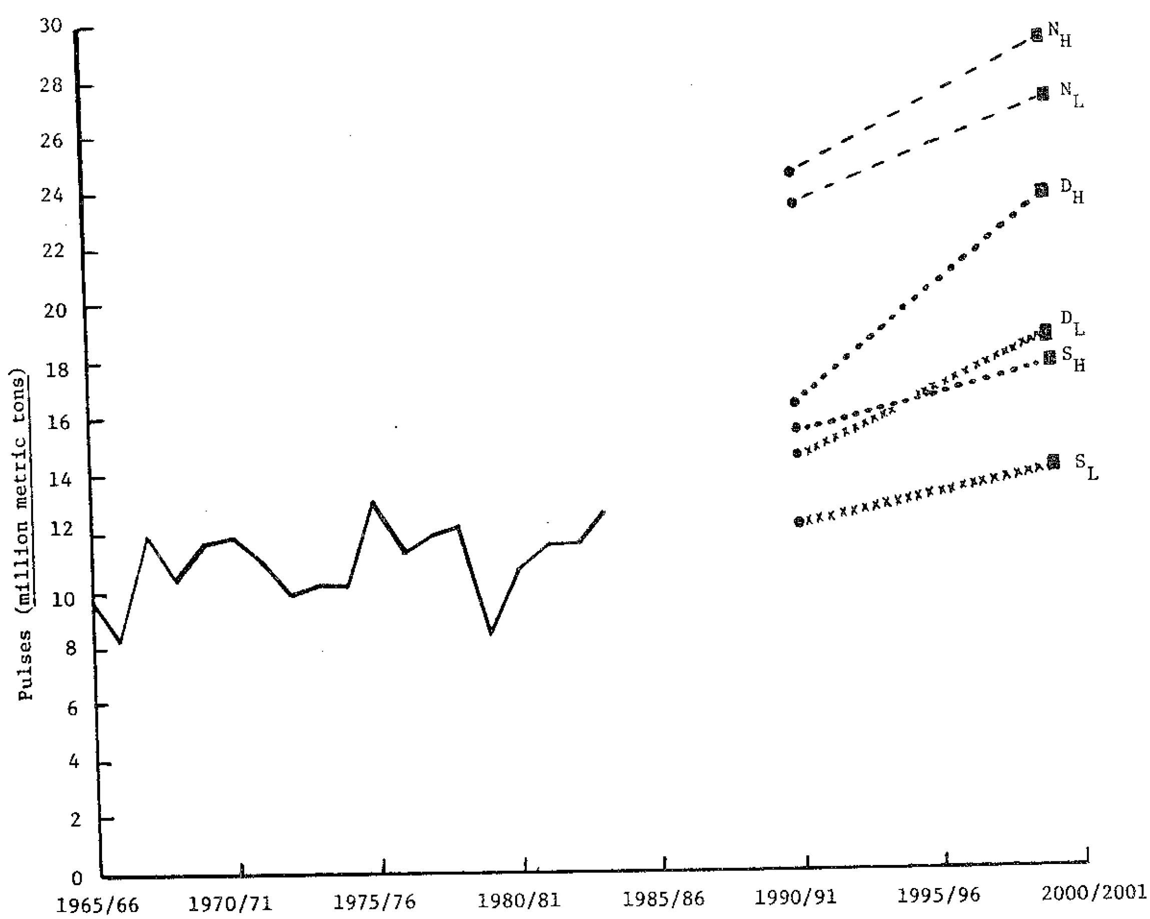
TABLE 6.11. PROJECTED DEMAND-SUPPLY BALANCES FOR PULSES IN 1990 AND 2000

(million metric tons)

Year	Demand		Supply		Deficit		Requirements based on Nutritional Norms		Supply		Deficit	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
1990	16.42	14.72	15.50	12.23	0.92	2.49	24.45	23.47	15.50	12.23	8.95	11.24
2000	23.76	18.61	17.81	14.15	5.95	4.46	29.12	17.07	17.81	14.15	11.31	2.92

Sources: Table 5.7, Table 6.9

FIGURE 6.10. INDIA: TREND IN PULSE PRODUCTION, 1965/66-1983/84, AND PROJECTIONS OF DEMAND AND SUPPLY FOR PULSES TO 1990 AND 2000



N_H and N_L -- High and Low Projections according to a minimum of 70 grams per day.

D_H and D_L -- High and Low Demand Projections

S_H and S_L -- High and Low Supply Projections

Source: Tables 5.9 and 6.9.

Importance of Area Versus Yield

Working on the assumption that the high scenarios for both supply and demand will obtain in 2000, the gap between demand and supply would be about 6 million metric tons. According to the projections for 2000, the area under pulses would be 27.9 million hectares and production 17.8 million metric tons. This gives an average yield of 638 kilograms per hectare for all pulses combined. The average yield of all pulses for the triennium 1981-83 was 490 kilograms per hectare, which implies an annual growth rate in yield of 1.8 percent for all pulses for the period 1983-2000. If the projected demand of 23.8 million metric tons is to be met, an additional 6 million metric tons has to be produced and the average yield would need to increase to about 850 kilograms per hectare. This implies an annual yield growth rate of 4.3 percent. Compared to a growth rate of 0.3 percent per annum over the last three decades, with highest yield in the post-Green Revolution period being 533 kilograms per hectare in 1967/68 and 1975/76, it would appear unlikely that the growth rate of 4.3 percent can be achieved in the next 15 years.

It is evident that the development of short-duration varieties will increase the scope for double and triple cropping, as well as intercropping of pulses and thereby significantly increase the area under pulses. In fact it is projected that the area under pulses in 2000 is likely to be 27.9 million hectares as against a triennium average of 22.9 million hectares in 1981-83, implying an annual growth rate of 1.3 percent. However the new technology has not made any major breakthrough in terms of yield increases as was the case with HYV cereals. True, improved varieties with the recommended package of inputs do increase yields, but the average farmer is still not inclined to invest in inputs for pulses, which he expects to cultivate with a minimum of investment, so as to be able to reap maximum benefits from a bonus or catch crop. It is this very reason which makes it difficult to expect any major increases in yields of pulses in the future, unless there is a breakthrough in technology.

The high projections for 2000 indicate that more than 65 percent of increased production will result from an expansion in area, brought about to a large extent through increased cropping intensity and to a lesser extent by the replacement of coarse cereals and other less-favored crops in some areas. The contribution of increased yields is projected to be much less.

CHAPTER VII
CONSTRAINTS TO PULSE PRODUCTION AND POLICY IMPLICATIONS

The major problems confronting pulse production are:

1) competition with high-yielding variety cereals in irrigated areas because of low yields of pulse crops.
2) variability in yields, because of uncertain weather conditions, in unirrigated areas.
3) variability in yields because of susceptibility of pulse crops to disease and pests.
4) inadequate availability of quality seeds of improved and short-duration varieties.

The factors constraining pulse production seem quite formidable and do not appear to lend themselves to easy resolution. It is therefore worth exploring alternative possibilities for increasing per capita availability. One option is to impose some kind of rationing on the existing supplies, through the process of procurement and distribution at subsidized prices in very much the same way as is done with wheat and rice. The other is to consider the possibility of imports. We shall examine the two options in the following sections.

Alternatives for Increasing Per Capita Availability of Pulses

Procurement and Distribution of Pulses

Two sets of administered prices are fixed by the Government of India, based on the yearly recommendations of the Agricultural Prices Commission:

1) minimum support prices for major field crops are meant to be the floor levels below which the market prices would not be allowed to fall.
2) procurement prices in respect of *kharif* and *rabi* cereals at which the grain is to be domestically procured by public agencies for release through the public distribution system.

In the case of pulses, only minimum support prices are announced. These are in the nature of a long-term guarantee, assuring the producer of a minimum price for his crop [42,p. 12].

However, the market prices for pulses, set according to the forces of supply and demand, have tended to prevail at levels significantly higher than the minimum support prices announced by the government. This is evident from Table 7.1.

If the government were to adopt a policy of procurement of pulses, and set a procurement price, it would have to be significantly higher than the minimum support price. In fact, if sizable stocks of pulses were to be purchased by government agencies, the price would probably have to be set well above the market price. Such a policy might provide some incentive to the producer, but it would drive the price of pulses higher, so that the situation of the lower income groups, who even now cannot afford an adequate intake pulses, would be further aggravated. To prevent that, government would have to distribute pulses through fair price shops at subsidized prices.

In Chapter IV it was seen that a certain proportion of cereal-pulse combination provided an optimum protein quality, determined by the Protein Efficiency Ratio (PER). If the quantity of pulses in the diet was increased beyond the critical ratio, it would add nothing further to the protein quality. In fact, experiments have shown that if pulse protein is increased beyond the optimum ratio, the quality of resultant protein actually begins to decline.

A second point which needs to be remembered is that rice-based diets require lesser amounts of pulses to complement the cereal protein than do wheat or coarse cereal-based diets. This is because rice protein is superior to wheat protein in terms of its amino acid makeup.

These facts may be utilized to distribute the limited quantity of pulses in the most nutritionally desired manner, and form a basis for rationing the existing supply of pulses. It is obvious that a small percentage of the population is consuming pulses in quantities which, in strictly nutritional terms, are quite wasteful, while many others may not be able to afford to consume any pulses at all, and are substituting vegetables, roots and tubers for this important protein source.

At present, the annual subsidy on foodgrains, mainly wheat and rice incurred by the government accounts for about 3-4 percent of the central government budget. The addition of pulses to the list of distributed commodities is not likely to burden the exchequer to any considerable extent. In theory, therefore, there is a strong case for rationing the existing supply of pulses.

However, there are a host of administrative problems associated with including pulses in the public distribution system. Storage of pulses on such a large scale would involve considerable losses during storage. It would imply an expansion in the bureaucratic structure of the marketing agencies of the state and central governments. With the government purchasing large stocks of pulses, the open market price of pulses would rise even more, increasing the possibility of black market trade in pulses.

TABLE 7.1. COMPARISON OF ADMINISTERED AND MARKET PRICES FOR GRAM IN UTTAR PRADESH, 1975/76-1980/81

(Rupees per quintal)

Crop Year	Minimum Support Prices	Farm Harvest Prices
1975/76	90.00	122.27
1976/77	90.00	121.39
1977/78	95.00	173.10
1978/79	125.00	172.52
1979/80	140.00	212.18
1980/81	145.00	294.12

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Farm (Harvest) Prices of Principal Crops in India (New Delhi, various issues).

India, Ministry of Agriculture, Directorate of Economics and Statistics, Bulletin of Food Statistics 1981-82 (New Delhi, 1982), p. 98.

If these problems could be overcome and it could be ensured that through the public distribution system the lower income classes would have access to the commodity, it would appear reasonable to include pulses with wheat and rice in the procurement and distribution operations of the government--until such time as the production of pulses could be increased sufficiently to allow for an adequate availability.

Possibility of Imports

Imports would not appear to be a likely solution to the problem of increasing pulse availability.

The bulk of pulses traded on the world market are comprised of soybeans and groundnuts. Soybeans are not acceptable to the Indian consumer as a substitute for gram, redgram, blackgram or greengram in the diet. Although soybean is produced in the country, it has not become a popular item of food. Its main uses have been for oil extraction and other industrial purposes. The pulses most commonly consumed in India are not available in sufficient quantity in the international market. In fact, India produces about 75 percent of the world production of gram and over 90 percent of redgram, greengram and blackgram. Pulses such as *khesari* and horsegram are grown almost exclusively in this country.

Strategies For Increasing Domestic Production

The long-term strategy for improving per capita pulse availability is to make all possible efforts to increase domestic production. Such a policy would require optimum utilization of available resources and technological improvements leading to maximization of land and labor productivity. This would have to be backed by a streamlining of the input supply line, to ensure timely and adequate availability of quality seeds of improved short-duration varieties. A concerted effort is also needed in the sphere of extension services, which up until now have concentrated mainly upon increasing production of cereals and cash crops. There is a need to restructure priorities, such that pulse production programs at both the national and state level receive greater attention than they have done hitherto.

Approach for Irrigated Areas

It is clear that as irrigation facilities spread, traditional cropping patterns will be replaced by high-yielding variety cereals. This is as it should be, because the first priority in Indian agriculture is to increase cereal production to meet the energy needs of a growing population. However, inirrigated areas, where double cropping is already being practiced, the short-duration summer greengram and blackgram varieties have been successfully introduced. A far greater potential to increase area through a triple cropping system exists in the northern wheat-growing belt of the country. A program of summer pulse production would enhance the income of the farmer and increase pulse production without confronting him with a choice between pulses and cereals. Additional area can be brought under short-duration varieties of greengram, cultivated with irrigation, in summer, after harvesting a crop of oilseeds, sugarcane, potato or wheat, and before planting the *kharif* crop paddy or maize [41, p. 291]. The concept of a triple cropping pattern, which should include summer pulses, must become as much a part of the agricultural scene in the next decade and a half as double cropping is today in the irrigated areas.

One of the main reasons for the wide fluctuations in the yield of pulses is the fact that most are grown in rainfed conditions. Variability in rainfall has a direct and significant effect on yields and consequently production. However, the expansion of pulse production in irrigated areas will lead to some stability in yields and have a positive effect on production of pulses as a whole.

Approach for Unirrigated Areas

By far the greatest potential for the production of pulses lies in the dryland rainfed areas in the regions comprising the central and southern states. Both gram in the *rabi* season and *kharif* pulses such as redgram, blackgram and greengram have potential in these regions. Area can be increased through double cropping where sufficient residual moisture makes a second crop possible. In the coastal regions of the central and southern states blackgram and greengram can be cultivated in rice fallows by making use of the residual moisture. Using mixed and intercropping systems, pulses can be grown as complementary rather than competing crops with cereals.

In the semi-arid areas pulses play an important role in the farming system. They generate food and income in a poor agro-climatic environment where many other crops would fail. In addition, they provide the cultivator with a low cost option to improve soil fertility without the use of purchased inputs [57, p. A139]. These special characteristics of pulse crops must be utilized to promote them in mixed and intercropping systems, together with appropriate cereal-pulse rotations, to maximize productivity in a deficient land resource base.

With the continued rise in the production of wheat and rice during the last two decades, the coarse cereals, sorghum, maize and millets, have lost their relative importance. In fact, many cultivators in the rainfed dryland areas no longer favor these crops, since the returns per hectare are often lower than those from pulses. It is quite likely that coarse cereals will find increasing use as animal feed in the future. It appears that the short-duration pulse varieties are already replacing coarse cereals profitably in many areas of the central and southern states.

The possibility of diversion of land from coarse cereals to pulses in rainfed areas holds considerable potential for the future, is a healthy one and needs to be encouraged. Pulses are nutritionally superior crops, and improve soil fertility as well. Coarse cereals, on the other hand, are inferior in terms of protein quality, and diets based solely on coarse cereals need large quantities of pulse protein to achieve the desirable amino acid balance. It, therefore, seems logical that, in the long run, coarse cereals be replaced to a large extent by pulses in the semi-arid regions, just as pulses are being replaced by the high-yielding variety superior cereals in the irrigated areas.

Disease and Pests

Apart from vagaries in weather conditions, susceptibility of pulse crops to disease and pests is the main reason for the wide fluctuations in yields. Information on the incidence of different pulse diseases in various regions of the country is limited, except in the case of pigeonpea wilt and sterility mosaic disease. On individual farmer's fields the incidence of the disease is often so severe that the entire crop may be wiped out, resulting in a total loss to the farmer [57, p. A144].

Subsidies on insecticides and spray equipment indicate the importance of plant protection measures and the concern of the government for this important aspect of pulse production. However, so long as pulses are considered low resource base crops, generally grown in rainfed areas and often on marginal lands, a majority of farmers will be either unable or unwilling to afford the cost of chemical plant protection measures, in spite of the subsidy.

Integrated pest management based on judicious use of insecticides, biological controls, and appropriate cropping systems would help to stabilize yields. This is not an easy task and would require a major research and extension effort.

Breeding of disease resistant varieties would be an effective approach to the problem and considerable progress has been made. Redgram varieties resistant to wilt and sterility mosaic have been identified and released for national demonstrations by ICRISAT. In addition to these two wide-spread diseases, plant pathologists are working to develop resistance to phytophthora blight.

A large number of varieties of gram resistant to wilt, dry root rot and black root rot have been developed. Also greengram and blackgram varieties resistant to yellow mosaic virus have been successfully introduced in the field. Efforts are in progress to develop varieties resistant to powdery mildew and leaf spot diseases [57]. However, if adequate quantities of seed of these disease resistant varieties are not made available to the farmers, the impact of this research will not be felt on the field.

Supply of Inputs

Seed. Of the recommended package of practices for increased pulse production, the most important is quality seed of improved and short-duration varieties.

During 1979-1982, the total quantity of breeder seed produced in the country was 30 metric tons, which was about one tenth of the requirement. Theoretically every kilogram of breeder seed should lead to a production of 1000 kilograms of certified seed. Although exact figures are not available, it is estimated that the factor by which breeder seed is actually multiplied does not exceed 20 [11, p. 37]. This results in a serious shortage of quality seed. Not more than 0.5 to 1 percent of farmers have been able to obtain seeds of improved varieties of pulses [11, p. 38].

One of the major thrusts of agricultural administration should be in the direction of seed production and multiplication programs, to ensure that the results of technical innovation reach from the laboratory to the land.

Other Inputs. Experiments have shown that the productivity of pulses can be improved through application of phosphatic fertilizer, one or two irrigations at critical points in the crop growth, and by treatment of seed with rhizobial culture.

The constraint in the case of phosphatic fertilizer is not so much a lack of availability, rather a lack of resources to purchase inputs. The latter could be improved through better institutional credit facilities. However, this constraint cannot be lifted overnight. The government is aware of the problem and efforts are being made through cooperative agencies and Regional Rural Banks to provide long-term credit as well as short-term crop loans to the cultivators.

The same applies to irrigation. Wherever irrigation facilities are available, extension services would play a major role in informing farmers of the timely requirements of irrigation for particular pulse crops. In unirrigated areas, an all out effort is needed to enhance the possibilities of water harvesting and moisture conservation through technology developed for dryland farming.

Many studies indicate that the treatment of seed with rhizobial culture increases productivity [11, 21, 41, 47]. In fact it is suggested that the culture should be provided as an essential component of the seed package [21]. There are, however, some conflicting opinions regarding the effectiveness of rhizobial culture in increasing pulse productivity [57, A142], which suggest further experimentation for conclusive evidence. However it is widely believed that treatment of seed by rhizobial culture has a positive effect on the fertility of the soil. There is an undoubted increase in the residual nitrogen left by the microbe in the soil, about 20 to 60 kilograms per hectare [11], which comes in useful both for the pulse crop and following crop. The rhizobial culture is very cheap and easily affordable by small and marginal farmers.

The supply of microbial culture at present is inadequate, and efforts are needed to increase its availability and streamline its distribution.

Research

In the past, pulses received low priority in terms of financial allocation for research and developmental activities relative to cereal crops. Limited scope and opportunities in the past failed to attract high calibre plant breeders and scientist into the field of pulse crops. This resulted in a considerable lag in developing new technology for pulses. The evolution of short-duration varieties, however, offers a great scope for increasing area under pulses through double and triple cropping systems.

A major research effort is now needed to maintain the momentum of genetic improvements. Improved varieties tolerant to drought, disease and pests need to be introduced constantly, if the potential of short-duration varieties is to be fully exploited.

Pulse production so far has been dominated by two crops, gram and redgram. The major gram growing areas have undergone significant changes in cropping patterns, as the resource base has improved with the spread of irrigation and the use of high-yielding cereal varieties. Gram is likely to lose its predominant position in pulse production in the future, especially in irrigated areas of the northern states. Emerging in importance in the future are the short-duration *kharif* pulses.

At many research institutions, agricultural universities and at ICRISAT, gram and redgram have held the pride of place for a long time. There is need to reconsider priorities and structure research to include the *kharif* pulses, namely greengram and blackgram, which appear to hold considerable promise for the future.

Extension

Agricultural education and extension services are spread very thinly and require major expansion. There is need for farmers to be informed in the use of improved short-duration varieties and also the agronomic practices needed to optimize productivity with available resources. States governments mount major campaigns in the *kharif* and *rabi* seasons for increasing production of rice and wheat. However, pulses have never claimed that kind of attention from policy makers and agricultural administrators. If pulse production is to be increased significantly by the end of the century, campaigns for pulse production will have to be fitted into the agricultural programs of the major states. Institutional and infrastructural improvement need to go hand in hand with extension for improved technology to have a meaningful and sustained impact on the field.

Prospects for the Future

While it is not possible to find a solution to all the factors that constrain pulse production, it is expected that by increasing area under pulses through multiple and intercropping, their production can be significantly increased.

The pattern of pulse production within the country is likely to change considerably in the future. It would be useful to take account of the location specificity of crops to make optimum use of various agroclimatic regions by using each to its best advantage. Some regions may specialize in pulses and oilseeds, some in cereals, others in plantation crops.

It is important to recognize the emerging trends in cropping patterns which indicate that the short-duration *kharif* pulses appear to be most suited for cultivation in the northern wheat growing belt. As irrigated area increases in this region, production of wheat and rice is likely to increase, leaving summer fallows for possible pulse production. The short-duration varieties of greengram and blackgram are best suited for summer cultivation, and emphasis must be laid on including these crops in the double and triple cropping patterns of this region.

In the rainfed areas of the central and southern states, both *rabi* and *kharif* pulses are expected to play an increasing role in the future. Efforts must be made to promote pulse production through intercropping and mixed cropping with other crops. Also, trends which indicate the replacement of coarse cereals by pulses should be encouraged.

The success of such a system would require a strengthening of the marketing and transporation infrastructure within the country.

Cereal crops have dominated Indian agriculture for a long time, accounting for more than 60 percent of cropped area in the country. This is a disproportionately large acreage, and needs to be reduced. The full potential of the Green Revolution is yet to be realized. The high-yielding varieties of superior cereals need to be more fully exploited, so that land can be released for other crops. In the new cropping patterns of the future, pulses are likely to find an important place.

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APPENDIX I.
STATISTICS RELATING TO PROTEIN AND
ENERGY VALUE OF PULSES AND CEREALS

I.1. DELHI: COST OF 100 GRAMS OF PROTEIN IN VARIOUS COMMODITIES

	Commodity	Protein in 100 gm of edible portion	Retail price (Rupees per kilogram)				
			1964	1968	1972	1976	1980
	Cereals						
1.	Wheat	11.8	0.57	0.71	0.94	1.50	1.51
2.	Rice	6.8	0.70	1.05	1.28	1.90	2.30
3.	Maize	11.1	NA	NA	0.86	1.05	1.52
	Pulses						
4.	Gram	17.1	0.76	0.92	1.22	1.50	3.51
5.	Redgram	24.0	1.10	1.55	1.92	2.19	4.23
6.	Lentil	25.1	NA	NA	2.08	2.25	4.30
	Animal Products						
7.	Milk	3.2	0.84	1.50	1.57	2.27	2.58
8.	Meat	21.4	3.21	4.50	4.00	9.17	17.42
9.	Fish	16.6	3.47	4.98	5.83	8.75	11.57
10.	Egg	13.3	2.50	3.80	3.78	4.49	4.72

			Cost of 100 gms of protein (Rupees)				
			1964	1968	1972	1976	1980
	Cereals						
1.	Wheat	11.8	0.48	0.61	0.80	1.27	1.28
2.	Rice	6.8	1.03	1.54	1.88	2.79	3.38
3.	Maize	11.1	NA	NA	0.77	0.95	1.37
	Pulses						
4.	Gram	17.1	0.44	0.54	0.71	0.88	2.05
5.	Redgram	24.0	0.46	0.65	0.80	0.91	1.76
6.	Lentil	25.1	NA	NA	0.83	0.90	1.79
	Animal Products						
7.	Milk	3.2	2.62	4.69	4.90	7.09	8.06
8.	Meat	21.4	1.50	2.10	2.80	4.28	8.14
9.	Fish	16.6	2.09	2.33	3.51	5.27	7.08
10.	Egg	13.3	1.87	2.85	2.84	3.37	3.55

N.A. = Not Available

Sources: Gopalan, C. et al., Nutritive Value of Indian Foods (National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, 1978), pp. 60-73.

India, Ministry of Agriculture, Directorate of Economics and Statistics, Bulletin of Food Statistics (Various Issues).

I.2. INDIA: PRODUCTION OF PROTEIN AND ENERGY FROM WHEAT AND GRAM IN SIX MAJOR WHEAT GROWING STATES*

	Yield (kg/ha)			Protein (kg/ha)			Energy (1000 Kcal/ha)		
	1964/65	74/75	82/83	64/65	74/75	82/83	64/65	74/75	82/83
Wheat	900	1414	1943	106	167	229	3114	4892	6723
Gram	615	657	684	105	112	117	2214	2365	2462

*Bihar, Punjab, Haryana, Madhya Pradesh, Rajasthan, Uttar Pradesh.

Sources: Ryan, James G., and Asokan, M., Effect of Green Revolution in Wheat on Production of Pulses and Nutrients in India (Economics Program, Occasional Paper 18, icrisat, Hyderabad, 1977), p. 29.

India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

I.3. HAPUR, UTTAR PRADESH: COST OF 100 GRAMS OF PROTEIN

(Rupees)

Year	Wheat		Gram	
	Nominal	Real	Nominal	Real
1965	0.69	0.69	0.42	0.42
1966	0.67	0.66	0.46	0.45
1967	1.03	0.77	0.76	0.57
1968	0.63	0.42	0.51	0.34
1969	0.67	0.61	0.58	0.53
1970	0.66	0.54	0.53	0.43
1971	0.62	0.56	0.52	0.47
1972	0.76	0.66	0.65	0.57
1973	0.79	0.54	0.94	0.65
1974	1.37	0.72	1.28	0.67
1975	1.16	-	1.10	-
1976	0.90	0.52	0.77	0.45
1977	1.03	0.62	0.97	0.58
1978	1.06	0.51	1.21	0.59
1979	1.08	0.55	1.18	0.60
1980	1.14	0.44	1.76	0.67
1981	1.27	0.44	2.08	0.73

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Agricultural Prices in India 1963-1982 (New Delhi, 1982). (For wholesale prices of wheat and gram at Hapur (U.P.), and Consumer Price Index for agricultural workers for U.P.)

Gopalan, C., *et al*., Nutritive Value of Indian Foods (National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, 1978).

I.4. INDIA: CALORIE AVAILABILITY PER CAPITA

(Kcals per day)

Supply Source	1950	1955	1960	1965	1970	1975	1977	1980
Pulses	183	215	202	192	169	132	138	120
Wheat	188	203	235	247	296	319	336	380
Rice	569	652	639	696	655	544	587	683
Coarse Cereals	332	406	400	368	349	290	330	306
Other Foods	378	414	434	500	516	494	528	567
Total	1650	1890	1910	2003	1985	1779	1919	2056

Source: FAO, Food Balance Sheets, various issues.

I.5. INDIA: PROTEIN AVAILABILITY PER CAPITA

(Grams per day)

Supply Source	1950	1955	1960	1965	1970	1975	1977	1980
Pulses	11.8	13.8	13.0	10.5	9.9	7.8	8.3	7.0
Wheat	5.3	5.7	6.6	9.1	8.6	9.3	9.3	11.1
Rice	10.6	12.1	11.9	11.5	12.3	10.2	11.1	12.8
Coarse Cereals	9.3	11.3	11.1	10.5	11.3	8.1	9.0	8.6
Other Foods	8.7	7.5	8.2	9.0	9.6	8.9	9.6	10.2
Total	45.7	50.4	50.8	50.6	49.4	44.3	47.3	49.7

Source: FAO, Food Balance Sheets, various issues.

I.6. INDIA: PULSE, WHEAT, RICE AND COARSE CEREAL PROTEIN AS PERCENTAGE OF TOTAL PER CAPITA FOODGRAIN PROTEIN

(percent)

Supply Source	1950	1955	1960	1965	1970	1975	1980
Pulse	32	32	31	27	24	21	18
Wheat	14	13	16	17	21	25	28
Rice	28	28	28	31	29	27	32
Coarse Cereals	25	26	26	25	27	28	22
Total Foodgrains	100	100	100	100	100	100	100

Source: FAO, Production Yearbook, various issues.

APPENDIX II.

STATISTICS RELATING TO AREA, PRODUCTION AND AVAILABILITY OF PULSES AND CEREALS

II.1. AREA AND YIELD OF PULSES IN MAJOR PRODUCING COUNTRIES

(Area in 1000 hectares)
(yield in kilograms per hectare)

Country		1980	1981	1982	Average
Brazil	Area	4,777	5,191	6,157	5,375
	Yield	420	460	489	456
China	Area*	5,462	5,363	5,515	5,447
	Yield*	1,236	1,203	1,244	1,228
India	Area	22,515	22,477	23,345	22,779
	Yield	399	498	475	457
Egypt	Area	145	138	139	141
	Yield	1,965	1,828	1,918	1,904
Mexico	Area	2,061	2,449	2,012	2,159
	Yield	628	743	711	694
Nigeria	Area*	4,115	4,115	4,318	4,183
	Yield	219	219	218	219
U.K.	Area	82	74	82	79
	Yield	3,171	2,851	2,855	2,959
U.S.A.	Area	902	1,028	849	926
	Yield	1,649	1,643	1,598	1,630

*FAO estimates.

Source: FAO, Production Year Book (1983) (Rome, 1983), p. 67.

II.2. INDIA: PER CAPITA NET AVAILABILITY OF CEREALS AND PULSES

(Grams per day)

Year	Rice	Wheat	Other Cereals	Cereals	Pulses
1951	158.9	65.7	109.6	334.2	60.7
1952	158.5	57.6	109.3	325.4	59.1
1953	165.9	62.5	121.5	349.9	62.7
1954	194.1	58.0	136.0	388.1	69.7
1955	179.7	58.3	134.9	372.9	71.1
1956	187.7	61.5	111.2	360.4	70.3
1957	192.7	71.6	111.0	375.3	71.8
1958	164.8	66.5	119.0	350.3	58.5
1959	191.0	78.5	123.9	393.4	74.9
1960	187.8	78.3	118.0	384.1	65.5
1961	201.1	79.1	119.5	399.7	69.0
1962	203.2	84.2	111.5	398.9	62.0
1963	186.9	79.2	117.9	384.0	59.8
1964	201.4	90.1	109.5	401.0	51.0
1965	210.2	93.6	114.7	418.5	61.6
1966	161.9	95.4	102.6	359.9	48.2
1967	154.0	90.5	117.3	361.8	39.6
1968	183.7	95.8	124.6	404.1	56.1
1969	190.5	100.5	106.8	397.8	47.3
1970	190.2	102.3	110.6	403.1	51.9
1971	192.6	103.6	121.4	417.6	51.2
1972	197.8	126.0	95.3	419.1	47.0
1973	172.0	118.1	90.7	380.8	41.1
1974	190.4	108.8	111.5	410.7	40.5
1975	159.2	112.1	94.8	366.1	39.7
1976	187.2	107.4	107.0	401.6	50.6
1977	168.8	116.4	103.3	388.5	43.3
1978	196.4	126.3	100.3	423.0	45.2
1979	200.4	129.9	99.2	429.6	44.9
1980	166.4	127.0	86.6	380.0	30.9
1981	199.2	130.9	90.7	420.8	39.2

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Bulletin of Food Statistics (New Delhi, 1981), pp. 140-141.

India, Ministry of Finance, Economics Divisions, Economic Survey 1984-85 (New Delhi, 1985), p. 106.

II.3. INDIA: AREA AND PRODUCTION OF PULSES IN MAJOR PRODUCING STATES AS PERCENTAGE OF NATIONAL AREA AND PRODUCTION, 1982/83

STATE	AREA		PRODUCTION	
	(1000 ha)	Percentage of total	(1000 M.T.)	Percentage of total
Punjab	208	0.9	122	1.0
Haryana	557	2.4	315	2.7
Uttar Pradesh	2,977	13.0	2,542	21.4
Bihar	1,189	5.2	702	5.9
	4,931	21.5	3,681	31.0
Rajasthan	3,533	15.5	1,570	13.2
Madhya Pradesh	5,129	22.5	2,608	22.0
Maharastra	2,574	11.3	963	8.1
Orissa	1,643	7.2	922	7.8
	12,879	56.5	6,063	51.1
Andhra Pradesh	1,458	6.4	585	4.9
Karnataka	1,585	6.9	519	4.4
	3,043	12.3	1,104	9.3
Total of the above states	20,853	91.3	10,848	91.5
National	22,833	100.0	11,857	100.0

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984), pp. 22-23.

II.4. INDIA: PULSE AREA IN VARIOUS REGIONS, 1960/61 - 1983/84

(1000 hectares)

States	Area					
	1960/61	1965/66	1970/71	1975/76	1980/81	1983/84[a]
Punjab, Haryana, Uttar Pradesh, Bihar	9584 (40.6)	8904 (39.2)	6924 (30.7)	6318 (25.8)	5371 (23.9)	4938 (21.1)
Rajasthan, Orissa, Madhya Pradesh, Maharashtra	9797 (41.6)	9986 (44.0)	11,198 (49.7)	13,318 (54.4)	12,252 (54.5)	13,328 (57.0)
Andhra Pradesh Karnataka	2603 (11.0)	2630 (11.6)	2582 (11.5)	2887 (11.8)	2711 (12.0)	2875 (12.3)
National	23,563	22,718	22,534	24,454	22,457	23,412

Figures in parenthesis indicate pulse area as percentage of national pulse area.

[a] 1983/84 figures are provisional.

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India (various issues).

II.5. INDIA: AREA UNDER *RABI* AND *KHARIF* PULSES IN MAJOR PRODUCING STATES

(1000 hectares)

States	Area 1970/71		1974/75		1982/83	
	Rabi	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*
Punjab, Haryana Uttar Pradesh, Bihar	5648 (43)	1257 (13.5)	4646 (38)	1166 (12)	3936 (32)	1107 (11)
Rajasthan, Orissa, Madhya Pradesh, Maharashtra	5763 (44)	5435 (57)	5806 (48)	5916 (60)	6962 (56)	5677 (57)
Andhra Pradesh Karnaraka	814 (6)	1769 (19)	916 (7)	1866 (19)	871 (7)	1796 (18)
National	13,070	9,464	12,209	9,815	12,466	9,942

Figures in parenthesis indicate pulse area as percentage of national pulse area.

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

APPENDIX III.
STATISTICS RELATING TO CONSUMPTION OF PULSES AND CEREALS

III.1. INDIA: ESTIMATES OF PER CAPITA CONSUMPTION OF FOODGRAINS

Round and Year		Per Capita Consumption Per Month			Per Capita Annual Consumption	Per Capita Daily Consumption
		Rural	Urban	Total		
		(kg.)			(kg.)	(grams)
16th, 1961/62	Cereals	17.55	12.49	16.63	202.5	554.33
	Pulses	1.50	1.53	1.51	18.2	50.33
	Total	19.05	14.02	18.14	220.7	604.66
19th, 1964/65	Cereals	16.19	11.65	15.32	186.6	510.67
	Pulses	1.66	1.18	1.56	18.8	52.00
	Total	17.85	12.83	16.88	205.4	562.67
27th, 1972/73	Cereals	15.29	11.27	14.45	175.9	481.67
	Pulses	0.85	0.93	0.87	10.5	29.00
	Total	16.14	12.20	15.32	186.4	510.67
28th, 1973/74	Cereals	15.13	11.40	14.35	174.7	478.33
	Pulses	0.86	0.88	0.88	10.6	29.33
	Total	15.99	12.28	15.23	185.3	507.66

Source: Sarma, J.S. and Shyamal Roy. Two Analyses of Indian Foodgrain Production and Consumption Data. Research Report No. 12, International Food Policy Research Institute, (Washington, D.C., 1979), p. 33.

III.2. INDIA: NET AND PER CAPITA AVAILABILITY OF CEREALS AND PULSES, 1950-1983

YEAR	Cereals		Pulses		Total	
	Net (million M.T.)	Per Capita (grams per day)	Net (million M.T.)	Per Capita (grams per day)	Net (million M.T.)	Per Capita (grams per day)
1950	47.44	363.8	8.78	67.4	56.22	431.2
1951	44.30	334.2	8.05	60.7	52.35	394.9
1952	43.98	325.4	7.98	59.1	51.96	384.5
1953	47.97	349.9	8.61	62.7	56.58	412.6
1954	54.19	388.1	9.73	69.7	63.92	457.8
1955	53.05	372.9	10.11	71.1	63.16	444.0
1956	52.42	360.4	10.23	70.3	62.65	430.7
1957	55.44	375.3	10.63	71.8	66.07	447.1
1958	52.94	350.3	8.84	58.5	61.78	408.8
1959	60.75	393.4	11.56	74.9	72.31	468.3
1960	60.82	384.1	10.38	65.5	71.20	449.6
1961	64.55	399.7	11.14	69.0	75.69	468.7
1962	65.85	399.0	10.24	62.0	76.09	461.0
1963	64.76	384.0	10.08	59.8	74.84	443.8
1964	69.29	401.0	8.81	51.0	78.10	452.0
1965	73.72	418.6	10.85	61.6	84.57	480.2
1966	64.80	360.0	8.68	48.2	73.48	408.2
1967	66.57	361.7	7.30	39.7	73.87	401.4
1968	76.23	404.1	10.57	56.0	86.81	460.1
1969	76.53	397.9	9.09	47.3	85.62	445.2
1970	79.29	403.1	10.20	51.9	89.49	455.0
1971	83.99	417.6	10.32	51.2	94.31	468.8
1972	86.52	419.1	9.70	47.0	96.22	466.1
1973	80.13	380.5	8.67	41.1	87.79	421.6
1974	88.38	410.4	8.76	40.8	97.14	451.2
1975	80.56	365.8	8.76	39.7	89.33	405.5
1976	84.42	373.8	11.42	50.5	102.08	424.3
1977	89.03	386.4	9.96	43.3	99.39	429.6
1978	99.56	422.5	10.69	45.5	110.23	468.0
1979	104.07	431.8	10.79	44.7	114.20	476.5
1980	193.79	379.5	7.63	30.9	101.42	410.4
1981	104.86	416.2	9.41	37.2	114.87	453.4
1982	106.82	414.5	10.07	39.2	116.89	453.7
1983	104.27	395.9	10.37	39.5	114.64	435.4
1984	119.41	442.1	11.07	41.0	130.48	438.1

Source: India, Ministry of Finance, Economic Division, Economic Survey 1984-85 (Delhi, Controller of Publications, 1985), p. 106.

III.3. INDIA: EXPENDITURE ON PULSES AND CEREALS AS PERCENTAGE OF TOTAL EXPENDITURE, 1964/65

(percent)

Monthly Per Capita Expenditure Class in Rupees	Cereals		Pulses*	
	Rural	Urban	Rural	Urban
0-8	57.00	48.80	4.36	5.42
8-11	56.85	45.08	5.42	4.66
11-13	58.27	46.29	5.15	4.79
13-15	55.17	44.11	5.92	5.82
15-18	54.42	44.09	6.74	5.51
18-21	51.87	39.44	6.30	5.74
21-24	48.51	37.46	6.35	5.16
24-28	46.41	33.73	6.18	5.23
28-34	43.08	29.93	6.47	4.93
34-43	38.10	25.14	6.16	4.62
43-55	33.01	20.35	5.71	3.98
55-75	26.97	15.45	5.35	3.19
75 and above	19.29	7.98	3.85	1.92
All Classes	42.17	23.67	5.90	3.97

*Pulses include gram.

Source: India, Cabinet Secretariat, The National Sample Survey: Tables with Notes on Consumer Expenditure. Nineteenth Round, July 1964 to June 1965, No. 192 (Delhi Controller of Publications, 1971).

III.4. INDIA: EXPENDITURE ON PULSES AND CEREALS AS PERCENTAGE OF TOTAL EXPENDITURE, 1973/74

(percent)

Monthly Per Capita Expenditure Class in Rupees	Cereals		Pulses*	
	Rural	Urban	Rural	Urban
0-13	58.18	34.71	1.89	-
13-15	56.77	43.80	2.06	1.55
15-18	60.74	43.39	2.20	3.53
18-21	59.02	50.25	3.00	2.86
21-24	58.31	46.07	2.98	3.51
24-28	58.32	48.53	3.76	3.82
28-34	55.46	45.73	4.26	4.33
34-43	53.00	42.90	4.48	4.05
43-55	49.03	37.70	4.43	4.21
55-75	40.11	32.52	4.53	4.11
75-100	37.32	25.80	4.49	3.84
100-150	28.28	19.52	3.72	3.53
150-200	20.39	12.60	3.21	2.30
200 and above	15.35	8.03	2.55	1.57
All Classes	43.39	26.89	4.25	3.50

*Pulses include gram.

Source: The National Sample Survey: Tables With Notes on Consumer Expenditure. Twenty Eighth Round, October 1973 to June 1974, No. 240 (Delhi, Controller of Publications, 1978).

APPENDIX IV.
STATISTICS RELATING TO AREA, PRODUCTION AND YIELD OF MAJOR PULSES BY STATE

IV.1. GRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop	Punjab			Haryana			Uttar Pradesh			Bihar		
Year	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1970/71	358	284	794	1046	774	740	2078	1544	743	244	174	713
1971/72	335	282	841	1119	647	578	1989	1567	788	241	170	706
1972/73	319	267	837	970	551	568	1921	1461	761	262	134	511
1973/74	352	315	896	994	448	451	1956	1044	534	261	114	439
1974/75	266	216	812	705	343	487	1721	1010	587	248	157	631
1975/76	381	376	986	1106	907	820	1726	1250	724	245	135	550
1976/77	349	311	891	1029	824	801	1659	1362	821	221	141	639
1977/78	353	322	912	1149	965	840	1656	1207	729	227	124	549
1978/79	351	284	809	1063	1044	982	1641	1228	748	217	134	617
1979/80	236	162	686	553	316	571	1554	693	446	184	113	611
1980/81	258	150	581	741	466	629	1496	1288	861	196	141	718
1981/82	243	115	473	1044	309	296	1571	1061	675	173	124	718
1982/83	124	62	500	509	282	555	1509	1391	922	193	138	718

Projected Area and Production

		P			P			P			P	
	A	High	Low	A	High	Low	A	High	Low	A	High	Low
1990/91	61	60	30	621	610	377	1216	1121	888	1216	1121	888
2000/2001	25	25	12	497	488	301	928	855	677	928	855	677

IV.1. (Continued) GRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

Crop Year	Rajasthan			Madhya Pradesh			National		
	A	P	Y	A	P	Y	A	P	Y
1970/71	1618	1195	739	1619	856	529	7839	5199	663
1971/72	1642	885	539	1686	1148	681	7912	5081	642
1972/73	1205	803	667	1625	1109	682	6968	4537	651
1973/74	1501	715	477	1851	1057	571	7761	4099	528
1974/75	1425	796	558	1842	1144	621	7042	4015	570
1975/76	1952	1498	767	1917	1226	640	8320	5880	707
1976/77	1776	1361	767	2018	1049	520	7974	5424	680
1977/78	1862	1488	799	1780	907	510	7974	5410	678
1978/79	1748	1589	909	1739	1032	593	7708	5739	745
1979/80	1376	750	544	2174	924	425	6985	3356	481
1980/81	1225	854	697	1807	1063	589	6584	4328	657
1981/82	1935	1257	650	2029	1362	671	7868	4642	590
1982/83	1803	1322	733	2157	1455	674	7225	5092	705
	Projected Area and Production								
		P			P			P	
	A	High	Low	A	High	Low	A	High	Low
1990/91	1937	1761	1367	2612	1781	1541	7970	5928	4692
2000/01	2120	1927	1496	3320	2264	1959	8468	6151	4935

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.2.

IV.2. REDGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop	Uttar Pradesh			Madhya Pradesh			Orissa			Andhra Pradesh		
Year	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1970/71	582	679	1165	500	409	818	51	32	629	199	62	313
1971/72	468	599	1281	505	425	842	50	24	490	186	42	227
1972/73	564	869	1540	529	475	897	51	27	535	183	38	207
1973/74	527	310	588	516	292	566	54	27	500	207	39	187
1974/75	540	618	1144	514	419	815	56	28	493	199	46	231
1975/76	529	775	1467	517	432	836	58	31	545	216	44	203
1976/77	531	752	1416	509	281	552	42	17	398	182	24	132
1977/78	521	750	1441	488	352	721	58	31	530	199	30	150
1978/79	501	647	1290	475	317	668	70	36	514	206	45	217
1979/80	542	539	994	512	229	447	76	31	401	193	49	252
1980/81	523	756	1448	523	304	581	82	43	521	227	44	194
1981/82	515	630	1223	534	482	903	104	76	731	284	60	243
1982/83	489	545	1113	512	343	670	118	87	739	240	45	189
	Projected Area and Production											
		P			P			P			P	
	A	High	Low	A	High	Low	A	High	Low	A	High	Low
1990/91	489	753	594	520	469	340	205	151	119	272	85	60
2000/01	489	753	594	530	478	346	409	302	237	320	100	70

IV.2. (Continued) REDGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop	Gujarat			Maharashtra			Karnataka			National		
Year	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1970/71	86	41	474	640	305	476	309	153	494	2655	1883	709
1971/72	86	44	514	482	251	521	306	163	532	2346	1683	718
1972/73	86	34	400	509	199	392	197	65	331	2424	1928	795
1973/74	96	42	439	627	360	574	312	157	504	2646	1408	532
1974/75	94	37	392	592	376	634	279	146	525	2529	1834	725
1975/76	102	48	466	642	406	633	315	185	586	2671	2099	786
1976/77	105	62	593	648	297	459	280	126	452	2566	1725	672
1977/78	111	44	397	660	344	521	320	223	695	2626	1930	735
1978/79	132	74	566	676	399	591	331	219	664	2635	1887	716
1979/80	153	88	573	663	411	621	354	235	664	2731	1757	643
1980/81	188	142	754	706	360	510	336	125	370	2842	1957	689
1981/82	228	180	790	706	427	605	374	183	490	3004	2237	745
1982/83	262	195	745	680	399	586	258	119	459	2844	1919	675

Projected Area and Production

		P			P			P			P	
	A	High	Low	A	High	Low	A	High	Low	A	High	Low
1990/91	551	436	378	709	449	413	459	319	243	3523	2992	2412
2000/01	873	690	599	747	473	435	499	347	264	4248	3532	2861

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.3.

IV.3. GREENGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71-1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop Year	Bihar			Uttar Pradesh			Rajasthan		
	A	P	Y	A	P	Y	A	P	Y
1970/71	103	36	351	13	4	288	250	91	363
1971/72	12	5	419	12	3	212	280	73	261
1972/73	99	36	368	12	3	258	234	47	203
1973/74	114	36	312	15	4	248	311	96	308
1974/75	125	29	230	16	7	407	280	27	96
1975/76	130	44	336	16	5	296	396	85	216
1976/77	134	49	367	17	5	298	358	94	262
1977/78	145	54	369	17	6	330	247	60	243
1978/79	142	52	365	16	3	188	204	31	152
1979/80	151	69	457	107	36	338	172	11	61
1980/81	149	70	466	140	54	384	206	52	250
1981/82	168	70	416	141	55	385	223	19	86
1982/83	167	77	463	167	74	442	215	17	81
	Projected Area and Production								
		P			P			P	
	A	High	Low	A	High	Low	A	High	Low
1990/91	231	108	100	555	245	193	194	71	25
2000/01	342	160	148	1118	494	388	172	62	22

IV.3. (Continued) GREENGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71-1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop Year	Madhya Pradesh			Orissa			Andhra Pradesh		
	A	P	Y	A	P	Y	A	P	Y
1970/71	231	63	271	322	193	597	497	149	300
1971/72	202	58	288	346	159	460	461	133	288
1972/73	230	60	262	348	185	530	465	65	140
1973/74	222	56	252	387	198	510	496	139	279
1974/75	236	62	262	392	161	411	494	127	257
1975/76	238	74	310	423	193	456	484	139	288
1976/77	247	69	278	372	162	435	496	168	339
1977/78	228	67	293	521	270	519	485	136	281
1978/79	211	53	252	629	331	526	519	150	289
1979/80	211	34	152	648	227	350	480	86	180
1980/81	246	58	237	690	372	540	572	183	320
1981/82	231	61	264	704	378	537	566	210	370
1982/83	225	59	264	561	319	568	524	235	449
	Projected Area and Production								
		P			P			P	
	A	High	Low	A	High	Low	A	High	Low
1990/91	225	70	53	811	484	409	543	244	175
2000/01	225	70	53	1021	609	514	568	255	183

IV.3. (Continued) GREENGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71-1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop Year	Maharashtra			Karnataka			National		
	A	P	Y	A	P	Y	A	P	Y
1970/71	435	97	224	81	19	235	2066	700	339
1971/72	296	56	190	90	21	238	1837	560	306
1972/73	343	55	159	71	11	148	1962	524	267
1973/74	552	148	269	95	48	506	2383	797	334
1974/75	504	146	290	112	41	369	2294	652	284
1975/76	562	167	296	121	45	371	2517	798	317
1976/77	542	168	310	97	24	247	2404	797	331
1977/78	543	164	301	113	55	484	2437	870	357
1978/79	534	150	282	133	35	263	2547	876	344
1979/80	516	140	270	137	28	205	2594	698	269
1980/81	548	95	173	135	33	241	2843	979	344
1981/82	488	143	294	168	53	317	2853	1060	372
1982/83	455	148	325	172	60	333	2630	1060	403
	Projected Area and Production								
	A	P High	P Low	A	P High	P Low	A	P High	P Low
1990/91	468	152	126	284	145	77	3524	1706	1300
2000/01	486	158	131	387	196	105	4595	2252	1735

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.4.

IV.4. BLACKGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop	Tamil Nadu			Uttar Pradesh			Madhya Pradesh			Rajasthan		
Year	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1970/71	97	24	251	152	52	340	628	156	249	55	28	504
1971/72	97	30	304	146	29	199	625	163	260	53	23	431
1972/73	148	49	334	151	57	379	640	136	213	61	24	395
1973/74	158	52	328	164	62	378	700	154	221	99	24	239
1974/75	96	26	268	151	58	385	620	141	228	109	20	187
1975/76	93	21	225	146	43	295	633	184	291	102	52	515
1976/77	120	42	345	134	39	288	623	152	244	91	41	445
1977/78	147	62	421	148	55	371	668	182	272	108	52	479
1978/79	167	65	391	174	43	246	686	156	227	113	36	318
1979/80	172	56	327	204	33	163	705	119	168	128	16	126
1980/81	168	45	267	200	55	275	751	175	234	161	64	395
1981/82	156	46	296	227	72	318	755	196	259	149	52	352
1982/83	198	52	263	201	49	244	705	169	239	143	48	333

Projected Area and Production

		P			P			P			P	
	A	High	Low	A	High	Low	A	High	Low	A	High	Low
1990/91	316	133	97	244	92	61	761	197	171	187	96	57
2000/01	571	240	176	310	118	77	837	217	188	243	125	74

IV.4. (Continued) BLACKGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop	Orissa			Andhra Pradesh			Maharashtra			National		
Year	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1970/71				190	90	474	457	114	250	2067	656	318
1971/72				186	90	412	338	75	222	1868	535	286
1972/73				182	80	439	326	68	208	1957	613	313
1973/74				217	85	391	522	145	278	2369	744	314
1974/75				192	86	449	511	155	302	2169	671	309
1975/76				188	84	445	510	175	343	2161	757	350
1976/77				177	65	366	496	173	349	2074	693	334
1977/78				155	50	325	503	172	342	2172	747	344
1978/79				227	98	429	490	157	320	2374	727	320
1979/80	382	126	330	244	92	376	453	147	325	2719	757	278
1980/81	410	217	529	232	107	460	475	106	223	2830	959	339
1981/82	434	237	545	219	90	410	445	150	337	2776	1010	364
1982/83	438	240	547	212	120	751	472	151	319	2714	864	355

Projected Area and Production

	A	P		A	P		A	P		A	P	
		High	Low		High	Low		High	Low		High	Low
1990/91	543	297	265	228	171	140	482	168	147	3174	1427	1158
2000/01	712	389	347	250	168	121	494	172	151	3929	1790	1401

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.5.

IV.5. HORSEGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop Year	Madhya Pradesh			Orissa			Andhra Pradesh		
	A	P	Y	A	P	Y	A	P	Y
1970/71	198	59	299	175	85	485	438	112	256
1971/72	198	64	321	174	75	434	390	92	237
1972/73	197	52	262	189	91	484	396	91	230
1973/74	205	58	282	190	87	458	382	104	274
1974/75	215	56	261	207	88	423	433	119	276
1975/76	210	68	324	242	111	459	418	107	256
1976/77	205	47	230	205	79	388	319	64	200
1977/78	196	59	298	310	143	462	345	85	247
1978/79	199	55	278	340	156	459	358	89	247
1979/80	187	40	215	363	111	305	346	74	214
1980/81	180	48	266	343	160	467	320	61	191
1981/82	181	53	294	332	155	468	295	78	263
1982/83	177	43	245	274	138	503	283	86	304
	Projected Area and Production								
		P			P			P	
	A	High	Low	A	High	Low	A	High	Low
1990/91	164	53	43	368	185	162	212	93	52
2000/01	146	47	38	533	268	235	148	65	36

IV.5. (Continued) HORSEGRAM: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop Year	Karnataka			Tamil Nadu			National		
	A	P	Y	A	P	Y	A	P	Y
1970/71	363	113	311	216	47	216	1762	547	311
1971/72	503	120	239	194	48	244	1836	509	277
1972/73	488	120	245	234	50	213	1845	497	269
1973/74	577	239	415	218	47	215	2021	665	329
1974/75	632	257	407	174	22	128	2123	701	330
1975/76	649	270	416	167	36	213	2183	761	349
1976/77	384	110	286	197	46	232	1731	482	278
1977/78	550	232	422	193	46	236	2002	700	350
1978/79	687	260	378	207	49	238	2178	740	340
1979/80	691	260	376	195	46	233	2189	665	304
1980/81	686	203	296	161	38	233	2121	616	291
1981/82	681	276	406	149	36	242	2044	720	352
1982/83	549	168	307	177	77	434	1801	612	339

Projected Area and Production

	Karnataka			Tamil Nadu			National		
	A	P High	P Low	A	P High	P Low	A	P High	P Low
1990/91	720	300	252	155	67	43	2024	831	656
2000/01	1012	420	357	133	58	37	2465	1022	836

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.6.

IV.6. LENTIL: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop	Uttar Pradesh			Bihar			Madhya Pradesh			National		
Year	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1970/71	166	101	604	141	91	643	272	109	401	754	375	497
1971/72	176	113	642	NA	NA	NA	265	103	389	625	301	481
1972/73	189	118	623	151	61	404	294	113	382	834	373	447
1973/74	199	93	468	142	66	464	345	121	351	925	407	440
1974/75	211	94	445	146	98	674	350	150	428	953	457	480
1975/76	230	122	520	152	89	582	325	144	441	937	461	492
1976/77	222	109	492	157	88	564	300	115	382	853	394	461
1977/78	240	115	477	163	82	504	310	100	324	881	384	436
1978/79	300	145	482	166	88	531	324	121	372	1006	446	443
1979/80	238	85	357	155	82	532	283	72	256	849	320	377
1980/81	276	157	569	200	128	641	273	108	394	935	465	391
1981/82	339	217	640	153	100	653	302	113	373	945	497	525
1982/83	383	203	531	153	113	736	301	118	393	981	500	509

Projected Area and Production

	A	P High	P Low	A	P High	P Low	A	P High	P Low	A	P High	P Low
1990/91	664	425	343	162	119	100	323	142	116	1368	808	657
2000/01	1118	715	577	173	127	107	352	997	810	1955	1174	953

NA = Not available

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.7.

IV.7. KHESARI: AREA, PRODUCTION AND YIELD, BY STATE, 1970/71 - 1982/83, AND PROJECTIONS TO 1990 AND 2000

(area (A) in 1000 hectares; production (P) in 1000 metric tons; yield (Y) in kilograms/hectare)

Crop Year	Bihar			Madhya Pradesh			National		
	A	P	Y	A	P	Y	A	P	Y
1970/71	668	388	581	707	313	443	1673	843	504
1971/72	NA	NA	NA	748	364	487	1043	493	473
1972/73	559	200	359	744	283	380	1491	561	377
1973/74	623	283	454	830	305	368	1712	702	410
1974/75	622	377	607	520	213	409	1453	751	517
1975/76	586	359	612	797	355	445	1720	871	506
1976/77	534	252	472	679	141	207	1524	524	344
1977/78	527	217	411	773	309	400	1578	641	406
1978/79	531	241	454	783	269	344	1599	617	386
1979/80	397	182	458	470	77	163	1084	351	324
1980/81	448	277	620	682	220	323	1353	566	418
1981/82	411	258	628	704	173	246	1307	498	381
1982/83	411	291	708	645	185	287	1191	514	432
	Projected Area and Production								
		P			P			P	
	A	High	Low	A	High	Low	A	High	Low
1990/91	295	209	170	606	295	165	1048	567	376
2000/01	196	139	113	561	273	153	880	463	299

Sources: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and Production of Principal Crops in India, 1981-84 (New Delhi, 1984).

Table 6.8.

COCONUTS AND OIL PALM IN THE INDIAN OILSEEDS ECONOMY

by J. V. Meenakshi

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GLOSSARY

AICORPO	All India Coordinated Research Project on Oilseeds
<u>Bajra</u>	Hindi for pearl millet
District	Administrative subdivision of a state
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center)
CPCRI	Central Plantation Crops Research Institute
FAO	Food and Agriculture Organization of the United Nations
FFB	Fresh fruit bunches of oil palm
<u>Ghee</u>	Clarified butter
GROFED	Gujarat Cooperative Oilseeds Growers' Federation
IRR	Internal Rate of Return
<u>Jowar</u>	Hindi for sorghum
<u>Kharif</u>	The main growing season in India. It begins with the onset of the southwest monsoon and usually lasts from May to mid-October.
NAFED	National Agricultural Cooperative Marketing Federation
<u>Rabi</u>	The second growing season in India. Usually lasts from mid-October to May. In some regions, if water availabilities so permit, a summer crop follows the rabi crop.
<u>Taluk</u>	Administrative subdivision of a district
<u>Vanaspati</u>	Hydrogenated composite of selected edible oils.

TECHNICAL NOTES

Cereals and Foodgrains:

In India, a distinction is made between cereals and foodgrains. Cereals refer to paddy, wheat, and the various millets, whereas foodgrains include cereals and pulses. However, in this study, the two terms are used interchangeably and refer to cereals unless specified otherwise.

Crop year:

The crop year in India begins on July 1.

Exchange rates:

The value of the Indian rupee is tied to a basket of currencies and is classifed by the International Monetary Fund as operating under a "managed float". It has been steadily depreciating with respect to the dollar as indicated below (121):

Year	Exchange Rate (Rupees per dollar)
1970	7.567
1971	7.524
1972	7.595
1973	7.742
1974	8.102
1975	8.376
1976	8.960
1977	8.739
1978	8.193
1979	8.126
1980	7.863
1981	8.659
1982	9.455
1983	10.099
1984	11.363
1985	12.048[1]

Gross Cropped Area:

Gross cropped area is the sum of the physical amount of land under crops (or net cropped area) and the area that is cultivated more than once during the same crop year.

[1]Exchange rate as of third quarter, 1985.

Production data on vegetable oil:

Production data on various vegetable oils are estimates only. They are made by subtracting certain seed, feed, and wastage allowances from oilseed production, and applying specified oil recovery rates to the remainder. Oil recovery rates (as percent of seeds or kernels crushed) are as follows (111):

	Percent
Groundnut	40
Rapeseed-Mustard	33
Sesame	40

Other allowances are not available.

Units:

All units in this study are metric.

CHAPTER I
OILSEEDS IN INDIA: STAGNATING PRODUCTION, GROWING DEMAND

Much of the interest in the Indian oilseeds economy has stemmed from India's large imports of vegetable oils recently. From being an importer of cereals and an exporter of vegetable oils in the 1960s, India has become an occasional and minor exporter of cereals, and a regular and major importer of vegetable oils. It currently imports over one million tons of vegetable oil at a cost of nearly seven billion rupees annually. This trade shift has occurred because the green revolution (which primarily benefited the cereals) did not extend to the oilseeds, and per capita production of oilseeds has declined. On the other hand, the demand for vegetable oils is expected to double by the year 2000 and, therefore, there is immediate need for augmenting their availability.

Performance of the Indian Oilseeds Economy

Oilseeds are important in the Indian agricultural economy. They constitute the second most important crop group (after cereals), occupying 11 percent of the total cropped area and contributing nearly 9 percent to the value of agricultural output. During 1981/82-1983/84, they were grown on nearly 18 million hectares, yielding 12 million tons of oilseeds or approximately 3.3 million tons of vegetable oil (116; 118).[1]

The focus on annual oilseeds in this study is confined to groundnut, rapeseed-mustard, and sesame, because although several different oilseeds are cultivated in the country, these three account for nearly 80 percent of the area, 90 percent of the production of oilseeds, and over 70 percent of total vegetable oil production (computed from 116 and Appendix IV.4):

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[1] The production of vegetable oils refers to groundnut, rapeseed-mustard, sesame, safflower, nigerseed, cottonseed, and coconut oils, which are edible, as well as linseed and castor oils, which are nonedible. The area and production of oilseeds includes all of the above with the exception of coconut and cottonseed: this is because the production of coconut is measured in millions of nuts and therefore cannot be aggregated with that of the other oilseeds; and cottonseed is excluded because separate data on the amount of cottonseed production used in the manufacture of vegetable oil are not available. Most of cottonseed production is utilized as cattle feed.

	Percent of		
	Oilseed		Oil
	Area	Production	Production
	(Average of 1981/82-1983/84)		
Groundnut	42	63	45
Rapeseed-Mustard	22	20	22
Sesame	14	5	5
Total	78	88	72

In addition, India accounts for a significant portion of the total area under and production of these three oilseeds worldwide (computed from 98):

	Percent of the World's	
	Area	Production
	(Average of 1982-1984)	
Groundnut	40	34
Rapeseed	31	16
Sesame	35	28

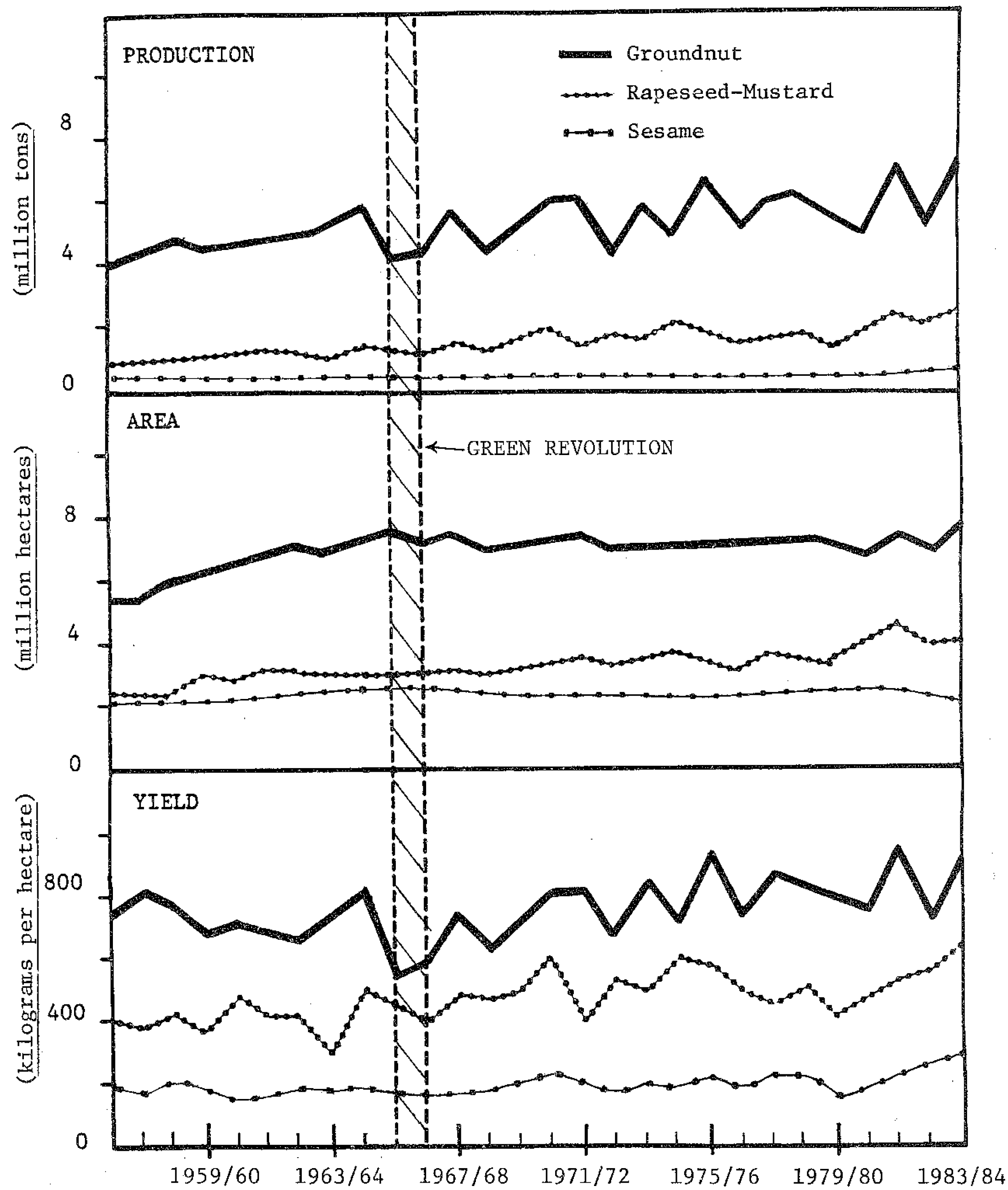
The performance of the oilseeds in India has not been spectacular, as is evident from the trends in the production, area, and yield of these three crops over the past three decades plotted in Figure 1.1. The production of groundnut and rapeseed-mustard increased slightly over the 30-year period, while that of sesame showed little change. The area under all three crops went up prior to the green revolution, and while that of rapeseed-mustard continued to rise subsequently, the area under the remaining two crops leveled off. Yields of all three crops remained virtually unchanged except during the early 1980s, when there was an upward trend.

This lacklustre performance of the oilseeds is mainly because the green revolution completely bypassed the oilseeds, and offers a stark comparison to the performance of the cereals which have benefited from the new technology. Thus, as presented in Figure 1.2, while cereal production kept up with population growth, that of oilseeds did not.

Anticipated Demand

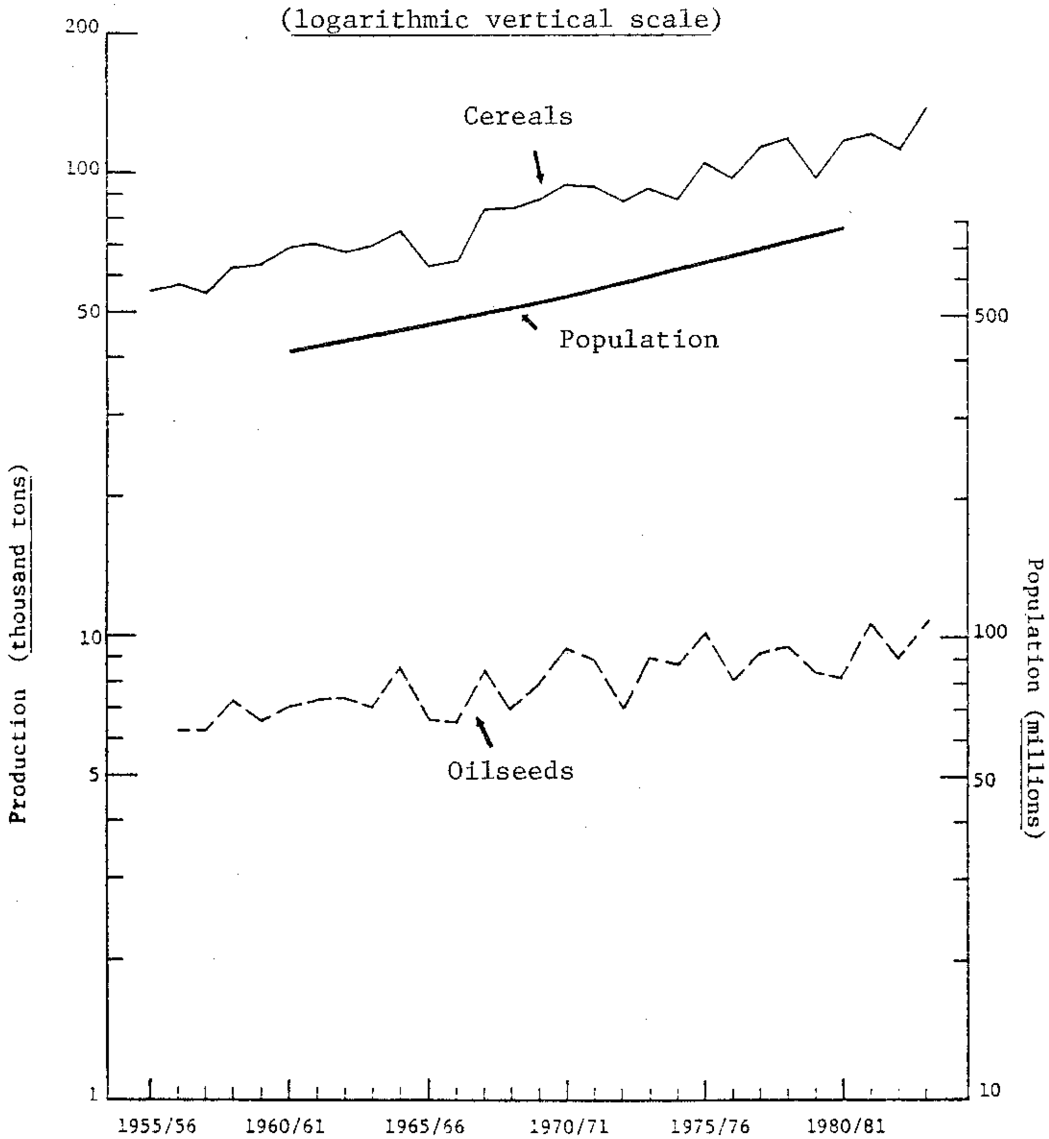
The demand for vegetable oils in India is driven primarily by that of edible oils: domestic utilization of oilseed cakes and meals is low and exports are restricted. In fact, oilseeds in India are produced in order to satisfy vegetable oil demand, rather than oilcake demand as is the case in the United States with soybean. Only a minor portion of oilseed production is used as seed or for snacks (in the case of groundnut) (16).

FIGURE 1.1. INDIA: PRODUCTION, AREA AND YIELD OF PRINCIPAL OILSEEDS, 1956/57-1983/84*



*Source: Appendices IV.1, IV.2, IV.3.

FIGURE 1.2. INDIA: POPULATION GROWTH AND PRODUCTION OF OILSEEDS AND CEREALS COMPARED, 1955/56-1983/84*



NOTE: Oilseed production refers to both edible and nonedible oilseeds.

*Sources: Population data from P. Padmanabha, Census of India 1981: Key Population Statistics (Centre for Monitoring the Indian Economy, Bombay, 1983); oilseeds data from Ministry of Agriculture and Irrigation, Directorate of Oilseeds Development, Oilseeds Statistics, (State-Wise Area, Production and Yield), Twenty-five Years at a Glance, 1955/56-to 1980/81 (Hyderabad, Andhra Pradesh, 1982); cereals data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, 1984).

Edible oils are used mainly as cooking media and constitute an essential component of the diet, being a major source of fatty acids. Their role as a protein source has also been recognized recently (30). Vanaspati, or hydrogenated vegetable oil (a composite of several oils), is also an important cooking medium.[2] Expenditures on edible oils rank fourth in urban and rural food budgets: approximately five percent of rural and seven percent of urban food expenditures are devoted to edible oils (123). Nonedible oils are used in the manufacture of paints, varnishes and soaps, but constitute only 10 percent of all uses of vegetable oils (16). The current utilization of edible and nonedible oils averages 5 to 7 kilograms per capita, which is low compared to the world average of 10 kilograms per capita (48, p. 69).

The demand for an individual edible oil is directly related to income and population size, and is inversely related to its own price and the availability of substitutes. The various edible oils are substitutable to a large extent in use, although regional taste preferences do exist. For example, groundnut oil is popular in Gujarat, coconut oil in Kerala, while mustard oil is preferred in Uttar Pradesh and West Bengal. Nonedible oil demand depends on additional factors: oil used in soap manufacture is also a function of the availability of synthetic detergents, and the demand for oils used in paints and varnishes depends on the amount of construction activity during that year and the obtainability of synthetic paints (16, pp. 98-114).

One way to estimate the aggregate future demand for edible oils, assuming relative prices are constant, is to apply the rate of growth in demand to an appropriate base consumption level. The demand growth rate is computed as follows:

$$d = (1+p)(1+i.e)$$

where d is the growth rate in demand
p is the percent growth in population
i is the percent growth in income
e is the income elasticity of demand

Since the demand projections are likely to be only as accurate as the parameters used in making them, it is best to develop a set of low and high demand scenarios, so as to delineate a range within which actual demand is likely to lie.

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[2] Ghee (clarified butter), is also used for cooking but is not considered in this study: its use is limited and moreover declining in per capita terms consequent to the "white" (milk) revolution which resulted in lower spoilage rates and therefore greater quantities of milk being used for direct consumption.

Population

The growth rate of population in India is starting to decline, mainly because of decreases in the crude birth rate, and stood at 2.2 percent per annum as of the 1981 census (Figure 1.3). At that time, there were 685 million people in India (126). It is reasonable to expect that with economic development, the crude birth rate will continue to decline. According to projections made by the United Nations, if decreases in the fertility rate are less than expected, then population would stand at 997 million in 2000 and 1.14 billion in 2010. On the other hand, if family planning efforts are a great success, then population would be 927 million in 2000 and 1.02 billion in 2010 (127, p. 302). These figures form the basis of the growth rates used in this analysis.

Income

Per capita income in India has grown at approximately 1.5 percent since the green revolution,[3] a period characterized by less-than-capacity industrial production. Therefore, a pessimistic income projection would be that the 1.5 percent rate of growth in per capita income will persist. A more optimistic projection would be to say that per capita income will grow at a somewhat arbitrary two percent. Data limitations preclude the consideration of changes in the savings rate which are assumed constant.

Income Elasticity of Demand

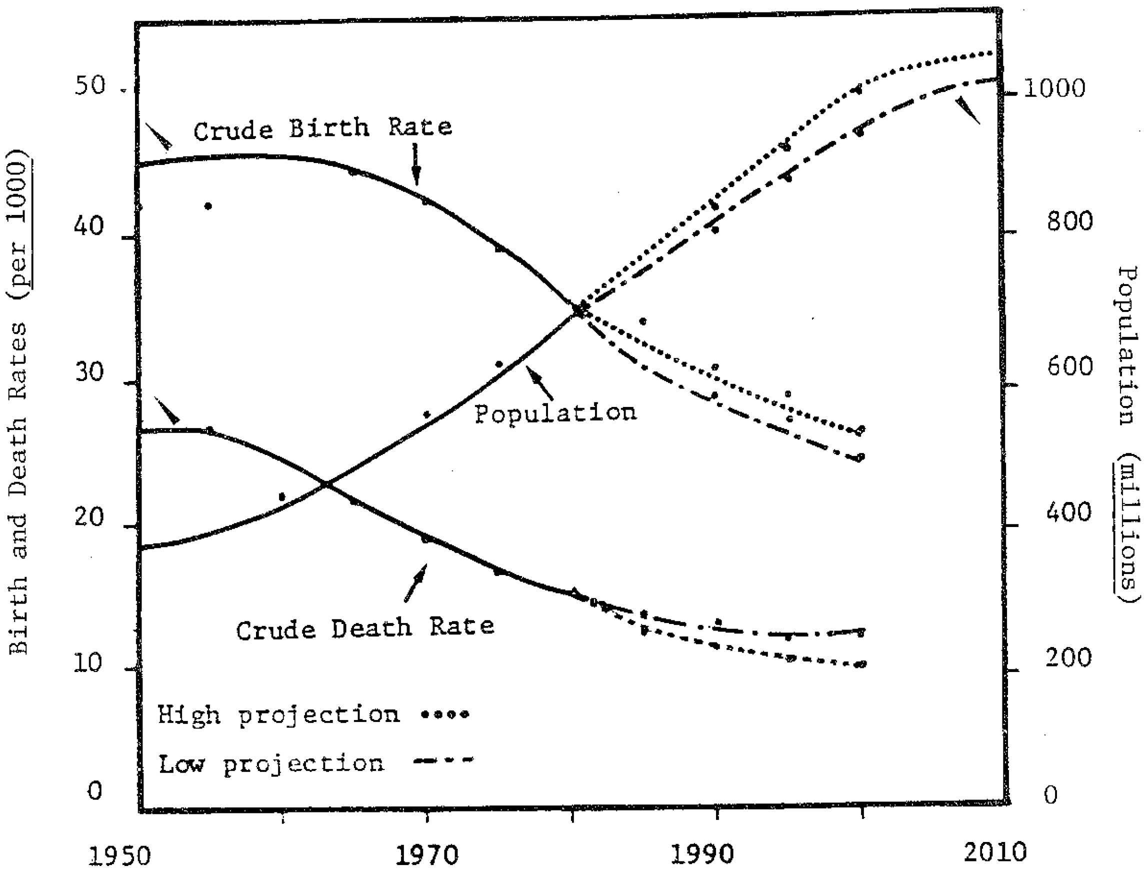
In order to project demand, it is necessary not only to know the growth in population and income, but also the percent of any increased income that is spent on a good. This percentage is known as the income elasticity of demand and when total expenditures are used as proxy for income, it is formally defined as the proportionate change in the amount spent on a good given a unit change in total expenditures, all else remaining equal. For edible oils in India, various estimates (based on cross-section data) put the expenditure elasticity of demand at close to one (7, p. 34; 16, p. 127; 48, p. 13):

Source	Year	Estimated Expenditure Elasticity	
		Rural	Urban
National Commission on Agriculture	1970/71	0.88	0.98
Pavaskar[a]	1970/71	----0.97----	
Harrison, Hitchings & Wall	1973/74	1.00	1.01

a: Excludes vanaspati

[3] Refers to per annum compound rate of growth in real net national product (in 1970/71 prices) from 1966/67-1968/69 to 1981/82-1983/84 (121).

FIGURE 1.3. INDIA: POPULATION GROWTH, CRUDE BIRTH RATE AND CRUDE DEATH RATE, 1950-2010*



*Source: United Nations, Demographic Indicators of Countries: Estimates and Projections as Assessed in 1980 (New York, 1982).

In other words, the per capita demand for vegetable oils grows approximately at the same rate as per capita disposable income. This analysis therefore uses a uniform expenditure elasticity of unity in both the low and high demand cases.

Policy makers do not usually plan for inflation or changes in the competitive position of the relevant commodities; therefore it is reasonable to assume that real and relative prices will be constant. Furthermore, it is convenient to presume that nonedible oils will continue to constitute 10 percent of total utilization; that is, individual determinants of nonedible oil demand are not explicitly taken into account here. Total vegetable oil demand is derived by simply dividing projected edible oil demand by 0.9. The results are set out below (and explained in detail in Table 1.1):

	Demand in 2000 (million tons)	Demand in 2010 (million tons)
Low Projection	8.0	10.2
High Projection	9.7	13.4

The projections for 2000 correspond quite closely to those made by the National Commission on Agriculture in 1976 and by Harrison, Hitchings, and Wall in 1981, as indicated in Table 1.1. The major implication of these projections is that oilseed production will have to nearly double by 2000 if demand is to be met entirely through domestic sources. Moreover, if area and processing technology are held constant, this means that yields of oilseeds will have to double over the next 15 years, a feat accomplished so far only by wheat in India.

The Changed Import Structure

Declining per capita production of oilseeds and vegetable oils juxtaposed with increasing per capita and total demand for vegetable oils has resulted in India's large imports of vegetable oils of late. Until the mid-1960s, India exported vegetable oil, and imported only small quantities (ranging between 30,000 and 100,000 tons) until the late 1970s, when demand pressures and the resultant skyrocketing of vegetable oil prices forced the Government of India to liberalize its import policy so as to ensure availabilities to the economically weaker sections of the population. The country at this time also enjoyed favorable foreign exchange reserves and could afford to import oils. Nearly 400,000 tons of vegetable oil were imported in 1976/77, constituting a 400-percent jump over levels in previous years, and imports in many subsequent years have been well over one million tons (Figure 1.4A). The value of imports has gone up correspondingly (Figure 1.4B), averaging over Rs. seven billion during the three years ending in 1984, comprising approximately half the value of agricultural imports. This expenditure constitutes a drain on India's foreign exchange reserves,

TABLE 1.1. INDIA. PROJECTIONS OF DEMAND FOR VEGETABLE OILS TO 2000 AND 2010*

(million tons)

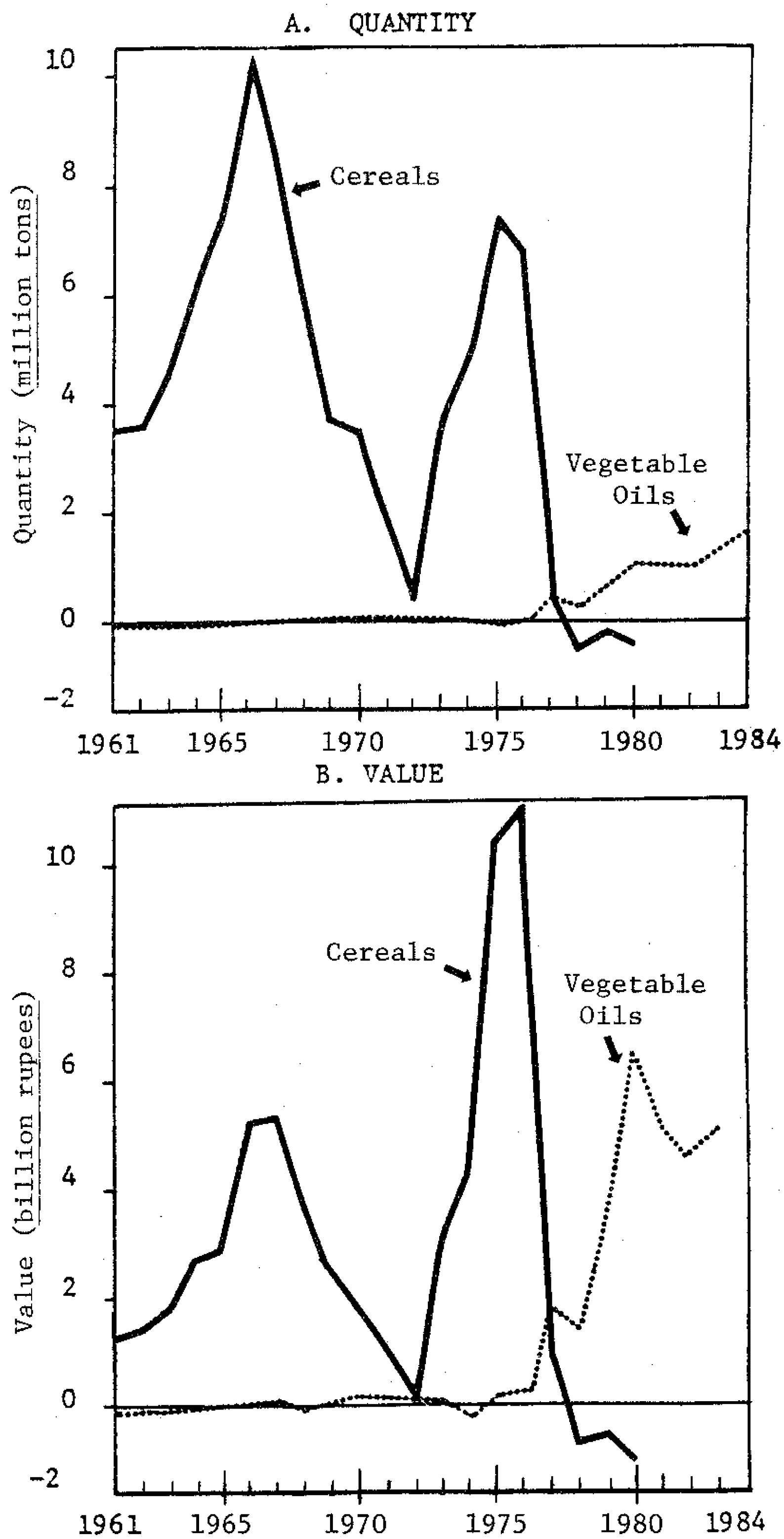
Source		Demand in: 2000	2010
National Commission on Agriculture	Low[a]	8.3	N.A.
	High[b]	10.2	N.A.
Harrison, Hitchings and Wall	Low[c]	7.9	N.A.
	High[d]	9.2	N.A.
Author[e]	Low	8.0[f]	10.2[h]
	High	9.7[g]	13.4[i]

Assumptions:

a. Population in 2000 is 935 million and growth in per capita expenditures is 1 percent per annum. Includes demand for vanaspati.
b. Population in 2000 is 935 million and growth in per capita expenditures is 2.9 percent per annum. Includes demand for vanaspati.
c. Growth in total expenditures is 3.5 percent per annum.
d. Growth in total expenditures is 5.0 percent per annum.
e. Base utilization of edible oils (consisting of groundnut, rapeseed-mustard, sesame, safflower, nigerseed, coconut, soybean and cottonseed oils) in 1978-1980 is 3.78 million tons. Total vegetable oil demand is derived as edible oil demand divided by 0.9.
f. Population growth rate is 1.61 percent per annum and that of income is 1.5 percent per annum.
g. Population growth rate is 2.00 percent per annum and that of income is 2.0 percent per annum.
h. Population growth rate is 1.38 percent per annum and that of income is 1.5 percent per annum.
i. Population growth rate is 1.77 percent per annum and that of income is 2.0 percent per annum.

*Sources: Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture, Part III, Demand and Supply (Delhi, 1976), p. 45; and James Harrison, Jon Hitchings and John Wall, India: Demand and Supply Prospects for Agriculture (World Bank Staff Working Paper Number 500, Washington, D.C., 1981), p. 74.

FIGURE 1.4. INDIA: IMPORTS OF CEREALS AND VEGETABLE OILS, 1961-1984*



*Source: Appendix IV.5.

and has replaced cereals expenditure as the second largest item on the import bill after petroleum (48, p. 69).

In addition to the increase in the quantity of imports, the composition of vegetable oil imports has diversified (Figure 1.5). Previously, soybean oil and palm oil constituted nearly all of India's imports of vegetable oil. Since the mid-1970s, however, rapeseed oil, groundnut oil and to a lesser extent, sunflower and linseed oils are also being imported, although soybean oil (from the United States and Brazil) and palm oil (from Malaysia) continue to dominate imports. The dependence on any one oil, nevertheless, has reduced considerably.

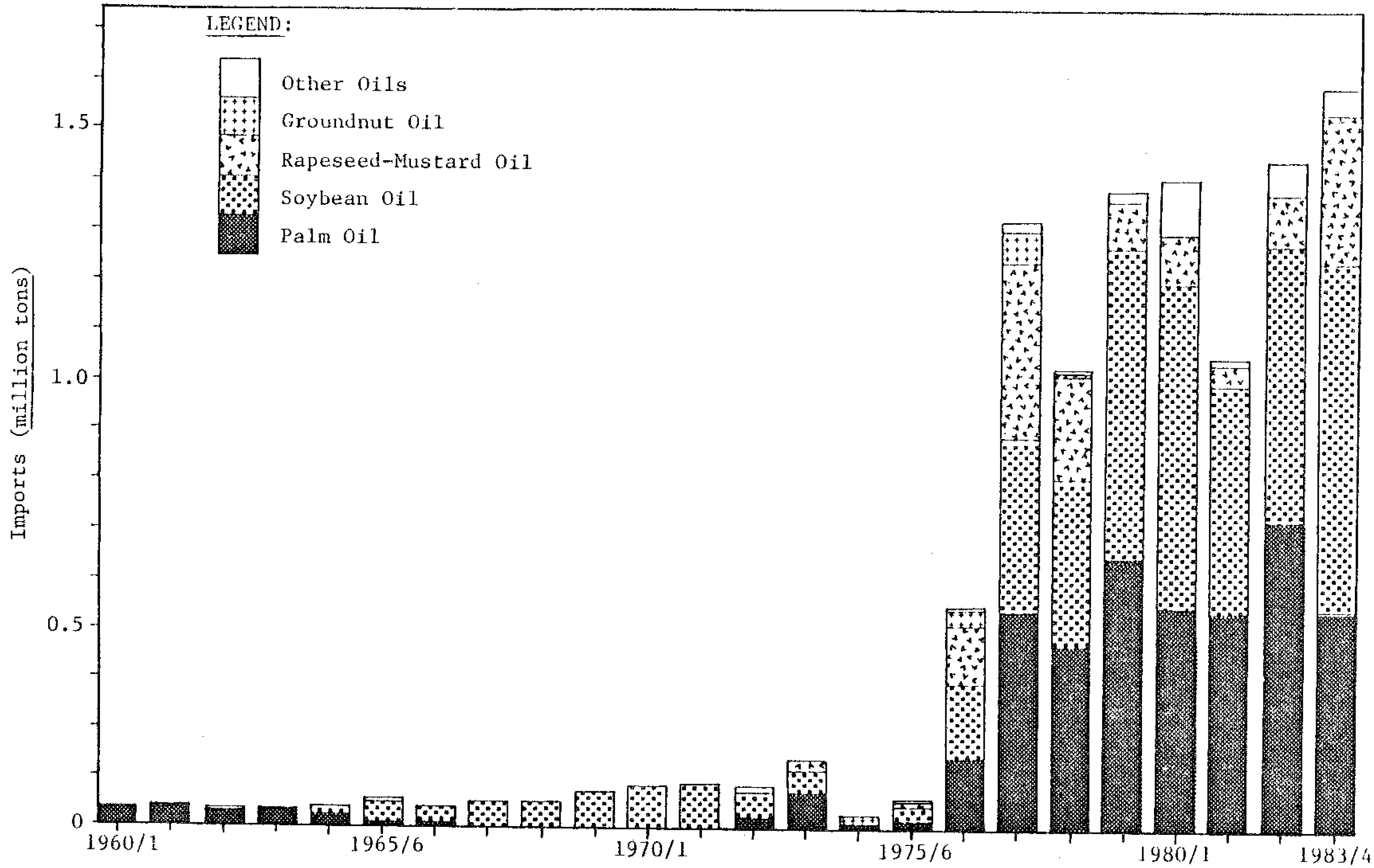
Until the late 1970s, vegetable oils could be imported free of customs duty. However, the Government of India felt that the benefits from such a policy "were not fully accruing to the consumers" (42, p. 10) and that private traders were making large profits by maximizing the difference between the landed price of imported oils and the domestic price through hoarding. Consequently in 1978 it channeled virtually all imports of vegetable oils through the State Trading Corporation of India. Also, since July 1981, the State Trading Corporation of India is being levied only a five percent *ad valorem* tax on its imports, while all other importers of vegetable oil are being charged a massive 150 percent *ad valorem* tax. This channelization has enabled the State Trading Corporation of India to monitor the international market effectively, and immediately use any downward price change to its advantage (42, pp. 10-11; 39, p. 1952).

The Objectives and Organization of This Study

There is immediate need for augmenting availabilities of vegetable oils. Supply projections for the annual oilseeds made in this study indicate that if past trends persist, then even with a low rate of growth in demand, demand will continue to outstrip supply. One option is to continue importing vegetable oils, but this requires the commitment of scarce foreign exchange. The other alternative is to encourage domestic production of oilseeds through extension of area or increase in yields. However, for the *annual* oilseeds, increases in area in a land-scarce country such as India are likely to occur at the expense of the cereals, and yield increases in the absence of high-yielding varieties of oilseeds are unlikely. On the other hand, the *perennial* (tree) oilseeds do not compete for land directly with the foodgrains and have the advantage that they yield the highest quantities of oil per unit land area.

The objectives of this study are: first, to detail the impact of the green revolution on the oilseeds economy of India (Chapter II); second, to determine prospects for two tree sources of vegetable oil, namely, coconuts (Chapter III) and oil palm (Chapter IV); and finally, to discuss means of augmenting availabilities by examining the trade-offs between imports and domestic production (Chapter V). Most of the necessary data were collected from various government and nongovernment agencies in India during the summer of 1983.

FIGURE 1.5. INDIA: VEGETABLE OIL IMPORTS, BY TYPE, 1960/61-1983/84*



*Source: Appendix IV.6.

CHAPTER II
THE IMPACT OF THE GRAIN REVOLUTION ON THE OILSEEDS ECONOMY OF INDIA

The green revolution in India, which entailed the adoption of high-yielding varieties of seeds, together with an appropriate combination of fertilizer application and water and pest management techniques, has, in fact, been a grain revolution. Its impact on Indian agriculture has been differential; in particular, while the cereals have benefited from it, the oilseeds have not.

Oilseeds in India usually compete with the foodgrain crops for land. The green revolution, and the associated yield augmenting technology, where successful, have made cereal production more attractive, and because no such technology is available for the oilseeds, increasing proportions of land are being devoted to the foodgrain crops at the expense of the oilseeds.

In this chapter, the impact of the green revolution on the oilseeds economy of India is detailed through a comparison of the trends in the proportion of gross cropped area devoted to the oilseeds and the corresponding trends in their competing cereal crops. The discussion indicates that the prospects for the traditional sources of vegetable oil are limited because of a variety of technological and institutional factors, as are those for the nontraditional sources, namely, soybean, sunflower, and rice bran oils. Demand and supply projections suggest that if past trends persist, India will need to augment its vegetable oil supplies by 2.8 to 4.5 million tons by the year 2000, and 3.4 to 6.6 million tons by 2010.

The Green Revolution[1]

Prior to the green revolution, several programs were launched with a view to attaining self-sufficiency in foodgrains. These programs, in a sense, brought about the preconditions which later ensured the success of the green revolution. Notable among them were the "Grow More Food" campaign (1943), the "Community Development Programme" (1952), the "Intensive Agricultural District Programme" (1961), and the "Intensive Agricultural Area Programme" (1964) (21, p. 19). However, on the eve of the green revolution, after two severe drought years, "the food situation ... was, to say the least, alarming" (1, p.32).

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[1] This section draws on C.H. Hanumantha Rao (20), J.S. Sarma (21), and Biplab Dasgupta (1).

Production was not increasing fast enough to keep up with population growth, imports of food were high and showed no prospects of coming down, and food prices were increasing. Most of the production increases up to this point had come through the expansion of area, but there was not much new land that could be brought under cultivation.

Finally, in 1966/67, a "new strategy" for agricultural development was put into effect. It essentially entailed introducing high-yielding varieties of cereals, encouraging irrigation, increasing the availability and use of scientific inputs, arranging access to credit and assuring remunerative prices to farmers. Under the new program, high-yielding varieties of wheat (from CIMMYT in Mexico), rice (from the International Rice Research Institute in the Philippines) and maize and millet (bred in India) were introduced.

The high-yielding varieties of cereals were a tremendous success. They were insensitive to differences in day length, early maturing, and responded well in terms of grain yield to fertilizer application. From the time that the CIMMYT varieties were introduced, wheat production doubled by 1972/73 to 25 million tons and nearly quadrupled by 1983/84 to 40 million tons. Similarly, rice production increased from approximately 30 million tons in the mid-1960s to 53 million tons by the early 1980s (<u>116</u>). As a result, total food production continued to rise and kept up with population growth.[2] India attained near self-sufficiency in foodgrains by the late 1970s and had even built up a stock of nearly 20 million tons.

The green revolution changed the structure of agricultural production in India. There was an increase in total cropped area brought about through the extension of irrigation and the greater use of shorter duration varieties which meant that more than one crop could be grown during the same crop year. The importance of <u>rabi</u> crops increased consequent to the green revolution because of the increase in the production of wheat which is grown during the rabi season. Thus, the cropping calender underwent a basic change. Labor use also increased because of the rise in the number of crops that could be grown during the year.

Apart from these aggregate changes, the impact of the green revolution has been localized. Interregional disparities widened because the green revolution primarily benefited areas that had assured water supplies; that is, those that had good irrigation systems or adequate rainfall. States such as Punjab, Haryana, and Uttar Pradesh, and to a lesser extent Andhra Pradesh and Tamil Nadu accounted for most of the increase in foodgrain production in the post-high-yielding

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[2] C.H. Hanumantha Rao believes however, that "even without the green revolution, the growth rate [of foodgrain production] would have been maintained...." because the increasing population would have put upward pressure on prices and induced the farmer to produce more and the government to invest in irrigation and fertilizers (<u>20</u>).

varieties period (116). Interpersonal disparities widened because the large and medium farmers with better access to credit facilities were able to take advantage of the new technology earlier than the smaller farmers.[3] Finally, in terms of crops, apart from the cereals, most other crops did not benefit from the high-yielding variety technology. Wheat is the classical success story. In the mid-1960s, wheat constituted 15 percent of all of cereals production. By the early 1980s, its share had increased to 33 percent (116). In addition, high-yielding varieties of rice became popular in Andhra Pradesh and Tamil Nadu. Bajra (pearl millet) was successful mainly in Gujarat.

The oilseeds were largely left out of the green revolution. No counterparts of the high-yielding varieties of cereals were developed for the oilseeds. The grain revolution acted to increase the relative profitability of the cereals vis-à-vis the competing oilseed crops, because, as Dr. C.H. Hanumantha Rao put it, "the High Yielding Varieties, typically, increase the profit per unit of the output, i.e., they lead to a reduction in the unit costs of production [as a proportion of output]...." (20, p. 75). Therefore, while cereal production kept up with population growth, oilseed production did not.

The Impact on the Oilseeds

Land allocation decisions are governed by changes in the relative profitabilities of the alternative crops: considerations such as subsistence needs, resource base, costs, prices, yields, riskiness of production, and the availability of assured markets are all taken into account by the farmer when evaluating the relative gains of competing crops, and the resulting decision is reflected in the area actually planted. One can therefore detail the impact of the grain revolution on the oilseed economy by examining trends in the gross cropped area under the oilseeds as compared to the corresponding trends in the competing crops. To do this, it is better to use percent figures so as to account for the effect of increases in total cultivated area. In what follows, linear trend lines for each crop during the pre- and post-grain revolution periods are fitted to support conclusions that

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[3] Recognizing that the scale neutral technology was not necessarily resource neutral, special programs such as the Small Farmers Development Agencies and the Marginal Farmers and Agricultural Labourers' Development Agencies were set up to allow economically weaker sections of the population to participate in the benefits of the new technology. These programs were, by and large, not very successful because of ambiguities in the definitions of "small" and "marginal" farmers and also because concessional credit targeted to these farmers eventually found its way to the large farmers.

are based on visual inspection.[4] In addition, in order to get a very rough idea of the success of technology adoption in these crops, information on the adoption of high-yielding varieties and area irrigated, where relevant, is also included.

Area Trends in Major Producing States

Groundnut

Groundnut is grown primarily as a kharif crop. It is grown on marginal lands under unirrigated conditions, and usually competes with jowar, bajra, and paddy, all of which are predominantly kharif crops (Figure 2.1). Five states account for almost 90 percent of the area and production of groundnut in India (computed from 116):

State	Percent of India's Area	Percent of India's Production
	(Average of 1981/82-1983/84)	
Gujarat	29	27
Andhra Pradesh	21	22
Tamil Nadu	14	16
Karnataka	12	10
Maharashtra	11	11
Total	87	86

In Gujarat, groundnut competes primarily with bajra. Prior to the mid-1960s, groundnut gained area at the expense of bajra; however, following the introduction of hybrid bajra in the mid-1960s, groundnut lost its relative share in gross cropped area until the mid-1970s. Since then, there has been an upward trend in groundnut acreage accompanied by a decline in bajra's area. Hybrid bajra has been particularly successful in Gujarat. Nearly seventy percent of the area under bajra is under high-yielding varieties as compared to the all-India average of 23 percent. Similarly nine percent of the bajra area in Gujarat is irrigated, while at the all-India level, the corresponding figure is five percent. There are no high-yielding varieties of groundnut[5] and only two percent of the groundnut in Gujarat is irrigated, compared to eight percent for India as a whole.

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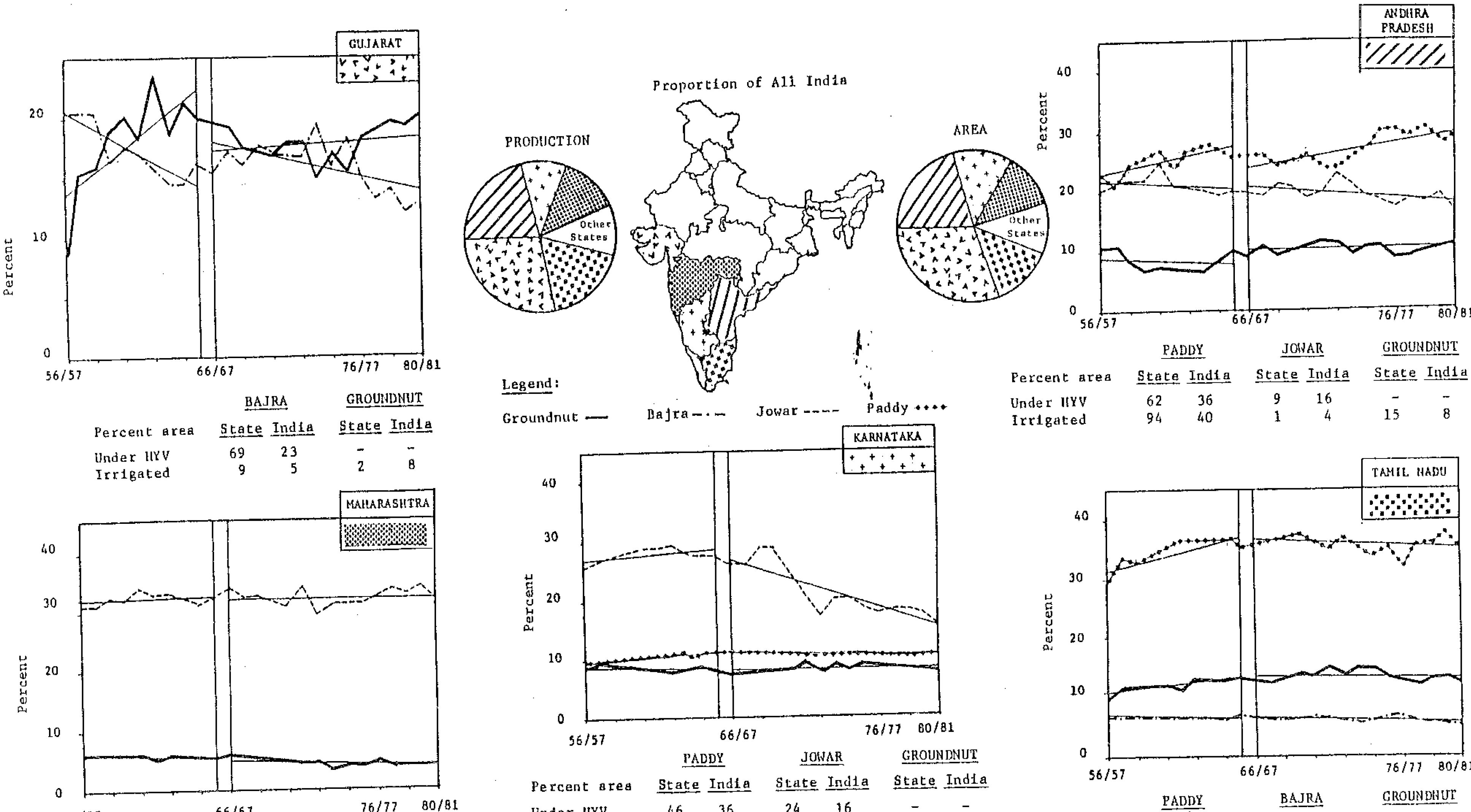
[4] The time periods are: for the pre-grain revolution period, 1956/57 to 1965/66, and for the post-grain revolution period, 1966/67 to 1980/81. It has been frequently argued that the two drought years, 1965/66 and 1966/67 should be excluded from the consideration of trends, because these were freak years, and as such, should be treated as outliers. In this instance, however, their inclusion did not, for the most part, alter the signs of the slopes of the trend lines.

[5] While there are no "high-yielding varieties", "improved" varieties exist for all the oilseeds, however, they are not popular and there has been no significant yield increase since their introduction.

FIGURE 2.1. INDIA: TRENDS IN PERCENT OF GROSS CROPPED AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY STATE, 1956/57-1980/81*



GUJARAT

Percent area	BAJRA State	BAJRA India	GROUNDNUT State	GROUNDNUT India
Under HYV	69	23	-	-
Irrigated	9	5	2	8

MAHARASHTRA

Percent area	JOWAR State	JOWAR India	GROUNDNUT State	GROUNDNUT India
under HYV	21	16	-	-
Irrigated	5	4	4	8

KARNATAKA

Percent area	PADDY State	PADDY India	JOWAR State	JOWAR India	GROUNDNUT State	GROUNDNUT India
Under HYV	46	36	24	16	-	-
Irrigated	60	40	6	4	6	8

ANDHRA PRADESH

Percent area	PADDY State	PADDY India	JOWAR State	JOWAR India	GROUNDNUT State	GROUNDNUT India
Under HYV	62	36	9	16	-	-
Irrigated	94	40	1	4	15	8

TAMIL NADU

Percent area	PADDY State	PADDY India	BAJRA State	BAJRA India	GROUNDNUT State	GROUNDNUT India
Under HYV	85	36	33	23	-	-
Irrigated	91	40	9	5	21	8

*Source: Appendix I.1, and Fertiliser Association of India, Fertiliser Statistics (Delhi, various issues).

In Andhra Pradesh, jowar and paddy compete with groundnut. From the late 1950s to the mid-1960s, paddy area increased at the expense of jowar and groundnut which exhibited a marginal decline. Following the grain revolution, area under paddy continued to increase and that under jowar fell while groundnut area remained the same. Jowar and groundnut continue to compete for land because for a given year, increases in jowar area are usually accompanied by a decrease in groundnut area and vice-versa. The introduction of high-yielding varieties of rice was quite successful in Andhra Pradesh. Over 60 percent of the area under paddy is planted to high-yielding varieties; in addition, more than 90 percent of rice is irrigated--both these figures are nearly twice the national averages. For jowar, only nine percent of the area is under high-yielding varieties and little over one percent is irrigated. The corresponding national figures are 16 percent and 4 percent, respectively. For groundnut, however, the proportion of irrigated area is higher than the national average.

In Tamil Nadu, area under groundnut increased slightly from the late 1950s until the mid-1960s as did that under paddy, accompanied by a slight decline in bajra. Subsequent to the grain revolution, paddy and groundnut areas remained stable while that under jowar declined steadily. The area under high-yielding variety bajra and that under irrigation in Tamil Nadu are higher than those at the all-India level. Similarly, high-yielding varieties of paddy have been adopted on a large scale in Tamil Nadu--85 percent of paddy area is planted to high-yielding varieties and over 90 percent is irrigated, more than twice the corresponding national averages, but, curiously, these factors have not been reflected in any increase in the relative area under these two crops. The implied loss in area under kharif groundnut has been more than counterbalanced by the increase in the area under summer groundnut which is grown under irrigated conditions, thus resulting in stable groundnut area even after the introduction of the new technology.

In Karnataka, prior to the grain revolution, area under groundnut remained stable while area under paddy and jowar, the major competitors, increased marginally. Subsequent to the green revolution, the area under groundnut and paddy was stable; however, jowar exhibited a steady decline. This is despite the fact that for the cereals, the state averages for the percent area under high-yielding varieties and under irrigation are higher than the all-India averages. Part of this decline in jowar area can be explained by the increase in the area under maize and other kharif crops.

Finally in Maharashtra, groundnut area was relatively stable prior to the mid-1960s as was that of jowar; since then, groundnut declined while area under jowar remained constant. As indicated by the statistics relating to the adoption of new technology, the area under high-yielding varieties of jowar is higher than the national average and the same is true of irrigated area under jowar. However, the percent of groundnut area irrigated in Maharashtra is nearly half the national average.

The production of groundnut within a state is extremely localized. Soil characteristics vary widely within the state and not all cereal producing areas are suited to groundnut. Therefore, although the analyses of state level trends are in themselves instructive, a more meaningful comparison can be made at the district level, since soil characteristics of a district can be assumed to be more homogeneous than for the state as a whole. Such a comparison would act to supplement and support findings made at the state level.

The top four producing districts of Gujarat (the major producer of groundnut) are: Junagadh, Rajkot, Jamnagar, and Amreli (96). These four districts together account for nearly three-fourths of the area and production of groundnut in the state. Relevant data for the years 1961/62 to 1973/74 are presented in Figure 2.2.[6]

Prior to the grain revolution, area under bajra was relatively stable in all four districts, while that under groundnut was increasing in Amreli and Junagadh, and stable in Jamnagar and Rajkot.[7] After the grain revolution, however, groundnut acreage declined slightly in all four districts while that under bajra increased. The increase in bajra area apparently leveled off by the early 1970s. Thus, district level trends tend to support state level findings.

Cost of cultivation surveys are carried out every year for major crops in producing states for the use of the Agricultural Prices Commission, the agency responsible for recommending support and procurement prices. Limited information from these surveys is available for Gujarat and Tamil Nadu. The data are not strictly comparable across crops because within the state the sample for, say, groundnut may differ from that for paddy. With the above caveat in mind, illustrative data for the mid- to late 1970s for groundnut and bajra in Gujarat, and, groundnut and paddy in Tamil Nadu, are presented in Table 2.1.

The data are generally consistent with the observed trends in area. In Gujarat, bajra generated higher income per hectare than groundnut in three of four years during the mid- to late 1970s. Similarly, in Tamil Nadu, paddy generated higher returns per hectare than groundnut in four of five years. What is curious, however, is that groundnut costs exceeded returns in three of five years in Tamil Nadu, a result which is not consistent with the observed increases in

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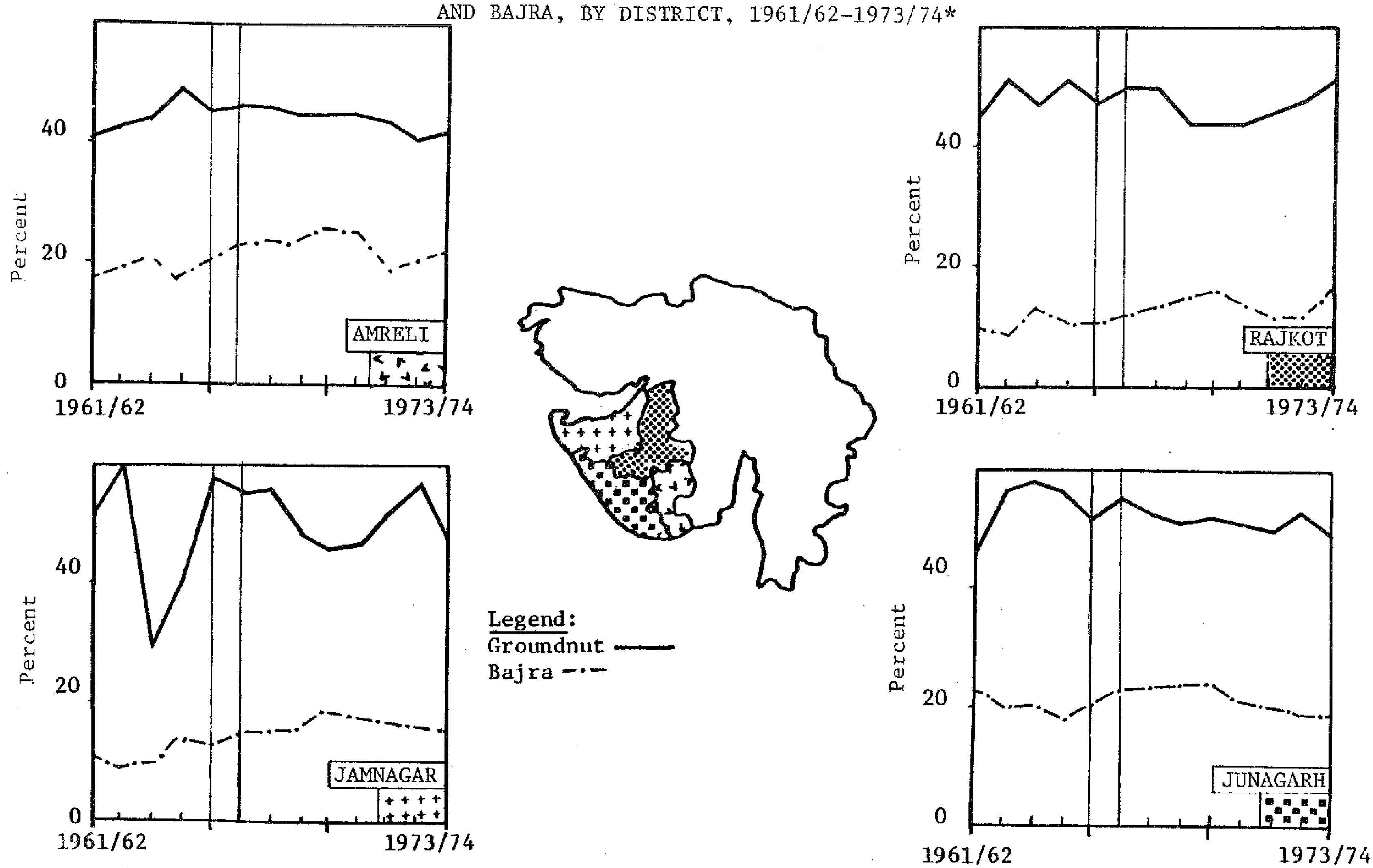
[6] 1973/74 is the latest year for which information on gross cropped area by district has been published.

[7] In Jamnagar, area dropped sharply by over 20 percentage points in two years, 1963/64 and 1964/65, but since these are obviously outliers, they have been discounted.

FIGURE 2.2. GUJARAT: TRENDS IN PERCENT OF GROSS CROPPED AREA UNDER GROUNDNUT AND BAJRA, BY DISTRICT, 1961/62-1973/74*



*Source: Appendix I.2.

TABLE 2.1. COSTS OF CULTIVATION OF GROUNDNUT AND ITS COMPETING CROPS*

(Rs. per hectare)

	GUJARAT					
	Groundnut			Bajra		
	Cost	Revenue	Income	Cost	Revenue	Income
1973/74	1,349	1,698	349	813	1,219	406
1974/75	1,254	1,309	55	1,007	1,378	371
1975/76	1,463	2,170	708	975	1,162	187
1978/79	1,735	1,906	170	1,583	2,034	452

	TAMIL NADU					
	Groundnut			Bajra		
	Cost	Revenue	Income	Cost	Revenue	Income
1972/73	1,102	1,330	228	1,723	1,623	(-)100
1973/74	1,857	2,267	410	1,754	2,198	443
1974/75	1,793	1,565	(-)228	2,489	3,919	1,430
1975/76	1,787	1,729	(-) 59	1,335	3,517	2,164
1978/79	2,090	2,021	(-) 69	3,136	3,685	549

Notes:

a. Revenue includes the values of the main crop and the value of by-products.

b. Costs include values of: hired labor, family labor, bullocks, machines, seed (both owned and purchased), manure and fertilizer, insecticides, pesticides, depreciation, irrigation charges, land and other taxes, interest on working capital, interest on owned capital, owned land, and rent for leased land.

*Source: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agriculture in Brief (Delhi, 1983).

area under groundnut in the state. It must also be kept in mind that the costs of cultivation used above include an imputed value for family labor: the actual cash costs incurred by the farmer are lower than what the figures show, so that actual cash income would be positive.

Rapeseed-mustard

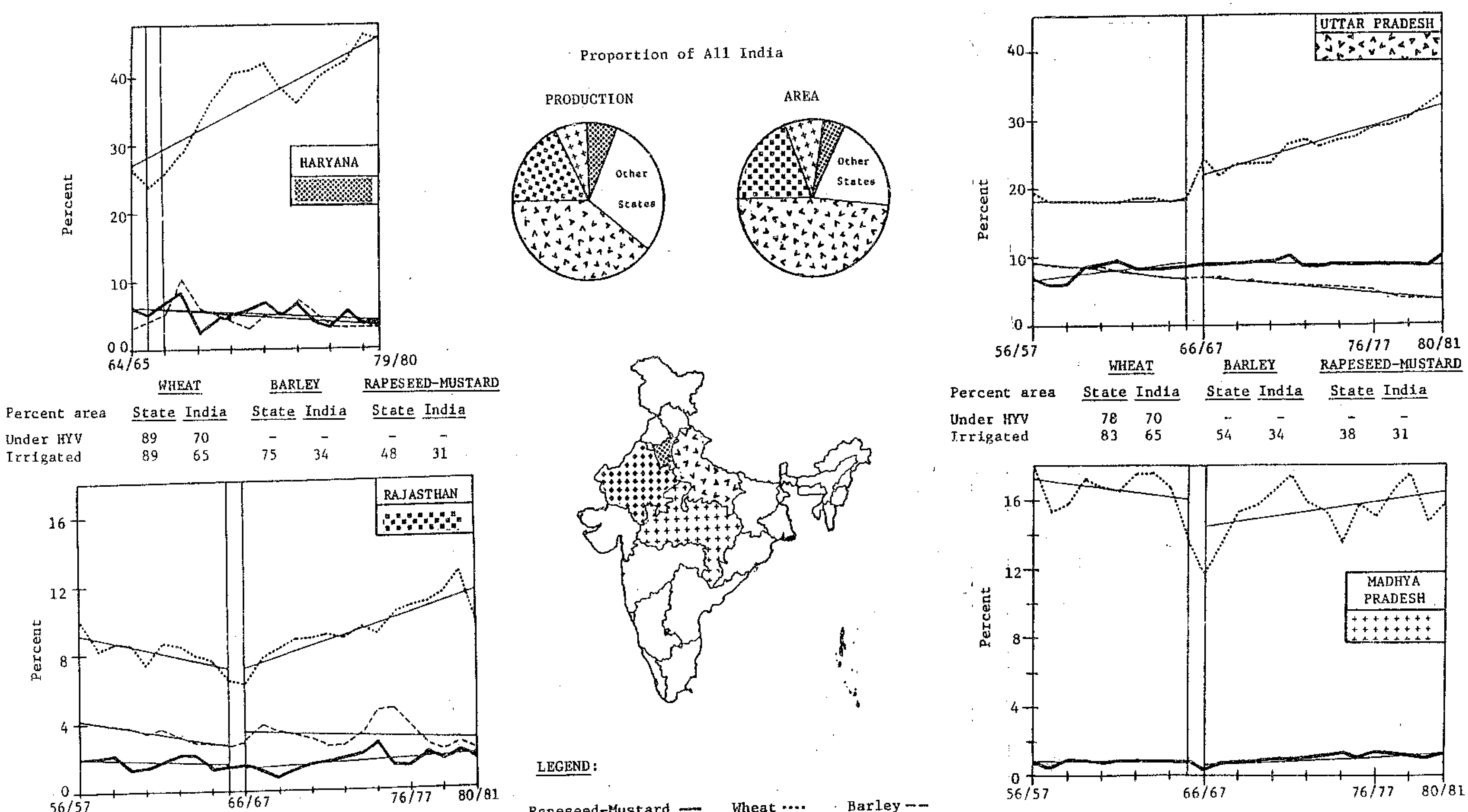
Rapeseed-mustard is a group of five related crops, namely, *Brassica juncea*, *Brassica campestris var. toria*, *Brassica campestris L. var. dichotma*, *Brassica campestris var. sarson*, and *Eruca sativa* (61). Statistics for all five crops are reported under the single category "rapeseed-mustard" and can in effect be treated as a single crop. Grown during the rabi season, they compete with the two other major rabi crops--wheat and barley. Rows of rapeseed-mustard are usually planted among wheat, therefore, one would expect area under rapeseed-mustard to go up with increased wheat area. However, in the event of an increase in the profitability of wheat, the farmer is likely to plant proportionately less of the field to rapeseed-mustard; thus, even though rapeseed-mustard is grown as a mixed crop with wheat, the two crops do compete for land.

Figure 2.3 presents trends in the percent of gross cropped area devoted to rapeseed-mustard and to wheat and barley in four states which together account for nearly 80 percent of the area and 70 percent of the production of rapeseed-mustard in the country (116):

State	Percent of India's Area	Percent of India's Production
	(Average of 1981/82-1983/84)	
Uttar Pradesh	48	38
Rajasthan	18	16
Madhya Pradesh	7	7
Haryana	5	6
Total	78	67

In Uttar Pradesh, where over one-third of the rapeseed-mustard is produced, area under this oilseed exhibited a slight increase and that of wheat remained relatively stable prior to the grain revolution. After the mid-1960s, area under wheat increased rapidly while that under rapeseed-mustard stagnated, implying that more of wheat was being grown as a pure crop. Part of the increase in wheat was also at the expense of barley where area actually declined during both time periods. In addition, since the early 1970s, wheat and rapeseed-mustard acreages have been moving in opposite directions. The wheat revolution in Uttar Pradesh has been quite successful, especially in the western part of the state. Nearly 80 percent of the area under wheat is irrigated and over three-fourths is under high-yielding varieties, well above the national averages. The percent of rapeseed-mustard area that is irrigated is also above the national average of 31 percent. Over half of the barley area in Uttar Pradesh is irrigated

FIGURE 2.3. INDIA: TRENDS IN PERCENT OF GROSS CROPPED AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS, BY STATE, 1956/57-1980/81*



Haryana

Percent area	WHEAT State	WHEAT India	BARLEY State	BARLEY India	RAPESEED-MUSTARD State	RAPESEED-MUSTARD India
Under HYV	89	70	-	-	-	-
Irrigated	89	65	75	34	48	31

Uttar Pradesh

Percent area	WHEAT State	WHEAT India	BARLEY State	BARLEY India	RAPESEED-MUSTARD State	RAPESEED-MUSTARD India
Under HYV	78	70	-	-	-	-
Irrigated	83	65	54	34	38	31

Rajasthan

Percent area	WHEAT State	WHEAT India	BARLEY State	BARLEY India	RAPESEED-MUSTARD State	RAPESEED-MUSTARD India
Under HYV	49	70	-	-	-	-
Irrigated	73	65	75	34	50	31

Madhya Pradesh

Percent area	WHEAT State	WHEAT India	RAPESEED-MUSTARD State	RAPESEED-MUSTARD India
Under HYV	29	70	-	-
Irrigated	26	65	18	31

*Sources: Appendix I.3, and Fertiliser Association of India, *Fertiliser Statistics* (Delhi, various issues).

as opposed to 34 percent for all-India, which appears to be somewhat inconsistent with the decline in relative barley area observed in the state.

In Rajasthan, wheat and barley area declined prior to the grain revolution while that under rapeseed-mustard also exhibited a marginal decrease. After the grain revolution, however, wheat area increased, pulling up rapeseed-mustard area only marginally and the extent of mixed cropping declined. Barley area continued to fall subsequent to the introduction of the high-yielding varieties. More than 73 percent of the area under wheat and 50 percent of the area under rapeseed-mustard in Rajasthan is irrigated, both of which are above the national averages. The percent of area of wheat that is under high-yielding varieties is lower than the national average of 70 percent.

In Madhya Pradesh, the comparison is made only between rapeseed-mustard and wheat because barley area is negligible. Area under rapeseed-mustard was stable during the pre- and post-grain revolution periods, while that under wheat declined during the first period and increased during the second. However, the exclusion of the two drought years would result in relatively stable trend lines for wheat over both time periods. Madhya Pradesh did not benefit from the grain revolution--and this is reflected in the percent of wheat area under high-yielding varieties and under irrigation which are much below the national averages. The same is true for rapeseed-mustard.[8]

In Haryana,[9] area under wheat increased shortly after the grain revolution, while barley and rapeseed-mustard acreages declined slightly. Thus, most of the increase in total gross cropped area was devoted to wheat, and the proportion of an average wheat hectare that is devoted to rapeseed-mustard declined. The percent of irrigated and high-yielding varieties wheat are both above national averages; so also for rapeseed-mustard.

The production of rapeseed-mustard is also localized although to a much lesser extent than groundnut. Therefore, for reasons discussed in the earlier section, district level trends for four districts of Uttar Pradesh, the largest producer of rapeseed-mustard, are presented in Figure 2.4. These districts, Agra, Kanpur, Etawah and Nainital are the four top producing districts in this state (<u>96</u>).[10]

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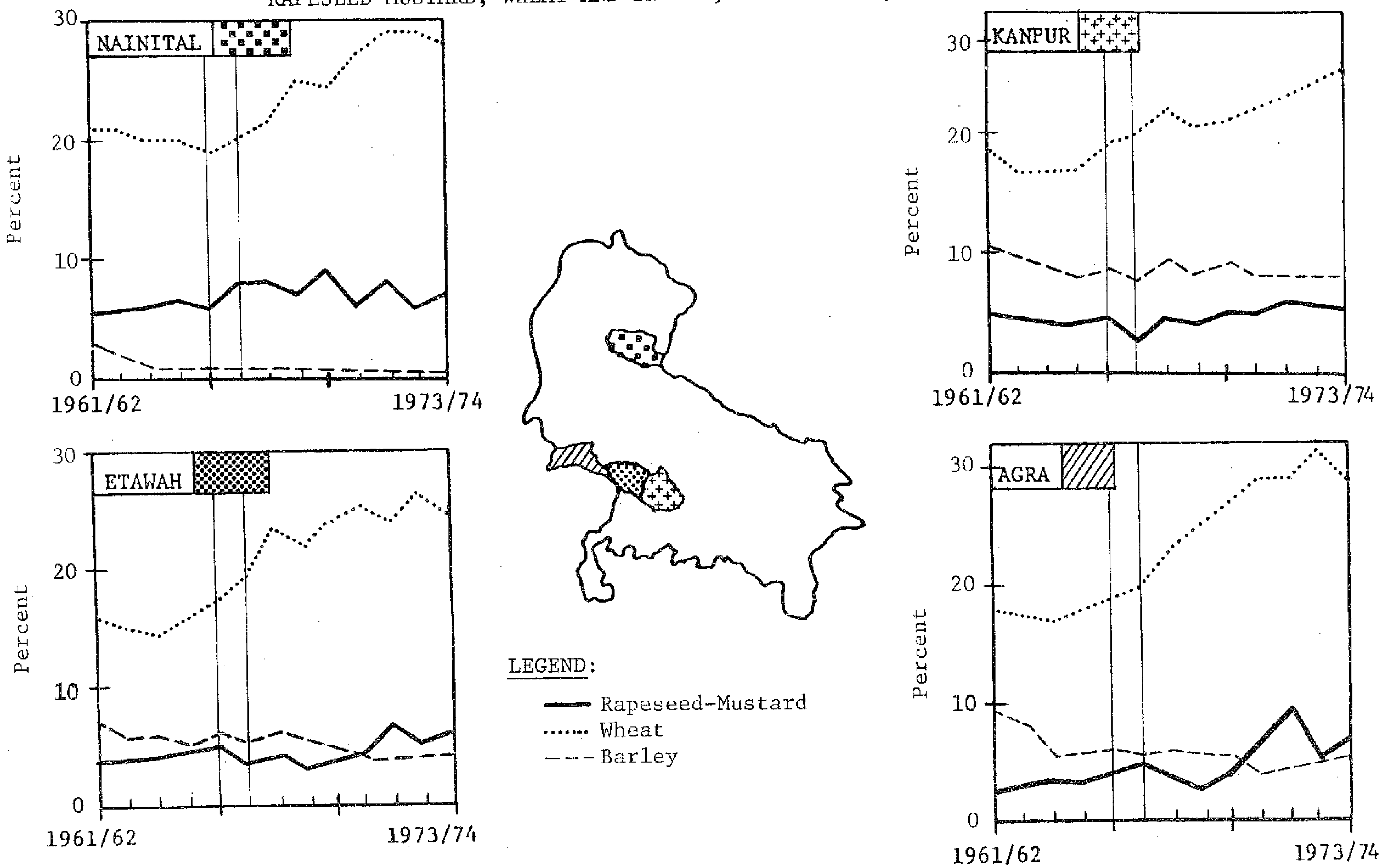
[8] No relevant cost-of-cultivation figures are available for rapeseed-mustard.

[9] Haryana state came into existence in 1966, thus only data from 1965/66 are available.

[10] Because of ambiguities in the way area under mixed rapeseed-mustard are reported, the actual percent of area and production accounted for by these districts is not presented. A comparison of the <u>trends</u> in area remains valid.

FIGURE 2.4. UTTAR PRADESH: TRENDS IN PERCENT OF GROSS CROPPED AREA UNDER RAPESEED-MUSTARD, WHEAT AND BARLEY, BY DISTRICT, 1961/62-1973/74*



*Source: Appendix I.4.

In all four districts, wheat area declined prior to the mid-1960s and increased rapidly consequent to the grain revolution. Barley area was stable or declining throughout both periods. As for rapeseed-mustard, area was stable in all four districts prior to 1965/66; after the grain revolution the same was true except in Agra, where area increased marginally. Area under barley declined continuously. Once again, the district level trends reflect state level trends.

Sesame

Sesame is grown predominantly as a kharif crop and competes with jowar and bajra. Production is not as localized as in the cases of groundnut and rapeseed-mustard, and four states constitute 63 percent of area and 50 percent of production (116):

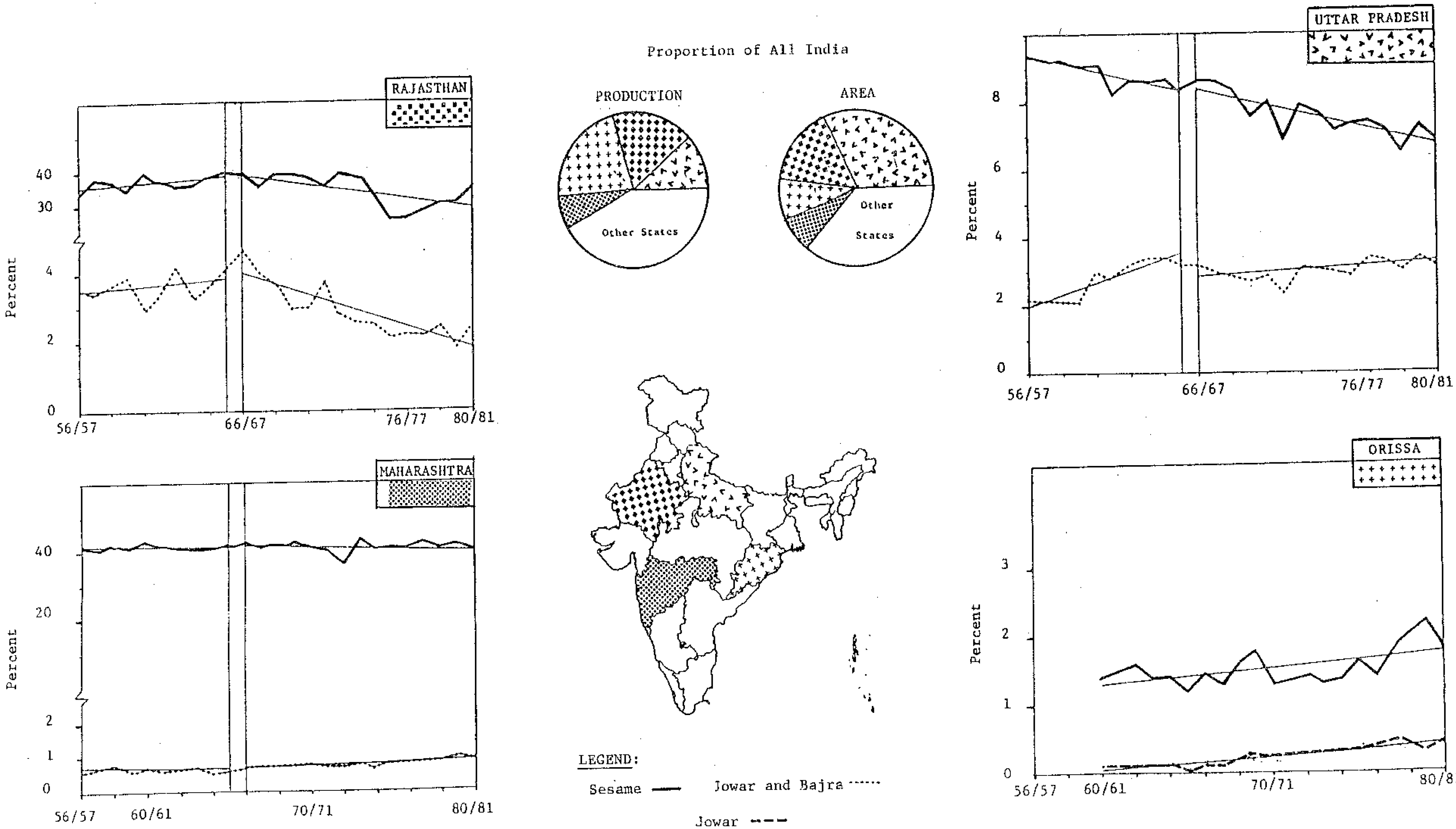
State	Percent of India's Area	Percent of India's Production
	(Average of 1981/82-1983/84)	
Orissa	8	21
Uttar Pradesh	31	14
Rajasthan	17	8
Maharashtra	7	7
Total	63	50

Figure 2.5 presents trends in the percent of gross cropped area under sesame, on the one hand, and that under jowar and bajra combined, on the other, since 1956/57. Sesame is not usually irrigated (and therefore, data on irrigated area under sesame are not reported); thus, comparisons of the kind carried out for the other two oilseed crops are not possible.

In Orissa, the largest producer of sesame, the proportion of total gross cropped area in the state devoted to sesame is small at less than one percent. In this state, jowar area increased slightly after the introduction of the new technology whereas sesame area increased only after 1977.[11] In Uttar Pradesh, area under jowar and bajra rose during the pre-grain revolution period at the expense of sesame, but subsequent to the mid-1960s area under jowar and bajra did not increase as rapidly, while that under sesame continued to fall. Part of the decline can be explained by the fact that most of the increase in gross cropped area in the state came with the increase in rabi season wheat. In Rajasthan, area under all three crops increased prior to the grain revolution, but declined after the grain revolution. Once again, this phenomenon is a result of the fact that the increase in rabi wheat

11 For Orissa, data are available only from 1960/61. In addition, the comparison excludes bajra, because its area is negligible.

FIGURE 2.5. INDIA: TRENDS IN PERCENT OF GROSS CROPPED AREA UNDER SESAME AND ITS COMPETING CROPS, BY STATE, 1956/57-1980/81*



*Source: Appendix I.5

area in this state contributed to most of the gain in total cultivated area. Even though high-yielding variety jowar and bajra were not very popular in Rajasthan, the absolute area under the two millets increased while that under sesame decreased. Lastly, in Maharashtra, sesame, jowar and bajra areas remained relatively stable prior to the grain revolution; however, subsequently, there was a slight increase in sesame area, but not in that of jowar or bajra.

The grain revolution, where successful, has thus served to negatively impact the competitive position of the oilseeds vis-à-vis the cereal crops. Moreover, even in areas not affected by the grain revolution, the oilseeds compete for land with the foodgrains. In addition, overall input use, including that of fertilizer, is lower for the oilseeds as compared to the cereals (78). There have been no counterparts of the miracle high-yielding variety seeds of wheat, rice and millets for the oilseeds.

The effect of this technological backwardness on the part of oilseeds is clearly evident if one disaggregates the change in total revenue per hectare over the grain revolution period into real price, yield and interaction effects in the largest producing states.[12] As indicated below, for all competing cereal crops, real prices declined slightly and revenue increases were effected entirely through higher yields. In the case of rapeseed-mustard, however, price rises were solely responsible for increased revenue; yields for this crop actually declined. For sesame, the increase in prices was not enough to offset the reduction in yields, so that revenue also fell. Only for groundnut did both yield and price increases contribute to higher revenues:

Crop	Change in Total Revenue	Yield Effect	Price Effect	Interaction Effect
	(1960/61 Rupees per hectare)			
		GROUNDNUT (GUJARAT)		
Groundnut	385.3	178.4	138.3	68.6
Bajra	263.6	265.5	- 0.6	- 1.3
		RAPESEED-MUSTARD (UTTAR PRADESH)		
Rapeseed-mustard	39.9	- 51.4	53.6	- 19.8
Wheat	92.7	197.7	- 69.5	- 35.5
		SESAME (UTTAR PRADESH)[13]		
Sesame	- 18.9	- 44.2	38.2	- 12.9
Jowar	30.5	34.9	- 3.5	- 0.9
Bajra	4.7	35.3	- 25.3	- 5.3

[12] Detailed calculations are in Appendix V.1.

[13] Data for Orissa, the largest producer of sesame, are unavailable.

Prospects for the Three Principal Oilseeds

Nearly two decades have passed since the first high-yielding varieties of wheat were introduced in India. The question now is whether any developments have occurred in the oilseeds economy since then, and what the implications are for the increased production of these crops. The following discussion indicates that although there have been a few success stories, by and large, the competitive position of the three principal oilseeds relative to the cereals is unlikely to change significantly in the near future.

Technological Factors

The poor production performance of the oilseeds is largely a result of the rainfed nature of their cultivation (only eight percent of the total area under cultivation is irrigated) (116), high-yield risk, and their vulnerability to pests and diseases.

Oilseeds research has not made much progress in India. The major responsibility for this research lies with the All India Coordinated Research Project on Oilseeds (AICORPO) which came into operation in 1968. In addition to the AICORPO and the research carried out in the State Agricultural University systems, several programs exist under the auspices of the Indian Council of Agricultural Research to undertake oilseeds research, notable among them being the The National Research Centre for Groundnut in Junagadh, Gujarat. The International Crop Research Institute for the Semi-Arid Tropics, in Hyderabad, India, also has a major groundnut research program. However, despite the institutional support, there have not been any major breakthroughs (61).

Part of the problem is that given the rainfed nature of most of oilseed cultivation, in order to ensure adoption by farmers, it is necessary to evolve varieties that are not only high-yielding, but are also drought-escaping, or drought and pest resistant, so as to diminish yield uncertainty. Some success in evolving drought resistant varieties has been reported at the National Research Centre for Groundnut, but apart from Gujarat, it has not been possible to duplicate these results elsewhere, pointing to the need for location-specific research (61).

In addition, there is a lack of proper coordination between the oilseed research institutes and the existing extension system, so that the little progress that is made on the research front does not get transmitted to the farmers, let alone allowing for feedback from the farmers to the researchers.[14]

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[14] For example, yields in national demonstrations for groundnut are often three to four times as high as those actually experienced by the farmers (78, p. 168). The difference is likely to be because of poor extension, but also because the cost of scientific cultivation practices necessary to bring about this increase in yield is very high. The proof of the seed is, after all, in the harvesting.

Another means of increasing yields is through the provision of reliable water supplies. It has been suggested (30, p. 11; 39, p. 256) that because irrigated yields of groundnut tend to be twice as high as unirrigated yields, incentives be provided to encourage the extension of groundnut cultivation on irrigated lands. Evidence indicates, however, that under irrigated conditions, farmers prefer to produce cereals because irrigated cereal yields are also higher than unirrigated yields (86, p. 620).

Institutional Considerations

The government has been actively involved in foodgrain markets. The Agricultural Prices Commission, set up in 1965, recommends procurement and support prices for the foodgrains, which are then enforced through the purchases of the Food Corporation of India (also set up in 1965) so that government markets often parallel private markets for foodgrains (21, p. 20). The oilseeds, however, did not come under the purview of the Agricultural Prices Commission until 1976/77, and no government agencies are involved in oilseed marketing.[15] The processing and marketing of oil is in the hands of a few traders who are in a position to exploit the farmers (12, p. 315; 87, p. 382).

Partially as a response to this fact, the Gujarat Cooperative Oilseeds Growers' Federation (GROFED) was set up in 1979 in major producing districts of Gujarat, in the belief that "by organising farmers around a commodity system, and resting with this farmers' organisation the management and control of technically superior processing and marketing facilities, ... a greater proportion of the consumer rupee can be paid to the producer in comparison to what the traditional trade can pay" (85, p. 1673). The GROFED offers to farmers higher prices, subsidized seeds, fertilizers, pesticides, modern farming equipment and a variety of other extension services. It owns two oil mills and has plans for constructing others. Despite the opposition of a powerful oil lobby that controlled most of the processing and marketing of the oil in the state, the GROFED has been a success in Gujarat. Starting from 43 cooperative societies in 1979, by 1982, the GROFED encompassed over 971 societies with a total membership of 68,100 farmers (85).

Preliminary evaluations of the project in 1984 looked encouraging. A comparison of villages which have cooperatives with those that do not indicated that, although the former on average incurred higher input costs, they received higher groundnut yields, higher prices, and higher incomes per hectare than the latter (85). The continued viability of GROFED's operation and the successful adaptability of such a system to other producing areas and crops could very well result in an increase in the production of oilseeds.

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15 One exception, however, is the soybean market, where the National Agricultural Cooperative Marketing Federation (NAFED) is actively involved in purchasing and marketing soybeans.

Prices

It is generally believed that increases in wholesale prices of oilseeds and vegetable oils are not passed on to the farmer in the form of higher farm harvest prices, but rather that they are captured in the profit margins of the traders. A comparison of farm produce value with final produce value[16] shows that in the case of groundnut, for example, in bad years, the percent decrease in farm produce value is much higher than the percent decrease in final produce value. In good years, the decrease in prices is usually associated with increased production. Producers lose much more relative to the traders in poor harvest years (66, p. A-115). In addition, evidence indicates that the spread between the farmers' and intermediaries' share of retail price has been increasing over time, and furthermore, the farmer's share *per se* has declined by more then eight percentage points between 1962/63 and 1980/81 (74, p. 189). The corollary argument is that assuring the producer of remunerative prices is one means of increasing the production of oilseeds; therefore, it is advocated that support prices recommended by the Agricultural Prices Commission, which are currently much below farm harvest prices, be increased to reflect realistic market prices (12).

However, a comprehensive study put out in 1982 suggests that prices are *not* a major factor in influencing production decisions. The study examined the relative importance of prices, yields, availability of water (both irrigation and rainfall), variability in yields and prices and technological factors in the determination of groundnut acreage.[17] It found that at the state level, in the southern states (Tamil Nadu and Andhra Pradesh), the presence of irrigation facilities, and in the western states (Gujarat and Maharashtra), the availability of high-yielding varieties of competing cereals, and price and yield *uncertainty* were the most important determinants of groundnut area. In no instance did relative prices significantly influence area. At the district level, similar conclusions held, with the exception that relative prices were important only in districts where irrigation facilities were present (13, pp. 116-143).

The supply elasticities with respect to price in this study were all positive but not statistically significant (13, pp. 144-145). The evidence from other studies is, however, mixed (Table 2.2). While most

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16 Farm produce value was derived by multiplying annual groundnut production with corresponding farm harvest prices. Final produce value was calculated by taking groundnut oil production at average wholesale prices with adjustments for seasonal variations and also taking into account the value of oilcake in the domestic and international markets.

17 The time period covered in this study was 1963/64 to 1974/75 for Andhra Pradesh and Gujarat, and 1954/55 to 1974/75 for Tamil Nadu, Karnataka and Maharashtra. No distinction was made between the pre- and post-grain revolution periods.

TABLE 2.2. ESTIMATES OF PRICE ELASTICITY OF SUPPLY FOR GROUNDNUT*

Region	Study	Period	Short Run	Long Run
Andhra Pradesh				
State	a	1951-57	0.69	0.52
State	b	1964-75	0.32	0.48
Anantapur	b		0.27	1.29
Chittoor	b		0.43	0.60
Kurnool	b		0.46	1.64
Gujarat				
State	b	1955-67	-0.11	-0.11
State	d	1963-75	0.18	1.17
Junagadh	b		0.35	2.50
Amreli, Bhavanagar, Jamnagar & Rajkot	b		0.16	0.89
Surat and W. Khandesh	b		-0.07	-0.08
Saurashtra	b	1954-68	0.22	0.59
Karnataka				
State	b	1953-67	-0.03	-0.06
State	d	1954-75	0.12	0.09
Belgaum & Kolhapur	b		-0.29	-0.35
Dharwar	b		0.11	0.11
Maharashtra				
State	b	1955-68	-0.14	-0.14
State	d	1954-75	0.16	0.56
Nasik	b		-0.19	-0.18
N. Satara	b		0.06	0.10
Central Maharashtra	a	1954-68	0.11	0.32
Tamil Nadu				
State	b	1950-67	-0.01	-0.01
State	c	1947-65	0.22	0.31
State	b	1951-75	0.04	0.06
Madurai	b		-0.53	-0.37
N. Arcot	b		-0.12	-0.09
Salem	b		0.15	0.13
S. Arcot	b		0.13	0.12

Sources:

M.L. Jhala, "Farmers' Response to Economic Incentives: An Analysis of Inter-Regional Groundnut Supply Response in India," Indian Journal of Agricultural Economics, January-March 1979, pp. 55-67.

b: John T. Cummings, "The Supply Responsiveness of Indian Farmers in the Post-Independence Period: Major Cereal and Cash Crops," Indian Journal of Agricultural Economics, January-March 1975, pp. 25-40.

c: M.C. Madhavan, "Acreage Response of Indian Farmers: A Case Study of Tamil Nadu," Indian Journal of Agricultural Economics, January-March 1972, pp. 67-86.

d: Uma Kapila, The Oilseeds Economy of India: A Case Study of Groundnut (Institute of Economic Growth, Agricole Publishing Academy, New Delhi, 1982).

confirm positive acreage response to price both in the short and long run, negative supply elasticities are not uncommon. The reason is that in areas where the competing crops are grown primarily for subsistence, the higher relative price of groundnut will not necessarily result in increased area under the oilseed unless the farmer is convinced that the income from groundnut will be sufficient for purchasing subsistence needs. In cases where the response to price has been negative, sowing-period rainfall and yield have played a greater role in determining acreage: if there is inadequate rainfall and yields are likely to be low, the farmer may not plant as much area to groundnut even if the relative price of groundnut increases (69).

In sum, a sound price policy alone would not be enough to bring about changes in the relative profitabilities of the oilseeds and the competing crops. As Kahlon and Tyagi, members of the Agricultural Prices Commission, argue, "in the case of such crops as oilseeds where technology is lacking, exclusive reliance on the price mechanism to induce production would prove to be an optical illusion...the resultant gain in production would be uncertain" (12, p. 298).

Prospects for Nontraditional Sources of Vegetable Oil

The scope for expanded production of the traditional oilseeds is limited. However, there are other annual nontraditional sources of vegetable oil. The recognition that diversification in oilseeds was one means to increased vegetable oil production and reduced dependence on groundnut led the Indian government to encourage the production of these nontraditional sources of vegetable oils. Unfortunately, results to date have been minimal.

Soybean

Feasibility trials undertaken during the late 1960s indicated that many regions in India were suited to the cultivation of soybean, and since India has traditionally imported soybean oil for use in the vanaspati industry, it was assured of a market. Therefore in 1971/72, the Government of India launched a soybean production project by providing good quality, cheap seeds, and various other subsidies. As the production of soybean oil increased, the NAFED stepped in to provide marketing facilities. It also enforced the government announced support prices by ensuring timely procurement and storage.

Grown primarily in Madhya Pradesh and Uttar Pradesh, area under soybean increased from 26,500 hectares in 1971/72 to 768,000 hectares in 1982/83. Production similarly grew from 10,300 tons to nearly 500,000 tons over this period (116). However, during 1981/82-1983/84 soybean oil accounted for less than two percent of total vegetable oil production.[18] One advantage in growing soybean is that it is a hardy crop and is drought resistant; the major disadvantage of soybean is that its oil content is low--the main product of soybean is the meal whose use as cattle feed is not yet popular in India (2, pp. 168-173).

Sunflower

Although sunflower cultivation has been known for a long time in India, it was not until 1969 that its use as a source of vegetable oil was explored. The sunflower is characterized by high yields and drought resistance, and is also drought evading by virtue of being a short duration crop. The government implemented a sunflower scheme in the mid-1970s in the southern states of Tamil Nadu, Andhra Pradesh and Karnataka. By 1982/83, 225,000 tons of sunflower were being produced on 431,000 hectares nationwide (116). Average production of the oil during the early 1980s was 84,000 tons.[19] The program was not a major success, however, because marketing channels for this new crop were not established properly, resulting in distress sales at low prices. In addition, seed multiplication programs had not stepped up production in order to meet demand (2, pp. 155-163).

Rice Bran

This oil is derived from the outer coating of rice called the bran. Rice bran is thus a product of rice milling. The extraction of oil requires that the milling be done in modern mills and not in the traditional hullers that predominate rice processing in India. That is, the production of rice bran oil depends not only on rice production but also on the proportion of rice that is processed in modern mills. Production of rice bran oil in India during 1977/78-1979/80 was 95,000 tons. The principal advantage of this oil is that increasing its production will not be at the expense of any other cereal crop. On the other hand, the major obstacles to increased production are, first, that in areas where rice is processed in small quantities at a time, there are no arrangements for pooling the bran so as to accumulate enough for processing; and second, the oil has to be extracted soon after the separation of the bran from the rice in order to prevent rancidity and therefore, the bran cannot be stored for long periods of time (2, pp. 192-202).

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[18] As per unpublished data from the Directorate of Economics and Statistics, Ministry of Agriculture.

[19] As per unpublished data from the Directorate of Economics and Statistics, Ministry of Agriculture.

Supply Projections

All the favorable developments in the oilseeds economy discussed so far have been isolated in small pockets--irrigated groundnut in parts of Tamil Nadu and Andhra Pradesh, the evolution of drought resistant varieties and the formation of cooperatives in parts of Gujarat. Since there have been no major developments for both the traditional and nontraditional oilseeds, it is perhaps best to project future vegetable oil supply by simply assuming that past trends will continue into the future. (In addition, since prices do not appear to be major determinants of acreage, these need not be taken into account in the supply projections).

Post-grain revolution trends in the growth of oil production may be considered appropriate for making supply projections for the years 2000 and 2010 because the factors influencing oilseed supply underwent a basic change in the mid-1960s. Compound rates of growth are used in projecting the production of groundnut, rapeseed-mustard, and sesame oils. For the remaining oils, a compound growth rate of 3.5 percent is used because much of the recent growth in the production of these oils has been a result of the increased production of the new oils, soybean, rice bran and sunflower; therefore, past trends are not valid indicators of future production.[20] Projections for the major crops for 2000 and 2010 are as follows:

Oil	Base Production[a] (million tons)	Rate of Growth[b] (percent)	Production in 2000 (million tons)	Production in 2010 (million tons)
Groundnut	1.52	1.81	2.06	2.46
Rapeseed-mustard	0.73	3.27	1.26	1.74
Sesame	0.18	2.08	0.26	0.31
All others	0.92	3.50	1.65	2.33
Total	3.35		5.23	6.84

a: Average of 1981/82-1983/84
b: Compound rate of growth over 1967/68-1969/70 to 1981/82-1983/84

It is evident that nontraditional oils such as soybean, sunflower and rice bran are likely to constitute larger proportions of domestic vegetable oil supply in the future. For the traditional oils, the

[20] Over the period 1967/68 to 1978/79 growth rate in production of "all other" oils averaged 5.8 percent per annum because of the low inital base. For the six years ending 1978/79, the growth rate amounted to about 3.3 percent per annum. These oils include coconut and palm oils, supply projections for which are made in the next two chapters.

increases in production are presumed to be effected primarily through increases in yield and processing efficiency and only marginally through increases in area under cultivation. When compared with the demand projections made in Chapter 1, this supply will not be sufficient to meet domestic demand and the demand-supply gap is likely to be on the order of 2.8 to 4.5 million tons in 2000 and 3.4 to 6.6 million tons in 2010:

Year	Demand Low	Demand High	Supply (million tons)	Deficit Low	Deficit High
2000	8.0	9.7	5.2	2.8	4.5
2010	10.2	13.4	6.8	3.4	6.6

Scope for Tree Sources of Vegetable Oil

Given that increases in the production of oilseeds through higher yields are unlikely in the short run, the only feasible means of augmenting production is through expansion of area. The annual oilseed crops, however, compete with foodgrain crops for land, and this competition has in the past resulted in more amounts of land being devoted to the foodgrains at the expense of the oilseeds. Therefore, in a land scarce country such as India, any attempts to expand area under the oilseeds would occur at the expense of foodgrains.

The achievement of food self-sufficiency is central to the formulation of the five-year economic plans in India. Although self-sufficiency in food was achieved by the late 1970s, it is still precarious since food imports may be necessary in some adverse years to meet possible deficits. Therefore, production increases in oils must occur through sources of vegetable oils that do not directly compete for land with other food crops.

One alternative is to consider tree sources of vegetable oil, for example, coconuts and oil palm.[21] These tree crops have the advantage

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[21] There are several other minor forest sources of vegetable oil such as sal, neem and mahua, which together can potentially yield one million tons of oil. Only 25 percent of this potential is realizable, however, because these trees are scattered in the forests and are not within easy access to roads. Moreover, they can be harvested only during a few days in a year and it is difficult to mobilize large amounts of labor for such a short period of time. Actual production averaged 103,000 tons during 1979/80-1981/82. Appendix IV.10 presents details.

in that they yield the highest amounts of vegetable oil per hectare, as evidenced in the following table (14, p. 4; 48, p. 70):[22]

Crop	Oil Yield (kilograms per hectare)
Oil palm	5,000
Coconut	615
Sunflower	275
Groundnut	201
Rapeseed/mustard	161
Soybean	120
Sesame	82

In addition, perennial crops do not compete for land _directly_ with the annuals, in the sense that, when a farmer plants a perennial crop, it is with the recognition that the land will not be used for anything else for the next 20-30 years, barring calamitous circumstances. In India, oil palm does not compete with the foodgrains for land; coconuts, on the other hand, are grown amongst paddy fields and thus do compete indirectly with this cereal. Chapter III looks at the potential for coconut production, a traditional crop in India. Chapter IV then considers prospects for oil palm, a new crop to India. The analysis is based on the structure and economics of production of these two crops.

22 Oil palm yields are for Malaysia during the mid-1970's; remaining figures are for India and relate to the year 1978/79. Data on average oil yields are unavailable.

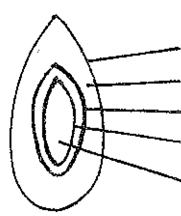
CHAPTER III
COCONUTS

The coconut economy of India is currently characterized by stagnation in production. This is because yields in the major producing state, Kerala, have been depressed by the root-wilt disease, aging palm population, and lack of proper maintenance. Nevertheless, coconuts enjoy a favorable economic environment and the analysis indicates that for a unit land area, coconuts are more profitable to cultivate than paddy despite the long gestation period associated with the former. Prospects for production increases are reasonably good but depend on the extent to which yield increases can be effected. Currently, coconut oil comprises eight percent of the total vegetable oil production in the country. Under optimal conditions, this might rise to 12 percent by 2010.

Kalpavṛkśa, the Wish-Yielding Tree

Coconut cultivation has been known in India since Vedic times nearly 3000 years ago. The coconut tree is popularly known as the Kalpavṛkśa (Sanskrit for "wish-yielding tree"), because of the many uses to which the tree is put.

The ripe coconut fruit, as shown below, consists of a smooth skin or exocarp which covers a fibrous husk. Enclosed in the husk is the nut, which in turn consists of a hard shell called endocarp that contains the meat or endosperm and coconut water. The dry endosperm is referred to as copra and is the part of the coconut that yields oil (94; 23, p. 15):



The nut is the main product of the palm, and it is estimated that 53 percent of total nut production is consumed directly--either sold as whole nuts to consumers, or used for food and seed by the farmer. About six percent of the nuts are used in the production of desiccated coconut and edible copra. The remaining 41 percent of the coconuts are converted to milling copra for the manufacture of coconut oil (5).[1] Apart from the nut, coconut leaves are also used extensively for

[1] Data are based on a survey and relate to the year 1977.

thatching roofs and making baskets. In addition, the husk of the coconut is the basic raw material for coir (hard fibre) manufacture, a major export commodity (90).

Varieties of Coconut Palm

There are two basic varieties of the coconut palm, each of which differs in yield patterns and input requirements. The Tall Variety palm grows to a height of 15-18 meters and lives up to 80-100 years. It starts bearing from six to seven years after planting and continues to yield until 75 years of age. In Kerala, the West Coast Tall variety is popular and under ideal management conditions, yields 60-80 nuts per palm per year. Oil yield from copra is a high 74 percent. The Tall variety palms usually cross-pollinate, and consequently, there is a high degree of genetic variability in the palms. The Dwarf Variety palm, as the name suggests, is relatively short, and grows to a height of five meters. It lives 35-40 years, and starts bearing earlier than the Tall variety at four to five years after planting. Yields are heavy, but tend to be irregular. Input requirements for this variety are also said to be higher. The dwarf Chowghat Orange variety grown in Kerala yields about 90 nuts per palm per year and oil yield from copra is 66 percent. The Dwarf varieties, unlike the Tall, are usually self-pollinating. In addition to these two varieties, there are several hybrids (known as the DXT and TXD), which combine the longevity of the Tall with the high-yielding characteristic of the Dwarf (23, pp. 32-35; 52).

Climatic Requirements

The optimal conditions for coconut cultivation include (23, pp. 18-25):

mean annual temperatures of 27° C. The palm does not flourish in areas where average annual temperatures are less than 21° C or where there are considerable temperature fluctuations.

annual rainfall of 1000-3000 millimeters distributed evenly over the year.

well-drained soils in heavy rainfall areas, and water retentive soils in areas with poor rainfall. The coconut thrives particularly on sandy soils in coastal regions.

Coconuts in India

Four states in southern India (Kerala, Tamil Nadu, Karnataka and Andhra Pradesh) meet the climatic requirements for the cultivation of coconut, and account for nearly all of the coconut area and production in the country (116):

State	Percent of India's Area	Production
	(average for 1981/82-1983/84)	
Kerala	61	50
Tamil Nadu	11	20
Karnataka	16	16
Andhra Pradesh	4	4
Total	92	92

The trends in production, area, and yield of coconuts in India, presented in Figure 3.1, indicate that total production of coconuts increased until the early 1970s, but exhibited a declining trend since then caused by a sharp drop in production in Kerala (and to a much lesser extent in Andhra Pradesh), despite increases in Karnataka and Tamil Nadu. Area under coconuts grew rapidly in all states from the late 1950s to the mid-1970s. Subsequently, however, although area continued to increase in Andhra Pradesh, Karnataka and Tamil Nadu, this expansion was not enough to more than offset the fall in area in Kerala; thus, total area under coconuts remained unchanged during the late 1970s. Yields in Kerala and Andhra Pradesh have declined gradually, while in Karnataka and Tamil Nadu, there have been modest increases. At the national level, yields during the early 1980s were 20 percent lower than those in the mid- to late 1950s, because of the drop in yields in Kerala.

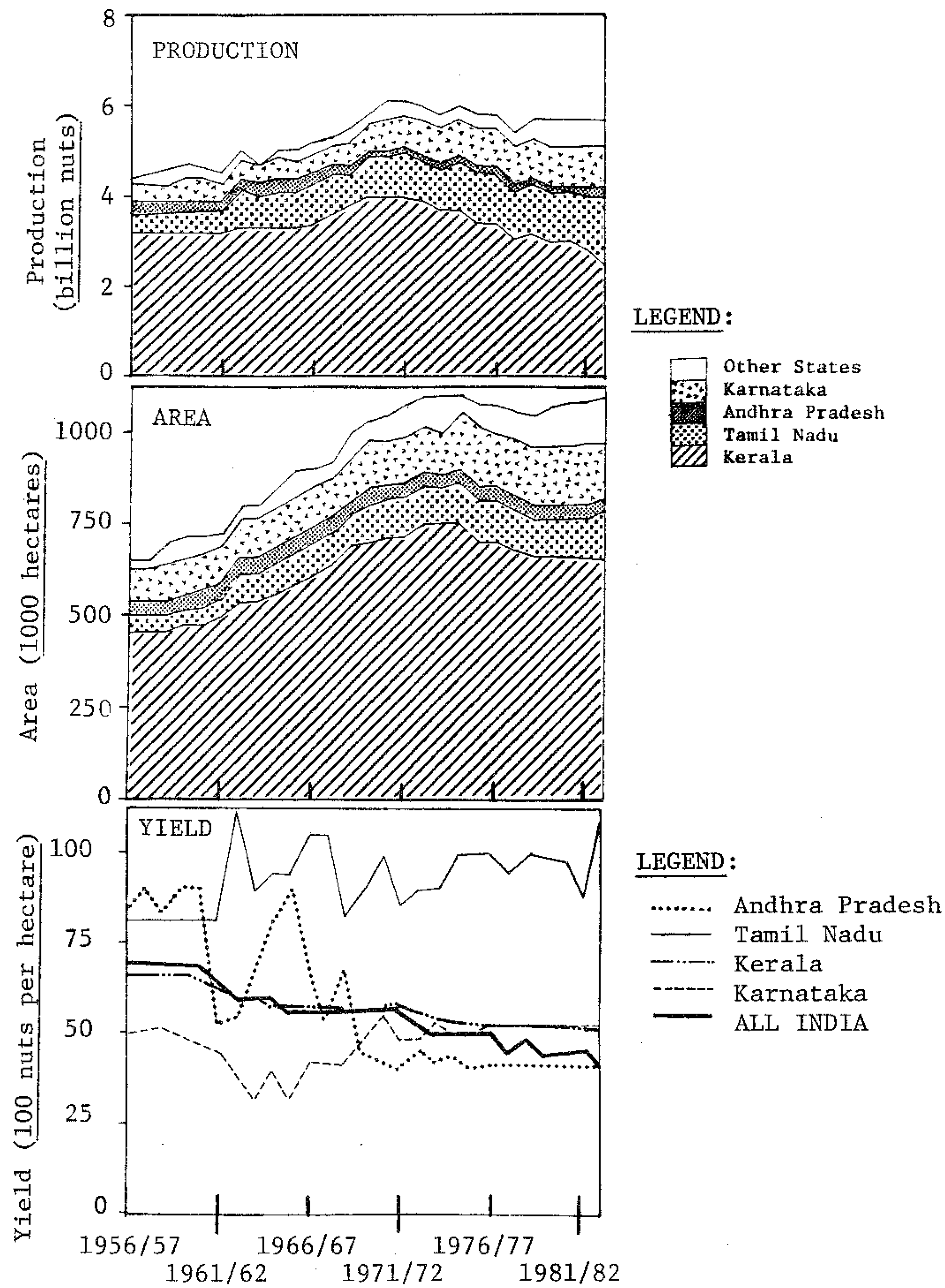
All-India trends are influenced most significantly by changes in the Kerala coconut economy because this state is the largest producer of coconuts; for this reason, the remainder of this chapter focuses on Kerala.

Coconuts in Kerala

Kerala lies in southwest India. It is characterized by a high population density of 655 persons per square kilometer, compared to 215 for all of India (126). The state receives the benefit of two monsoons --the North East monsoon from October to February, and the South West monsoon from June to September--and most areas in Kerala receive in excess of 2000 millimeters of rain every year. Temperatures range from 21° C in the winter to 37° C in the summer and the state as a whole is thus ideally suited to the cultivation of coconut (104, p. 5).

The Kerala economy is essentially agricultural: this sector constitutes 43 percent of the net state domestic product (106, p. 159) and nearly 60 percent of the total geographical area is devoted to crops (107). Within the agricultural sector, rice cultivation predominates, followed by coconuts, which occupy 28 percent and 23 percent

FIGURE 3.1. INDIA: PRODUCTION, AREA AND YIELD OF COCONUTS, BY STATE, 1956/57-1982/83*



*Source: Appendices II.1, II.2.

of the gross cropped area in the state, respectively (104; 106).[2] However, the grain revolution has not much affected Kerala rice cultivation and the state is currently food-deficit.

Kerala is divided into eleven administrative districts.[3] The formation of two of these is recent in that they have each been carved out of two other districts without affecting the total area of the state. Mallappuram, formed during 1970/71, is composed of areas from the former Palghat and Kozhikode districts; and Idikki, formed in 1972/73 was created out of parts of the former Kottayam and Ernakulam districts. Since it was not possible to obtain information on the actual areas that went into the formation of these new districts, Mallappuram, Palghat and Kozhikode on the one hand, and Idikki, Kottayam and Ernakulam on the other, are each treated as a single region wherever necessary in this analysis.

Production Characteristics

Coconuts in Kerala are a small holder crop: an estimated 59 percent of the area under coconut is in holdings less than one hectare in size.[4] Plantation scale coconut cultivation is virtually non-existent and the production structure approximates perfect competition (105, p. 39):

Holding size (hectares)	Area under coconut (percent)
0.02 - 0.99	59
1.00 - 1.99	20
2.00 - 3.99	14
4.00 - 9.99	6
≥ 10.00	1
Total	100

[2] No information was available on the value added by each of these crops to the agricultural sector.

[3] A twelfth district, Wynad, was formed from Cannanore and Kozhikode districts in 1981 but because the data series refer mainly to the sixties and the seventies, Wynad has been excluded from this discussion.

[4] Another estimate puts 90 percent of the area under coconuts being grown in holdings less than one hectare in size (23, p. 16). This difference is presumably because of differences in the definition of "area under coconut" -- most coconuts are grown among rice fields and these estimates probably exclude the area under rice.

Coconuts are grown in rainfed (unirrigated) conditions--only seven percent of the total irrigated area is under this crop (<u>105</u>, p. 36).[5] They are not usually grown in pure stands, but rather are commonly found on the fringes of paddy fields, or on bunds that demarcate paddy plots.

The production of coconuts within Kerala is not localized. As shown in Figure 3.2, nearly all districts have similar amounts of area under coconut, and contribute almost equally to coconut production in the state. Two exceptions are Palghat and Idikki, which have relatively less area under this crop and therefore do not produce as much as the other districts. This discussion therefore takes into account trends in all districts.

The rates of growth in area, production and yield of coconuts during the 1960s and 1970s differ widely among districts (Figure 3.3). The northern areas of Trichur, Cannanore, Mallappuram, Palghat and Kozhikode had the highest rates of expansion in area; production in these districts, however, did not go up by much. In the remaining southern regions, area grew more slowly, but production decreased over this period. Yields in all districts fell, although the rate of decline in the southern districts (except Alleppey) was higher than that in the northern districts (except Cannanore).[6]

<u>Yields of coconuts</u>

Much of the observed decrease in the production of coconuts at the state level during the late 1970s is a result of a sharp reduction in yields. Many factors have contributed to falling yields, but the most important is the root-wilt disease.

<u>Root-wilt disease</u>: The root-wilt is a debilitating disease which causes yields to drop, but by itself does not kill the palm: unfortunately, no cause nor cure for the disease is known. A diseased tree is usually characterized by the following symptoms (<u>53</u>):

yellowing of older leaves.
flaccidity and necrosis in the leaves.
decrease in the number and size of leaves.
shedding of buttons.
shedding of immature nuts.

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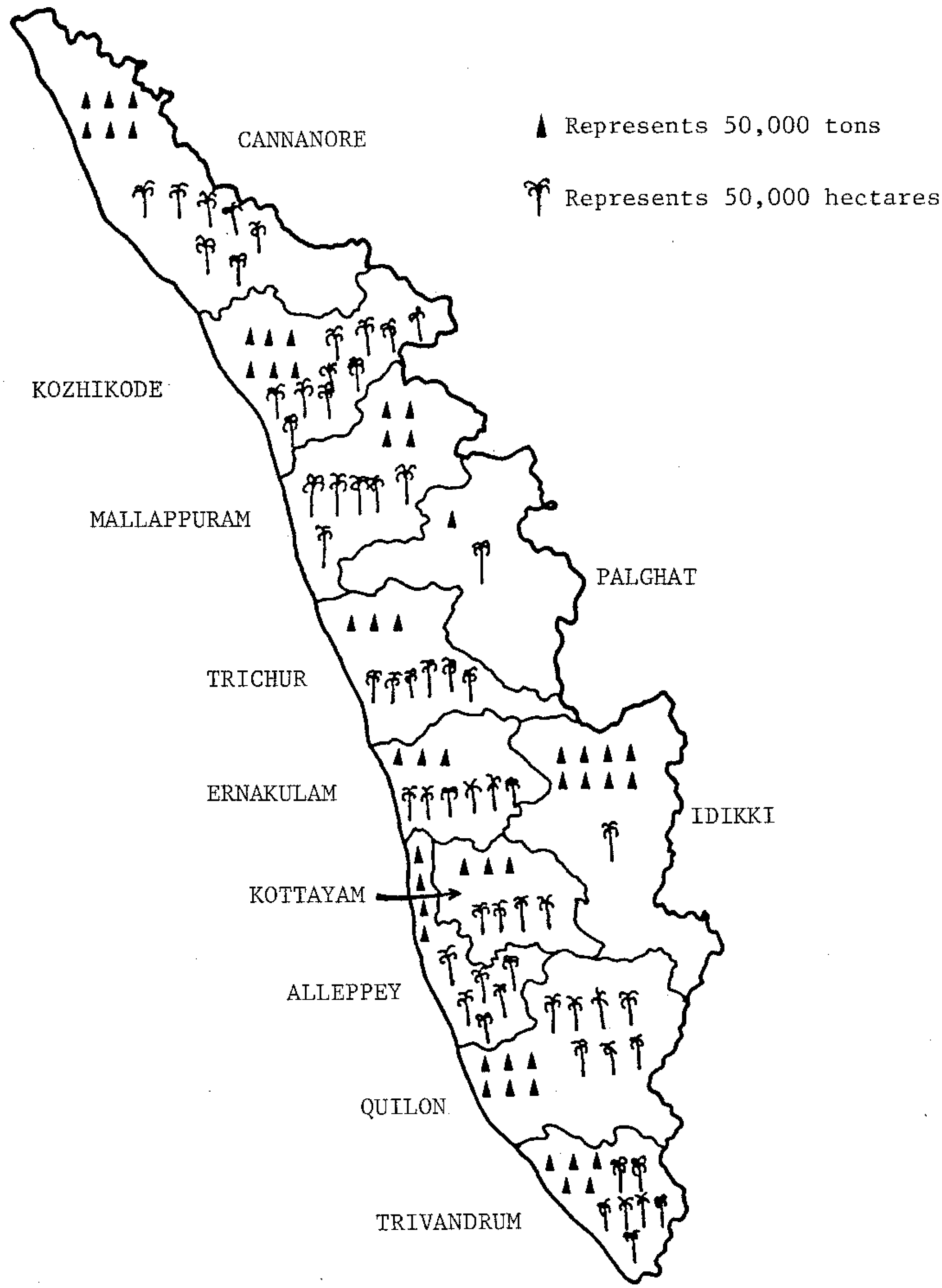
[5] Data relate to 1976/77, the year of an Agricultural Census.

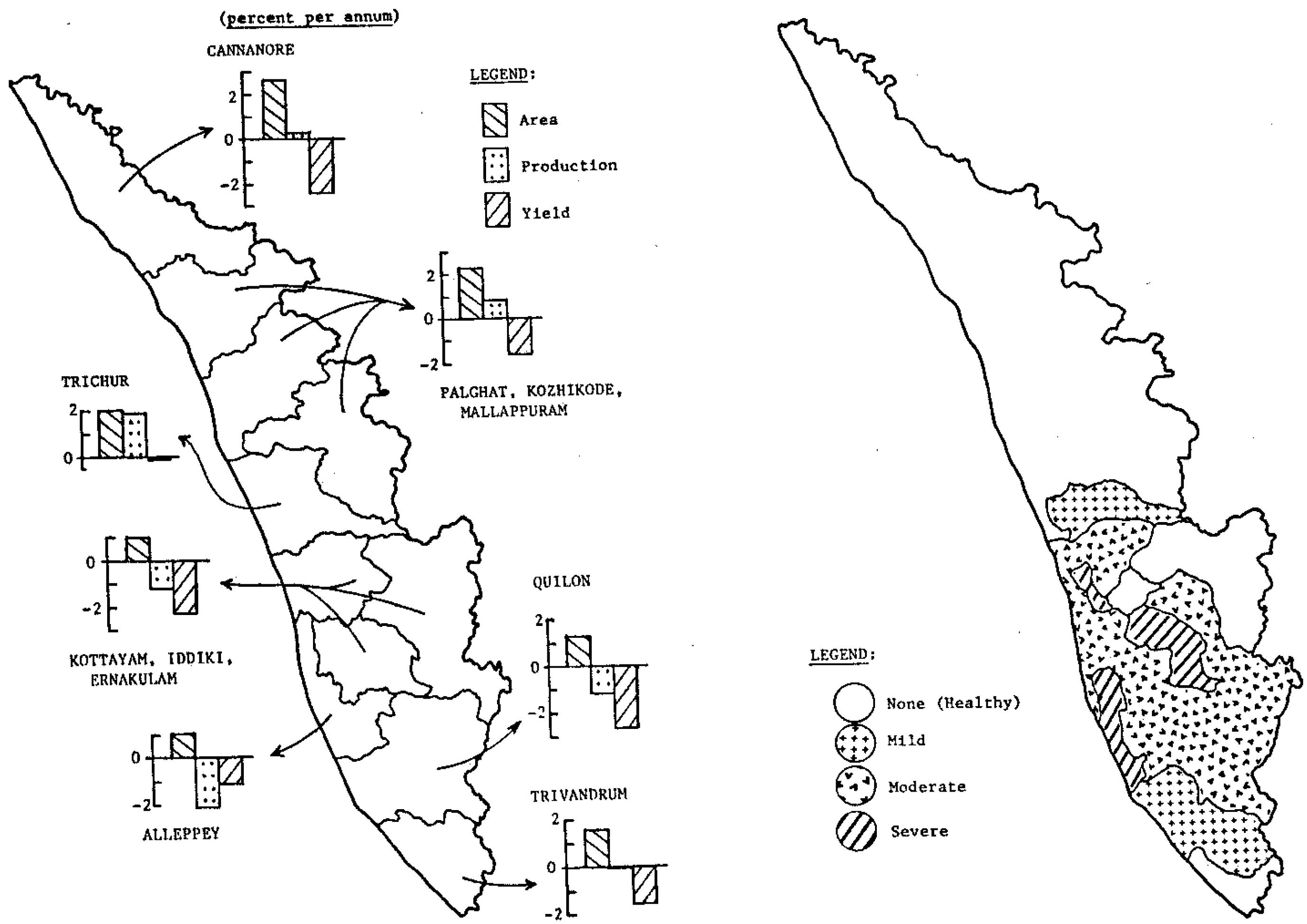
[6] Estimation procedures for determining area and production of coconuts changed in 1965/66, consequently, data prior to this year are not strictly comparable in <u>magnitude</u> with those after this point. Conclusions regarding the direction of change remain valid.

FIGURE 3.2. KERALA: COCONUT PRODUCTION AND AREA, BY DISTRICT, AVERAGE OF 1977/78-1979/80*



*Source: Appendix II.3.

FIGURE 3.3. KERALA: GROWTH RATES OF AREA, PRODUCTION AND YIELD OF COCONUTS AND INCIDENCE OF ROOT-WILT DISEASE*



*Sources: Area, production and yield data from Appendix II.3; root-wilt incidence data from M. Gopalakrishna Nair, Scientist, Central Plantation Crops Research Institute, Kerala.

The disease has reportedly affected palms in seven of 11 districts, as shown in Figure 3.3, beginning with Trivandrum in the south and going up to Trichur in the north. It is no coincidence that the central and southern districts which experienced the lowest rates of growth in coconut area have large tracts of palms categorized as severely diseased. In fact, nearly all of the severely diseased palms are located in these districts.

Estimates made in the late 1970s of the area that is affected range between 225,000 hectares and 270,000 hectares. The annual loss is put at 340 million nuts. These figures represent about 35-40 percent of the total area under coconuts and a loss amounting to a little more than 10 percent of total production (32; 89). This works out to an average yield loss attributable to the disease of approximately 1,360 nuts per hectare. The per palm productivity is affected as follows (53):

Disease index	Yield (nuts per palm)
0 - 10	50.3
11 - 25	33.7
26 - 50	22.5
Over 50	19.0

The root-wilt was first reported in Erattupetta (Meenachil) *taluk* in Kottayam district in 1882 after the occurrence of floods. Within the next decade, diseased trees were also reported from Alleppey and Quilon districts. However, it was not until 1970, when the Central Plantation Crops Research Institute (CPCRI) was set up as part of the research network of the Indian Council of Agricultural Research, that a comprehensive program was laid out to determine the epidemiology of the root-wilt (63, p. 15).

A feature of the disease is that the afflicted trees do not follow any consistent pattern; perfectly healthy trees are found next to diseased trees, indicating that an aerial vector is responsible for the spread of the disease. Until recently, efforts to identify the cause and agent of spread of the disease were unsuccessful; however, new evidence indicates that the disease is caused by a mycoplasma, an organism in between a bacteria and a virus, but still, no cure has yet been discovered. Given this fact, planners have concentrated efforts on:

a. Containing the disease to the boundaries delineated so far. To this end, the Kerala Department of Agriculture, with financial assistance from the Indian Coconut Development Board and the World Bank, has tried to create a buffer zone between the completely healthy and diseased tracts by uprooting sick palms on the northern fringes of the diseased area, planting healthy seedlings free of cost to the farmer, and subsidizing their maintenance for the first few years. Presumably, these palms would be closely monitored for any symptoms of the root-wilt (68).

b. Sponsoring a set of replanting incentives such as subsidies on fertilizers, seedlings, and irrigation facilities, in order to help eradicate diseased palms in key affected areas. This program is funded with the help of the erstwhile Agricultural Finance Corporation, the Coconut Development Board and the World Bank. For total replacement of all root-wilt affected palms, it is estimated that 50 million seedlings will be required, which is well outside the present capacity of the state seed nurseries (32, p. 10).

c. Identifying means of increasing production from the diseased palms themselves. Research has indicated that better management practices result in significantly higher yields from the sick palms themselves. For example, regular application of farm yard manure is reported to increase yields by 26 percent over a six year period. Intercropping tuber crops such as elephant foot yam and yam, irrigation and the application of chemical fertilizers, particularly magnesium sulphate, are reported to be other means of augmenting yields (89, p. 14; 53). These increases do not, however, fully compensate for the initial loss in yield caused by the disease.

d. Identifying varieties of trees that are resistant or at least tolerant to the disease. Scientists at the Central Plantation Crops Research Institute claim to have found evidence that the "DXT hybrids are more productive and have a lower incidence of the disease when compared to the ordinary WCT [West Coast Tall] palms...." (32; 53). Officials at the Coconut Development Board, on the other hand, challenging the sampling techniques on which the CPCRI results are based, argue that "... [the TXD and DXT hybrids] are also susceptible to the disease and are in no way different from the other types in the degree of susceptibility"; they concede, however, that in the absence of any other resistant varieties, the DXT hybrids, by virtue of their early bearing and high-yielding characteristics, are the only choice for use in replantation (89, p. 14).

Although the root-wilt explains much of the observed decline in yields, it does not explain all of it. For example, a comparison of yields in the diseased tracts with those in areas not affected by the root-wilt reveals that the disease does not explain why Alleppey, where all taluks have a 20 percent or higher disease incidence, had the third highest average yield among all districts, while Cannanore, which is not affected by the disease at all, had the lowest yields during the late 1970s (Appendix II.3). Both these districts contribute about equally to total coconut production in the state. Thus, other factors have also contributed to declining yields. These include:

Low proportion of bearing palms: Coconut seedlings in Kerala are being planted at a faster rate than that at which old trees are being removed, so that there is a net addition of area under coconuts without any production in the initial years. In addition, there are increasing numbers of old and virtually unproductive palms. Available data indicate that these factors have resulted in the proportion of the total palm population that is yielding to decline, causing per hectare yields to fall (70):[7]

Year	Kerala	Trivandrum	Quilon	Alleppey	Cannanore
		(percent bearing palms)			
1963/64	66	61	68	68	63
1964/65	65	58	68	72	60
1965/66	64	56	66	71	60

Low yields per palm: Concomitantly, yields per bearing palm are low because the palm population is in general old: 34 percent of the trees are older than 40 years of age and therefore past peak productivity (47). However, as the new seedlings planted in the mid-1960s have begun to mature, the per palm productivity has started to rise slowly in most districts, despite the increase in incidence of the root-wilt (70; 55):

Year	Kerala	Trivandrum	Quilon	Alleppey	Cannanore
		(nuts per bearing palm per year)			
1963/64	30	32	30	32	24
1964/65	29	32	31	32	27
1965/66	29	31	32	31	26
1975/76	35	41	37	36	23
1976/77	36	41	37	36	22
1977/78	32	40	30	32	25

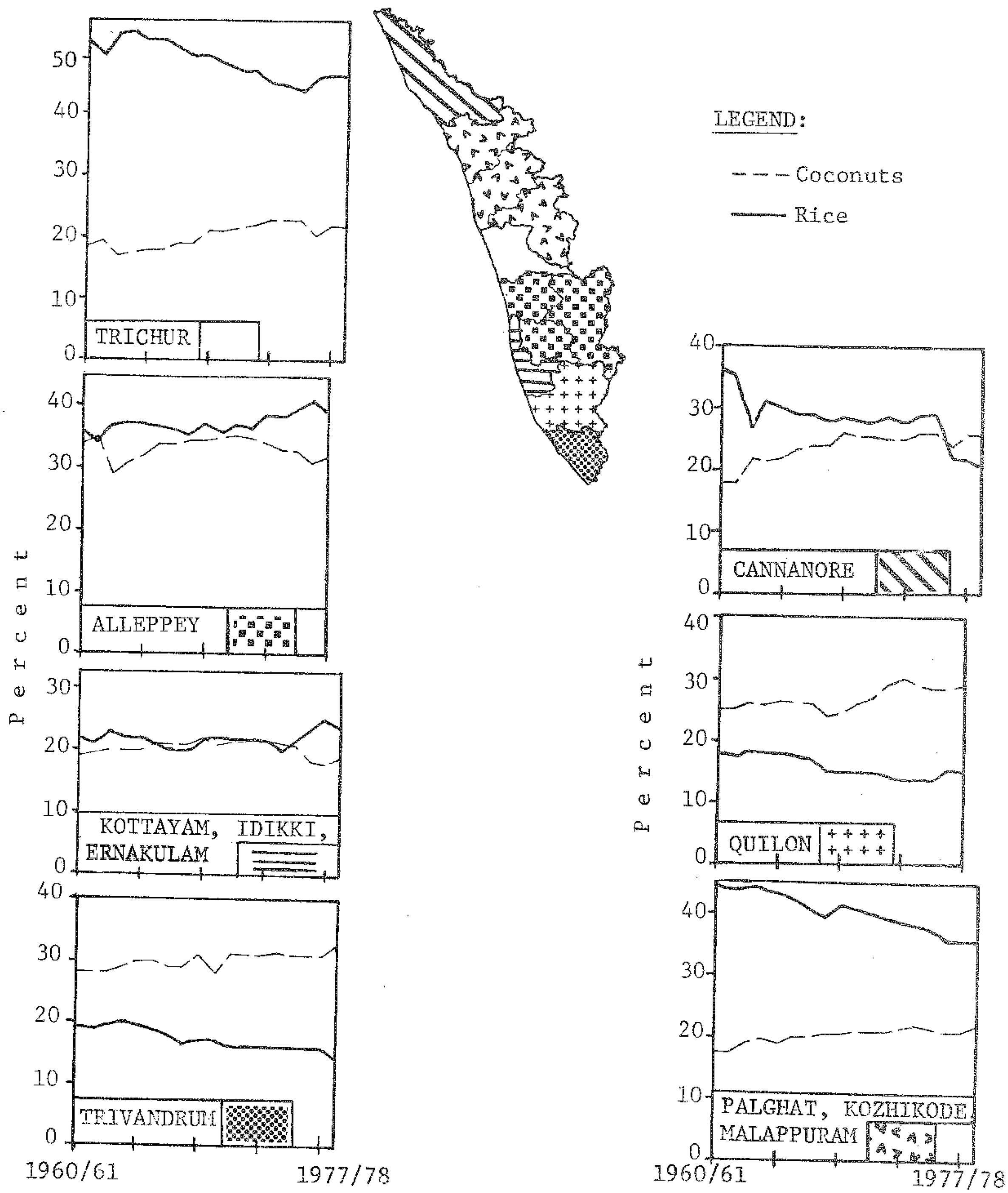
Poor Quality Seeds: In addition, the lack of quality planting materials has also contributed to the poor yield performance of the coconuts in Kerala. It is estimated that a mere eight percent of total seed requirements are met by government nurseries, 18 percent by private nurseries, and 74 percent from the cultivators' gardens themselves (70, p. 20). Area under hybrid varieties of coconuts is negligible, amounting at most to five percent of the area under coconuts (72).

The Competition Between Coconut and Paddy

The area trends in coconuts can partly be explained by the competition they face from paddy cultivation. Figure 3.4 presents trends in

[7] More recent information is unavailable.

FIGURE 3.4. KERALA: TRENDS IN PERCENT OF GROSS CROPPED AREA UNDER COCONUTS AND RICE, BY DISTRICT, 1960/61-1977/78*



*Source: Appendix II.4.

percent of gross cropped area under coconuts and rice. In all except the root-wilt afflicted districts, coconut area has been increasing at the expense of rice. This increase is likely to be long-term in nature because competition between coconut and paddy does not exist annually, but rather on a long term basis; once the land has been planted to coconuts, paddy is not likely to be sown for at least the next 20 - 30 years. In the root-wilt districts of Alleppey, Kottayam, Ernakulam and Idikki, coconut area has, in fact, lost to paddy since the early 1970s (these four districts account for nearly 30 percent of the area and production of coconuts in the state). This explains why at the state level, area under coconuts declined slightly after the mid-1970s.

One of the primary reasons why farmers have tended to devote increased proportions of their gross cropped area to coconuts in most districts is because of the real increases in farm harvest prices of coconuts; this is despite the Land Utilization Act which prohibits the conversion of paddy lands to other uses. Paddy lands converted to coconuts reportedly increase 20 to 30 times in value (60). Unfortunately, time series data on the costs of cultivation of coconuts and paddy are not available; however, paddy costs (per hectare) are higher because of the larger labor requirements of this crop compared to those of coconut. Studies have indicated that the costs associated with paddy cultivation typically comprise half of the gross value of output, and the corresponding costs for coconuts comprise only 25 to 30 percent of the gross value of output (93; 47). The relative profitabilities of the two crops can therefore be evaluated by estimating net revenue per hectare, calculated by multiplying the relevant farm harvest price with yield per hectare for each year, and subtracting from it half of the product in the case of paddy and one fourth in the case of coconuts. As set out in Figure 3.5, coconuts have consistently generated higher revenue per hectare compared to paddy in Kerala.[8]

Prospects for Increased Coconut (Oil) Production

Despite declining productivity, coconuts have enjoyed a favorable economic environment since the 1960s. Figure 3.6 presents trends in farm harvest prices of coconuts, and wholesale and retail prices of coconut oil in Kerala, deflated by the consumer price index over the period 1963 to 1981. Real prices in all three instances have gone up. In addition, the three prices have moved very closely, as further evidenced by the high correlation coefficients between pairs of prices as shown below (computed from data in Appendix II.5):

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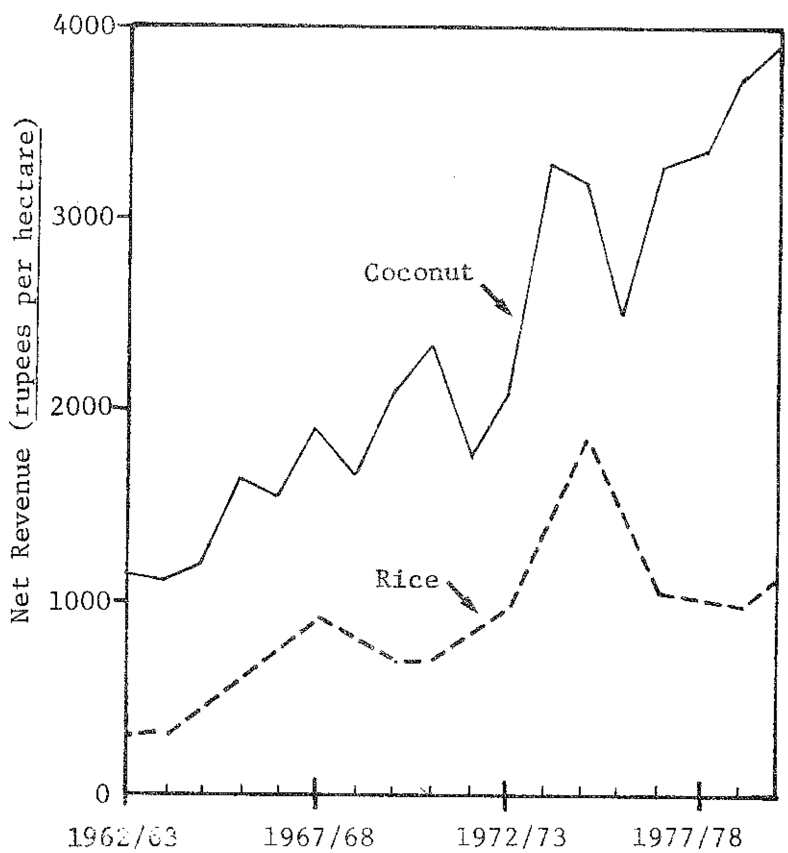
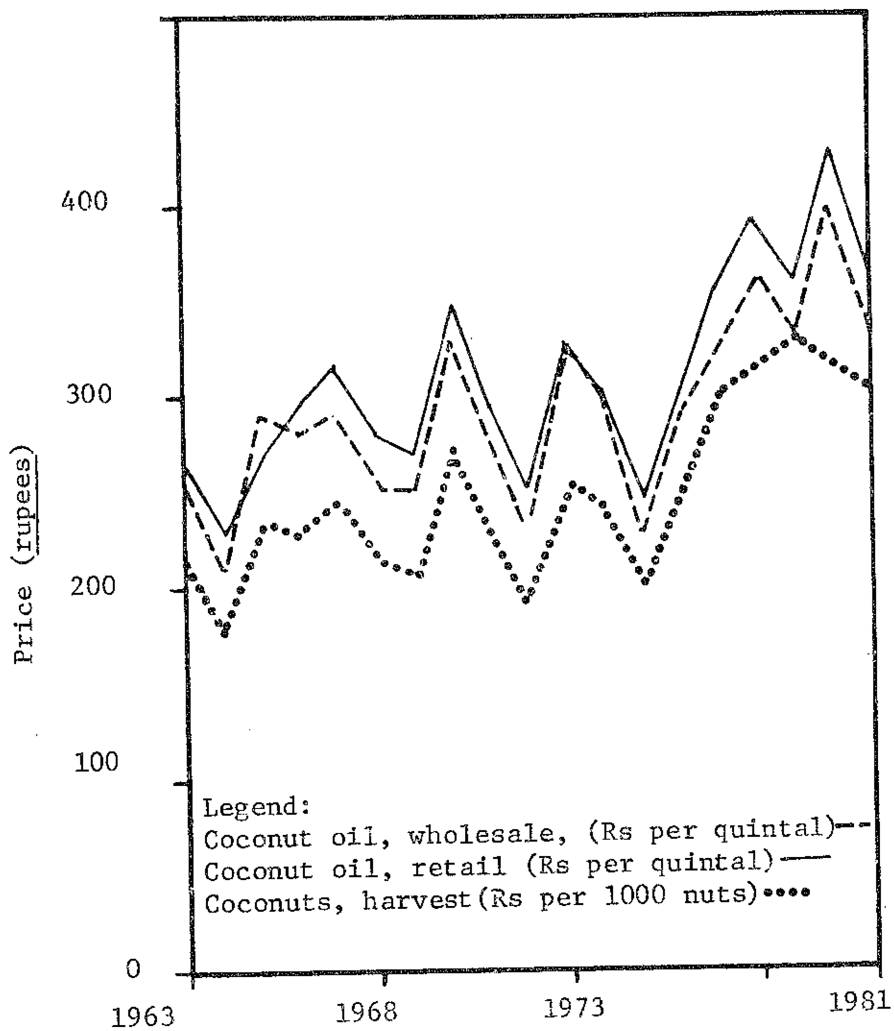
[8] This result is not very sensitive to changes in the cost percentages. Even if 45 percent of coconut and 30 percent of paddy revenue is attributed to costs, the net income from coconut would still be higher than that from paddy.

FIGURE 3.5. KERALA: NET REVENUE PER HECTARE FROM COCONUT AND RICE, 1962/63-1979/80*



*Sources: Price data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Farm (Harvest) Prices in India (Delhi, various issues), and Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

FIGURE 3.6. KERALA: REAL PRICES OF COCONUTS AND COCONUT OIL, 1963-1981*



*Source: Appendix II.5.

	Retail (coconut oil)	Wholesale (coconut oil)	Farm Harvest (coconuts)
Retail (coconut oil)	1.00	0.97	0.95
Wholesale (coconut oil)		1.00	0.93
Farm harvest (coconuts)			1.00

This close movement of prices indicates that wholesale and retail price information is readily available to the farmers, and because of the nonseasonality of coconut production, this information is reflected in the harvest prices of the crop during the same year, rather than with a time lag.[9]

The farmers in Kerala have an effective political lobby. They have succeeded in getting the State Government to persuade the Central Government not to import coconut oil and copra because, as the State Agriculture Minister in 1984, A.L. Jacob, put it, "the farmer in Kerala will suffer" (59). In fact, in November of 1985, the Kerala Congress party launched a successful "stop the trains" campaign in order to publicize the farmers' demand for support prices (58). There has been no consumer opposition to the overall increase in prices.

Financial Feasibility

This favorable economic environment in the aggregate is further supported by an analysis of the internal rate of return of the coconut crop. Perennial crops involve high initial investments and long gestation periods during which they do not generate income. Anticipated returns have to be discounted in order to arrive at a measure of present worth.

An internal rate of return (hereafter IRR) is often used as a means of evaluating project worth when an initial period of heavy investments is necessary in order to generate future returns. It is defined as the "rate of return on capital outstanding per period while it is invested in the project." (3, pp. 330-331). The rule of thumb that is generally adopted is to pursue all investments whose IRR is greater than the opportunity cost of obtaining capital. In India, a small farmer with access to government credit would pay a nominal interest rate of 12 percent, and this figure can be used as a proxy for the opportunity cost of capital.

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[9] This assumes that changes in the retail prices of coconut oil cause changes in wholesale prices of coconut oil which in turn affect the changes in farm harvest prices of coconuts; or that determinants of price changes in coconut oil are the same as those for whole coconuts.

In order to estimate an IRR for coconuts, one needs to make a few assumptions. Farmers make planting decisions regarding perennial crops only after considering their long-term profitability; a reasonable measure of the farmer's planning horizon might be 30 years.[10] In addition, perhaps the best way to approximate revenue is to multiply the average state yield of 4,500 nuts per hectare with the mean harvest price of Rs. 1.5 per nut. Unfortunately, the lack of reliable data does not permit the consideration of income through such sources as the sale of coconut leaves used for thatching roofs and making baskets. The available data on costs relate to a pure stand of trees and were obtained for a typical one-hectare plot of coconuts from the CPCRI. The calculations and a detailed list of assumptions are presented in Appendix V.2. The resulting IRR works out to be 37 percent and thus, despite disease problems and poor maintenance, coconuts are extremely profitable; therefore, prospects for the expansion of its production are good.

The next issue that needs examination is to what extent production increases can be effected through area expansion and yield augmentation.

Acreage Expansion

The scope for bringing new, previously uncultivated lands under coconut cultivation is limited. The coconut does not thrive well on hilly areas, which are the only remaining uncultivated lands in Kerala. In addition, as discussed earlier, increases in area under coconut tend to be at the expense of rice cultivation.

Acreage response studies have traditionally been based on the Nerlovian model of expected profitability of the crop vis-à-vis a competing crop.[11] Such a model is inappropriate in the present context

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[10] In any event, numerically, increasing the planning horizon beyond 30 years does not greatly influence the internal rate of return.

[11] The Nerlovian model, modified for a perennial crop may be, for example, of the form (31):

$$X_t = a + bP_t + cS_t + u_t$$

where $P_t = \sum_i P^*_{t+i} \;/\; (n+1)$

$S_t = \sum_i S^*_{t+i} \;/\; (n+1)$

X_t = Area (or number of trees) planted in year t,

P^*_{t+i} = The expected real producer price of coconut in year t+i,

S^*_{t+i} = The expected real producer price of an alternative crop in year t+i.

n = Expected age after which trees planted in year t cease to produce, and

u_t = a disturbance term.

because it does not explicitly take into account the strategies a farmer must adopt for meeting basic family needs during the initial six or seven years of coconut cultivation which involve high investments but no returns. In addition, farmers are unlikely to switch out of rice completely because it is a semi-subsistence crop in Kerala and because, even though Kerala is a net importer of foodgrains, strong taste preferences exist for the local variety.

A comparison of the present worth of income generated through paddy cultivation, on the one hand, and mixed cultivation of coconuts and paddy on the other, is one appropriate means of evaluating to what extent coconuts can replace paddy. This involves certain assumptions. First, because rice is the staple food of the Kerala farmer, other crops can impinge on it only to a certain point. Therefore, the 30 percent of gross cropped area currently under rice is taken to be the lower bound on acreage planted to paddy. Second, for reasons discussed earlier, the computations are performed for a 30 year planning period. Third, the 12 percent cost of government loans is used as the opportunity cost of obtaining capital. Although the value of land would presumably play an important role in a farmer's decision, this factor cannot be considered; data limitations preclude it. The analysis is done on a per hectare basis for the sake of simplicity.

The gross value of output (or total revenue) is approximated by multiplying farm harvest price with yield for 1977/78-1979/80 for the two crops and averaging these amounts. Costs of cultivation are taken into account in the manner discussed previously, so that net income from paddy amounts to 50 percent of the gross value of output, and that for coconuts, 75 percent of total revenue. This means that pure paddy cultivation would fetch a net income of Rs. 1,029 per hectare, and coconuts would yield Rs. 3,918 per hectare. In addition, it makes sense to assume that sixth and seventh year yields for coconuts will be lower than the peak yield at the eighth year, and this translates into net revenue per hectare from six and seven year old coconuts of Rs. 3,482 and Rs. 3,700, respectively.[12]

It is instructive to compare the present worth of income generated from four alternative systems of mixed cropping with that generated from paddy alone. Detailed calculations are presented in Appendix V.3, but the results summarized below indicate that in all instances, the present worth of an income stream from mixed coconut and rice cultivation is nearly one and a half times higher than that from rice cultivation alone:[13]

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[12] Six year old coconuts are assumed to yield 4,000 nuts per hectare, and seven year old coconuts, 4,250 nuts per hectare.

[13] The analysis is based on only one crop of paddy being grown during the year. Separate data on the cropping intensity of rice are not available, but even if one attributes the overall cropping intensity of 130 percent to paddy, then mixed cultivation continues to

System	Present Worth (Rupees)
100 percent paddy	8,289
60 percent paddy, 40 percent coconut after 4 years	11,243
60 percent paddy, 40 percent coconut after 2 years	11,613
30 percent paddy, 70 percent coconut after 7 years	12,648
30 percent paddy, 70 percent coconut after 4 years	13,593

It is also interesting to note the relatively small differences in present worth between the four cases of mixed cropping, indicating that a variety of planting schedules and cropping patterns result in the generation of nearly equal amounts of income although the need to purchase rice to meet family needs obviously varies widely under each scenario. What is clear, however, is that mixed cropping is more profitable than pure paddy cultivation. Net revenue from paddy would have to increase by over 70 percent in order for its present worth to equal that obtained from mixed cropping. The analysis indicates that a shift in area from paddy to coconut is feasible, although the exact magnitude of the shift will depend on the farmer's resource base and degree of risk aversion. It is likely that the more risk averse farmers will devote more of their area to rice, even though the production and yield variability for rice is much higher than that for coconut.[14] Regardless of the degree of risk aversion, however, not all of the rice area in Kerala is likely to be switched over to coconuts, for the nuts do not substitute for rice in consumption, and local varieties of rice are much preferred to imported varieties.

Yield Augmentation

There are reasons to believe that the trend of declining yields experienced so far will be reversed in the future. This is because the rate of new plantings has been higher than the rate at which old palms are being removed, so that the composition of the palm population has

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generate more income than paddy alone:

System	Present worth (Rs.)
100 percent paddy	10,775
60 percent paddy, 40 percent coconut after 4 years	12,497
30 percent paddy, 40 percent coconut after 2 years	12,655
30 percent paddy, 70 percent coconut after 7 years	14,642
30 percent paddy, 70 percent coconut after 4 years	14,565

[14] Over the period 1960/61 to 1980/81, the coefficient of variation of paddy production was 24.9 percent while that of coconuts was 9.5 percent. The coefficient of variation of yields over the same period was 24 percent for paddy and 11.5 percent for coconuts.

been gradually moving toward younger, higher-yielding palms. In addition, efforts to encourage the adoption of high-yielding varieties of coconuts are also likely to bear fruit. Finally, a dramatic increase in the spread of the root-wilt does not appear probable because the concentrated efforts at controlling the disease discussed earlier should succeed in at least containing the disease, if not overcoming it.

Supply Projections

Once again, it is worthwhile to consider the projections of coconut and coconut oil production arising out of a range of area and yield assumptions. The worst area scenario that could be envisaged is one where there would be no increase in the present area under coco-nuts. A more likely scenario is that area will continue to increase at the same rate as it did during the past decade-and-a-half, that is, at a compound rate of 0.21 percent per year.

By the same token, a pessimistic yield projection would be that yields of coconuts remain unchanged at current levels. A more reason-able projection would call for a modest, 5 nuts per palm, rise in yields brought about by an increase in the proportion of palms that are bearing, or alternatively, by the eradication of the root-wilt. Finally, an optimistic projection would involve better management of the coconuts such that they would receive regular fertilizer applica-tions and water in the dry season, and would mean that yields will more than double and approach those actually obtained in the neighboring state of Tamil Nadu. These area and yield assumptions imply production levels in 2000 and 2010 as follows:

Yield (nuts per hectare)	2000	2000	2010
	Area under coconuts with:		
	No increase (664,000 ha)	Past trends (690,000 ha)	Past trends (705,000 ha)
		(million nuts)	
4,500 (no increase)	2,988	3,105	3,173
6,000 (medium increase)	3,984	4,140	4,230
10,000 (high increase)	6,645	6,907	7,057

These projections suggest that with reasonable increases in yield, coconut production would rise by 20 to 70 percent over current all-India production levels by the year 2000 and by 75 percent by 2010. Most of this increase would occur through higher yields.

Approximately 40 percent of coconut production goes into the manufacture of oil. The remaining 60 percent is used directly as food or seed, and in the manufacture of edible copra and desiccated coco-nut. However, with increases in production, it is likely that the proportion of production converted to oil will increase. Therefore, it may be better to attribute an arbitrary 50 percent of the production in 2000 and 60 percent of the production in 2010 for use in the manufacture of oil, which requires 8,125 nuts for each ton of coconut oil (94). These assumptions translate into the following projections of coconut oil production:

	2000	2000	2010
	Area under coconuts with:		
Yield (nuts per hectare)	No increase (664,000 ha)	Past trends (690,000 ha)	Past trends (705,000 ha)
	(tons)		
4,500 (no increase)	183,877	191,077	195,262
6,000 (medium increase)	245,169	254,800	260,300
10,010 (high increase)	408,923	425,000	434,300

For the other major producing states, Andhra Pradesh, Karnataka, and Tamil Nadu, post grain revolution compound rates of growth are used for projecting coconut production. The conversion factors used in deriving coconut oil production are the same as those used for Kerala:

State	Compound Rate of Growth[a]	2000	2010
Coconuts		(million nuts)	
Andhra Pradesh	-0.50	160	150
Karnataka	3.05	1,612	2,176
Tamil Nadu	2.30	1,952	2,350
Coconut oil		(tons)	
Andhra Pradesh		9,846	11,077
Karnataka		99,200	160,689
Tamil Nadu		120,123	180,923
Total		229,169	352,689

a: Refers to the compound rate of growth from 1967/68-1969/70 to 1980/81-1982/83

Total production in the four states combined would constitute approximately nine to 12 percent of the projected vegetable oil supply in 2000 and 2010, thus improving slightly on its current share of eight percent:

	2000		2010	
	Low[a]	High[b]	Low[a]	High[b]
	(thousand tons)			
Kerala	254,800	425,000	260,000	434,300
Other States	-----229,169-----		-----352,689-----	
Total Coconut Oil	483,969	654,169	612,689	786,989
(Percent of Total)	(9.25)	(12.51)	(8.96)	(11.51)

Notes:

a: Corresponds to medium area, medium yield assumption

b: Corresponds to medium area, high yield assumption

Implications for Rice Imports

For Kerala, the implications of any diversion in area from paddy to coconut for rice production and imports need also to be considered. An increase in the area under coconut need not necessarily be accompanied by a decline in production of rice provided there are increases in yields, cropping intensity, or both for the latter crop. Simple calculations indicate that even if one conservatively assumes that all of the increase in coconut area occurs at the expense of rice, and that there are no increases in rice yields and cropping intensity, then the suggested upper limits on the increased import requirements and the percentage of rural consumption of rice that is purchased are not infeasible.[15]

Currently, a significant proportion of total and rural rice requirements are imported. An area of 802,000 hectares was under rice cultivation in 1980/81, yielding a production of 1,272 thousand tons of rice or 1,586 kilograms per hectare. Imports of rice into the state during that year, a typical year, were 1,575,000 tons, amounting to 55 percent of total disappearance (<u>106</u>).[16] With a population of 25.45 million, this means that per capita gross availability was 112 kilograms per capita per annum (<u>126</u>). In addition, 81 percent of the Kerala population lives in rural areas. If one assumes that all of the domestic production in the state is used to feed only the rural population, then per capita rural consumption from production alone would be 61 kgs per capita per annum. Thus at least 46 percent of the requirements of the rural population are met through imports--that is, purchased.

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[15] The percentages used in all the calculations present a "worst case" scenario, and are by no means intended to be representative. Detailed calculations are presented in Appendix V.4.

[16] Not enough data were available to make these calculations on the basis of averages.

If population between 1981 and 2000 continues to grow at the same rate as it did between 1971 and 1981, and if per capita availability of rice remains at 112 kgs per annum, then total requirements in 2000 would be 3,979,000 tons and in 2010, 4,742,000 tons. As for production, in 2000, 690,000 hectares under coconut would mean that 34,000 hectares would be diverted from rice; that is, 768,000 hectares would remain under rice, which would yield 1,218,000 tons of rice, implying that 70 percent of consumption needs will have to be imported. Similarly in 2010, 705,000 hectares under coconut implies the diversion of 53,000 hectares from rice to coconut. Area under rice would therefore be 749,000 hectares which would result in 1,118,000 tons of rice, necessitating the import of 75 percent of rice requirements.

If 81 percent of the population continues to live in the rural areas, and all of domestic production is, as before, consumed on the farm, then 60 percent of rural rice requirements in 2000, and 70 percent in 2010 would have to be purchased.

When yield augmentation and increases in cropping intensity are taken into account, the proportion of requirements that would need to be met through imports would be much less. At any rate, given that 55 percent of rice requirements are currently met through imports and at least 46 percent of rural consumption needs are purchased, the above percentages are not unreasonable. The expansion in area under coconuts would not adversely affect the Kerala rice economy.

More than area, however, the key to higher coconut production in Kerala is better yields. Two major policies to ensure increased coconut yields merit consideration. First, as far as the root-wilt disease is concerned, research efforts must continue to concentrate on firmly establishing a cause for the disease, and determining a cure for it. Scientists in breeding programs may also consider using as parent material healthy trees found amidst diseased trees, as the former are likely to have natural resistance to the root-wilt. Second, there is also need for committing greater resources to developing seed farms that would supply quality seedlings at reasonable prices. Such a measure would reduce the costs of seeds as a percentage of production costs. A comparison of the targets set for the distribution of seedlings by the Kerala Department of Agriculture and actual achievements so far indicates that in the past few years, although achievements have exceeded targets with regard to the actual distribution of seedlings, the targets themselves have been low, in view of the fact that 50 million seedlings are required for the rejuvenation of rootwilt affected areas. In addition, the allocated budget for these programs has not been utilized to the fullest extent (55):

Year	Physical:		Financial:	
	Target	Achievement	Target	Achievement
	(number in thousands)		(100,000 Rs.)	
1977/78	50	53	7	3.6
1978/79	50	52	7	3.4
1979/80	50	51	7	4.7

Stepped-up seedling production, however, needs also to be accompanied by an effective extension and distribution system. Kerala has recently switched to the "Training and Visit" system of extension, designed to promote increased communication between the farmer, the extension agent, and the research staff. It will be interesting to see if yield increases will be effected as a consequence of the new system.

The likely source of future increases in coconut (oil) production is through higher yields. In Kerala, although coconuts are profitable to cultivate, a combination of factors have kept yields of coconuts low; the ability of the farmers to overcome these technical constraints will determine the extent of production increases that can be expected from coconuts.

CHAPTER IV
OIL PALM

Oil palm is the other major tree source of vegetable oil worth study: it yields the highest quantity of oil per hectare--higher than any other source of vegetable oil. Although a native of West Africa, most oil palm is now cultivated in East Asia. Palm oil has had the most dynamic performance among all the vegetable oils, thanks mainly to spectacular increases in Malaysia's production. Might the same success also be achieved in the regions of India that are climatically suited to oil palm cultivation?

This chapter reviews the performance of the first oil palm plantation in India and evaluates the economics of its cultivation. Supply projections for the years 2000 and 2010 made in this study indicate that India is not likely to replicate the Malaysian performance for two reasons: first, only 80,000 hectares are suitable for rainfed oil palm cultivation, and second, Indian yields have so far been low.

The Miracle Palm

The success of the palm oil industry worldwide has, in large part, been the result of Malaysia's decision to enter oil palm production in a major way. Although commercial plantings of oil palm in Malaysia began in 1917, oil palm was not a major contributor to the value of its total agricultural output--rubber was the mainstay of the economy then. By the early 1960s however, world prices of rubber had declined in real terms. The World Bank recommended that Malaysia diversify its base of agricultural production and accordingly, in 1961 the Malaysian government decided to actively encourage the cultivation of oil palm. Where ever suitable soils and climates were found, oil palm was promoted even at the expense of rubber. Vast jungles were cleared and planted to oil palm, and small holders were provided with heavy subsidies to replace rubber trees with oil palm. Thus, while between 1950 and 1959 area under oil palm grew at a modest rate of 5.5 percent, between 1959 and 1972 area increased at a phenomenal growth rate of 16.2 percent.[1] Additionally, investments in research produced significant yield increases. Malaysia's entry into large scale palm oil production resulted in a surge of world production and exports of the oil (14, p. 26). In the mid-1970s, palm oil accounted for 10 percent of world production and 25 percent of world exports of vegetable oils; by the early 1980s, it increased its share to 15 percent of

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[1] Area in 1950 was 31,567 hectares, in 1959, 50,992 hectares, and in 1972 was 358,968 hectares (14). The percentages refer to compound rates of growth. Area has continued to increase through the mid-1980s.

world output and 33 percent of world exports (computed from Appendix IV.7).

Varieties of Oil Palm

Palm oil is derived from the fruit of the oil palm, which consists of three parts: the mesocarp, or the fleshy portion, the shell, and enclosed in it, the kernel. The mesocarp yields palm oil, while the kernel yields palm kernel oil.

There are three kinds of fruit, each of which differs in the relative proportions of mesocarp, shell and kernel to the fruit, and thus yield differing amounts of the oils (Figure 4.1) (14; 24):

The **Dura** fruits are characterized by a large kernel and a thick shell, which comprise 45 percent and 10 percent of the total fruit, respectively. The mesocarp content of the fruit is thus 45 percent, and oil yield as a proportion of fruit bunch weight is a low 17-18 percent.

The **Pisifera** fruits lack a shell, but contain a ring of fibers around a small kernel, which comprises one percent of the total weight of the fruit. The mesocarp oil content is thus high; however, since this variety is female sterile and produces only a few bunches between 6 and 8 years after planting, it has no commercial value.

The **Tenera** variety is a hybrid of Dura and Pisifera. The fruit has a relatively thin shell, a kernel which comprises 10 percent of the fruit, and a mesocarp which is 70-85 percent of the total fruit. Oil yield as a ratio of bunch weight is 22-24 percent and thus, compared to the Dura palms, this variety has higher oil yields per unit land area.

The discovery that Tenera was the product of a cross between Dura and Pisifera was not made until 1941. Earlier attempts to breed the high-yielding Tenera from itself were largely unsuccessful because, being a hybrid, only 50 percent of such progeny would, on average, be Tenera. The discovery gave the oil palm breeding industry an impetus and enabled the quick spread of high-yielding Tenera varieties of oil palm. In Malaysia, for example, pre-war plantings of oil palm were primarily Dura, but since then, have mainly been Tenera.

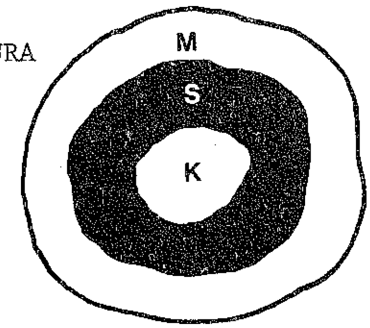
Climatic Requirements

Areas of highest productivity of oil palm are characterized by the following (4, p. 96):

rainfall of 2000 millimeters or more distributed evenly over the year.

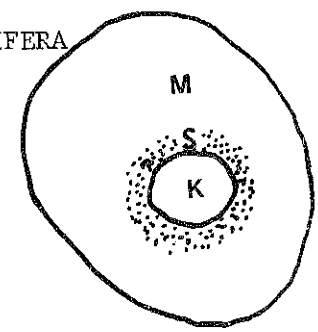
FIGURE 4.1. THE OIL PALM FRUITS*

DURA



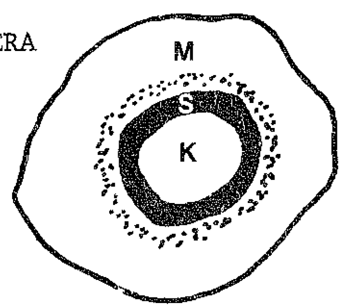
	Percent weight
Mesocarp (M)	45
Shell (S)	45
Kernel (K)	10

PISIFERA



	Percent weight
Mesocarp (M)	99
Shell (S)	0
Kernel (K)	1

TENERA



	Percent weight
Mesocarp (M)	70-85
Shell (S)	5-20
Kernel (K)	10

*Sources: H. S. Khera, The Oil Palm Industry--An Economic Study (Penerbit Universiti Malaya, Kuala Lumpur, 1976); P. D. Turner and R. A. Gillbanks, Oil Palm Cultivation and Management (The Incorporated Society of Planters, Kuala Lumpur, 1974).

a mean maximum temperature of 29° C to 33° C and a mean minimum temperature of 22° C to 24° C.

sunshine for at least five hours a day in all months and seven hours a day in some months.

Oil palm can be grown on most soils but four kinds of soils are generally thought to be unfavorable, these are: poorly drained soils, lateritic soils,[2] very sandy coastal soils, and deep peat soils (4). Nevertheless, oil palm can be profitably cultivated under suboptimal conditions because it produces more oil per hectare than any other source of vegetable oil. As Figure 4.2 indicates, the only areas in India that satisfy the rainfall and temperature requirements are the western coast and the Andaman and Nicobar Islands.

The plantations are generally found in contiguous land areas. Oil palm fruits must be processed within 24 hours of harvest because the fruits have an enzyme, lipase, which starts to break down the oil into free fatty acids; and the higher the free fatty acid content, the harder it is to process. Therefore, the processing unit needs to be located within easy transporting distance to the site of production. A large capacity processing unit serves several hundred hectares of oil palm, and this factor, combined with the high costs of transportation, requires that the production area be contiguous.

Oil Palm in India--A Brief History

Palm oil finds major uses in the soap, candle and tin plate industries. In addition, it is used extensively in margarines, salad oils, shortenings, cooking oils, confectionery and ice cream. Palm kernel oil is used in the manufacture of soap and in a variety of edible products, and is a close substitute for coconut oil (95).

Imports of palm oil into India have taken place since the early 1960s. They have played an increasing role in the vegetable oil economy following import liberalization in 1978, when imports of palm oil jumped to a high 375,100 tons. Since then, annual imports have continued to remain well over 400,000 tons (Appendix IV.6). Commercial production of oil palm was, on the other hand, unknown in India until recent times.

Oil palm was introduced to India in 1834 when an ornamental tree was planted in the Sibapore Botanical Gardens in Calcutta (81). However, it was only in 1958 that the first experimental "African Red

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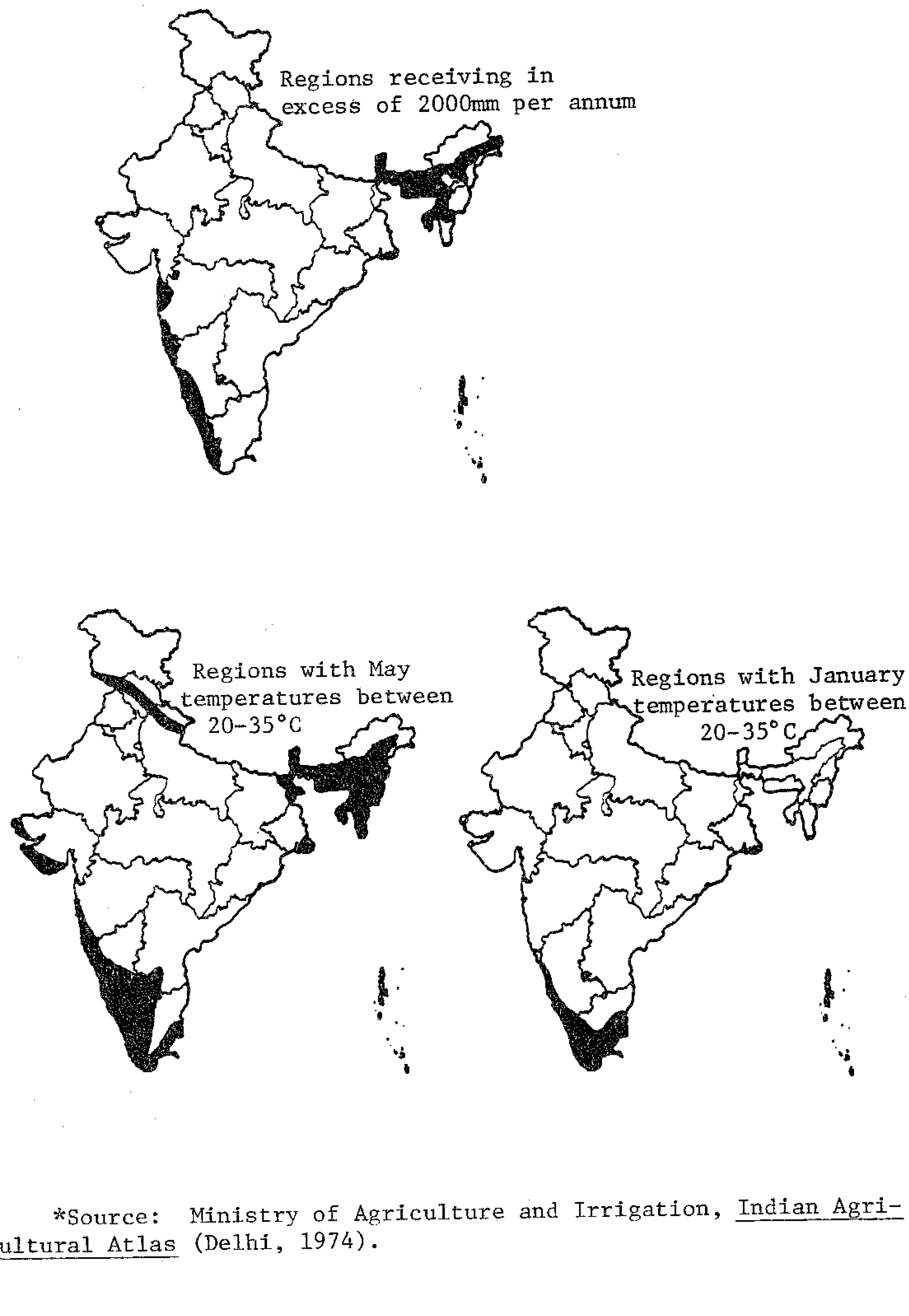
[2] Lateritic soils are defined here in the sense of soils that tend to dry out rapidly in the dry season, causing palms to suffer drought conditions even when the annual precipitation has been normal.

FIGURE 4.2. INDIA: AREAS SATISFYING THE CLIMATIC REQUIREMENTS FOR OIL PALM CULTIVATION*



*Source: Ministry of Agriculture and Irrigation, Indian Agricultural Atlas (Delhi, 1974).

Oil Palm" plantation was set up by the Indian Central Oilseeds Committee at the Pepper Research station in Thodupuzha, Ernakulam district, Kerala (51). Ernakulam has an annual rainfall of 4000 millimeters distributed over 8-9 months and temperatures ranging from 21° C to 35° C over the year; it is therefore climatically suited to the cultivation of oil palm (104). Accordingly, in January 1961, the following plantings were made at the research station (51):

Variety	Number of seeds sown
Dura X Dura	2,052
Dura X Pisifera (Tenera)	2,100
Dura X Tenera	1,038

Further plantings of Malaysian and Nigerian Dura and Tenera were made in 1962, 1963, 1965 and 1969, covering a total of 40 hectares. Some trial plantings were also made in Andhra Pradesh. Early agronomic studies of the performance of these plantings concluded that oil palm cultivation was certainly feasible in India (82; 83).

During the early 1960s, private industries (notably, Hindustan Lever, Incorporated) exhibited an active interest in oil palm cultivation; however, "plans remained on paper only," mainly because of the lack of response from the Indian Government to the initiative. As an editorial to the Indian Oil and Soap Journal pointed out, "... paucity of funds was not the problem... [and] comprehensive technical and commercial data too had been collected" (62).

It was not until 1971 that an attempt was made to diversify the base of oilseed production through oil palm. Commercial cultivation on 120 hectares was started under the auspices of the Plantation Corporation of Kerala, Limited.[3]

In 1973, a study team formally evaluated the prospects for oil palm cultivation in India based on the performance at the Thodupuzha Pepper Research Station. The report concluded that oil palm cultivation was feasible in certain parts of India and could yield two and a half tons of oil per hectare and an annual net return of 17 percent on investment. The report also pointed out that because of the three-month dry period in winter, "one cannot expect the yields as obtained in Malaysia and Sumatra, where there is virtually no dry period throughout the year" (56). In subsequent years, as the scope of cultivation expanded, a separate company, Oil Palm India, Limited, was formed with headquarters in Kottayam, Kerala.

A total of 2000 hectares of forest land was allocated for oil palm cultivation in Punalur taluk of Quilon district, which is located just

[3] The Plantation Corporation of Kerala is a public sector institution set up in 1962 to manage government-owned plantations--its main responsibilities involve rubber and cashew cultivation.

north of Trivandrum district (Figure 4.3). Temperatures and rainfall at Punalur satisfy the minimum requirements for the cultivation of oil palm even though the soils are lateritic and, therefore, suboptimal. While Punalur is not the only location which meets the climatic requirements for the cultivation of oil palm, it is one of the few areas that has sufficiently large tracts of contiguous land available for cultivation.

There are five estates at Punalur, which have a total of 3,705 hectares under oil palm (25):

Estate	Area planted (hectares)
Yeroor	
Yeroor	1,752
Maravinchira	329
Chithara	944
Kulathupuzha	
Kulathupuzha	400
Arippa	280
Total	3,705

Yeroor estate is the earliest and is the only one that has started commercial yielding. Of the total 1,752 hectares that had been planted at Yeroor, 560 hectares were mature as of June 1986. Commercial production had not yet begun on the other estates. For this reason, the rest of this discussion focuses on Yeroor plantation.

Oil Palm in Kerala--Yeroor Estate[4]

All of Yeroor estate is planted to high-yielding tenera seeds of various origins as indicated in the following table:

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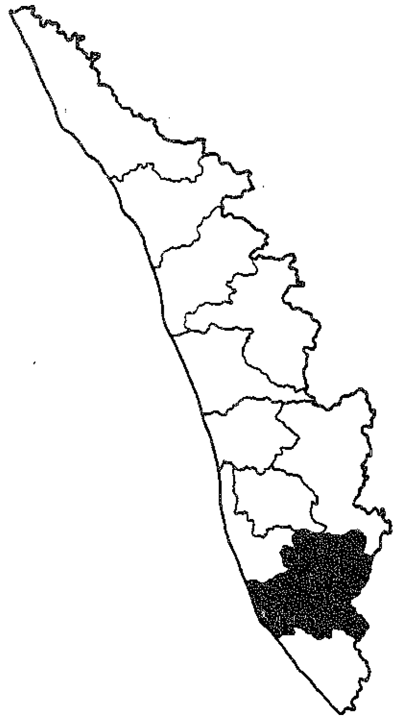
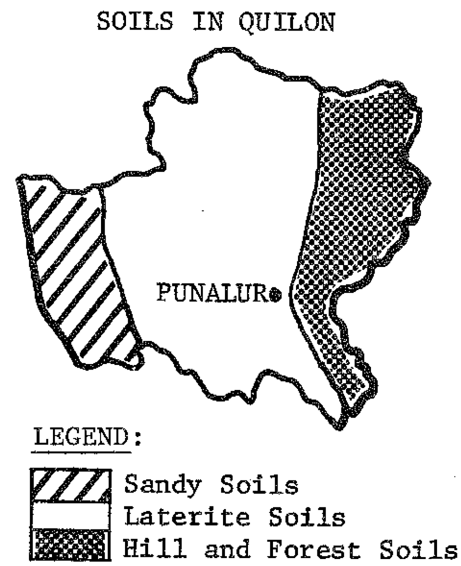
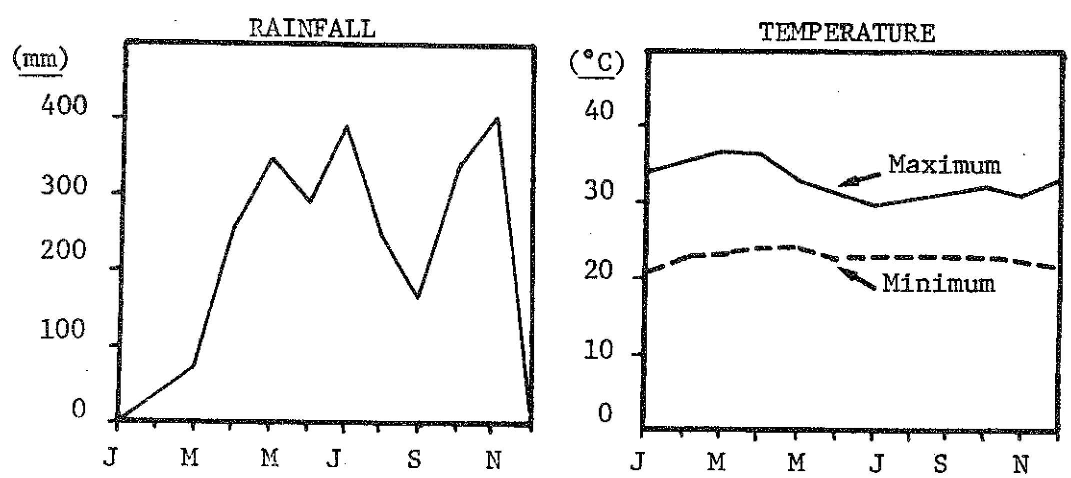
[4] Most of the data for this section were gathered from the records maintained by Oil Palm India, Limited, Kottayam, and from discussions with their staff during July-August 1983. Supplementary data were obtained in June 1986. Some inconsistencies in the data--which are yet to be resolved--do exist, but these do not influence the major conclusions.

FIGURE 4.3. QUILON DISTRICT: SOILS, RAINFALL AND TEMPERATURES AT PUNALUR TALUK*







*Source: Kerala Department of Agriculture, Bureau of Economics and Statistics, Kerala in Maps (Trivandrum, Kerala, 1978).

Year	Hectares Planted	Country of Origin
1971	120	Malaysia
1972	202	Nigeria
1973	225	Nigeria
1975	503	Nigeria
1979	417	Papua, New Guinea
1980	283	IRHO[5]
Total	1,752	

The seeds are grown in a nursery in polythene bags and transplanted between 12 and 18 months of age. Trees are placed in a triangular fashion nine meters apart so as to accommodate 135 trees per hectare. This corresponds to the optimal spacing usually suggested: greater or lower tree densities would result in lower yields (4, p. 411). The trees are placed in pits of one meter radius in order to facilitate water and fertilizer absorption. Leguminous crops such as Pueraria are grown in between until the trees mature.

Fertilizers are applied regularly to every palm and constitute one of the more expensive operations on the plantation. Experiments carried out at Yeroor indicate that yield responses to fertilization are significant, with 800 grams of Nitrogenous, 400 grams of Phosphatic and 1800 grams of Potassic fertilizers per year being required for maximum fresh fruit bunch production (FFB) (26). The actual fertilization of mature palms is as follows (25):

	First application (grams per mature palm)	Second application
Nitrogenous	500	--
Phosphatic	1,250	--
Potassic	750	750

Harvesting of the palms is done when most of the fruits have changed color from dark purple to orange. A chisel is used for younger (smaller) palms and a sickle attached to a long bamboo pole is used for the taller palms. The harvested bunches are deposited on the sides of the roads to be picked up by trucks that transport bunches to the mill for processing.

A Superintendent is in charge of the nearly 1,752 hectares at Yeroor estate; in addition, there are four assistant superintendents and twenty-one field staff. In 1983, Yeroor estate employed 422 laborers on a permanent basis, or nearly one person for every four hectares. The workers are paid Rs. 14.38 per day (in 1983) and wages are adjusted every quarter. However, additional labor is hired as needed on a contractual basis, especially after the monsoons to control

[5]Institut de Recherches pour les Huiles et Oleagineaux.

weeds. Despite the labor intensity of this operation and the high wages prevalent in Kerala, manual weeding is evidently a cheaper operation than the application of weedicides.

Production Characteristics

The overall performance of Yeroor estate has been poor. A detailed examination of production patterns reveals that the major contributing factors to this are water deficits and poor genetic stock. However, yield variations seem to exist between trees of different origins: in particular, the Malaysian stock have so far proved to be better than the African stock. This information then can be used to devise means of increasing total productivity.

The plantation has suffered frequently from moisture stress. Droughts have occurred in years when most of the plantation consisted of immature trees which are particularly susceptible to dry weather; the result has been that nearly 50 percent of the plantation is affected in one way or another by drought (49). In 1985/86, only 92 of the 120 hectares planted in 1971, 189 of the 202 hectares planted in 1972 and 63 of the 225 hectares planted in 1973 were mature. This excludes palms that will suffer from stunted growth as a result of the drought.

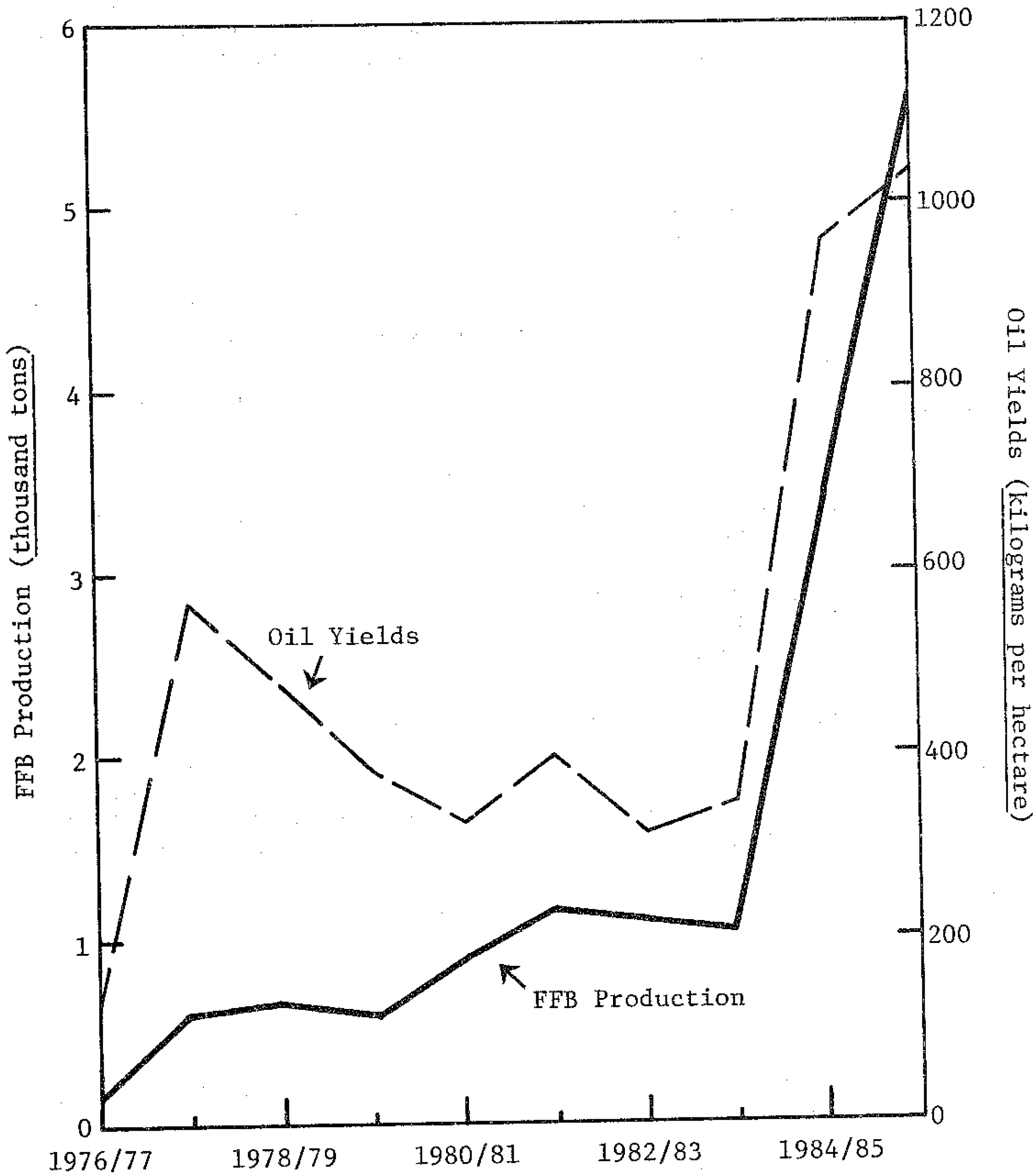
The droughts have also had a direct impact on production. As indicated in Figure 4.4, although the extent of mature area has been increasing steadily every year, fresh fruit bunch production actually declined from the previous year's level in three years, 1979/80, 1982/83 and 1983/84.

The yield performance of the estate has therefore been poor compared to what was anticipated in the project report as evidenced by the following data (76; 77):

Year from planting	Actual Yields (ton fresh fruit bunch/hectare)	Predicted Yields
5	1.1	1.9
6	3.4	3.7
7	3.0	6.2
8	2.8	9.9
9	1.9	12.4
10	2.3	12.4
11	2.2	12.5

One problem in examining trends in actual yields in sections where the plantation has been phased in, is that in a given year, the mature area consists of trees of various ages. This is especially important in young plantations where the difference in yield between a five year old tree and a ten year old tree is likely to be significant. A ten year old plantation where the majority of the trees are five years old

FIGURE 4.4. YEROOR PLANTATION: PRODUCTION AND YIELD OF OIL PALM, 1976/77-1985/86*



*Source: Appendix III.1.

cannot be expected to yield amounts as high as a plantation where all the trees are ten years old. The comparison between actual and predicted yields at Yeroor is therefore not strictly valid because the actual phasing program was quite different than what was envisaged in the project report. Enough information is available, however, to back-calculate anticipated yields by age of the tree from the phasing schedule. In particular:

$$\text{Total production}_j = \sum_i \text{Area}_{ij} \times \text{Yield}_{ij},$$

where i = age of trees (5,6,...,11)
j = production year (1,2,...,6)

Then, since total production$_j$ and area$_{ij}$ are known, the predicted age-wise yields y_i can be sequentially estimated across production years by first calculating yield$_5$, using this information to calculate yield$_6$, and using the information on both yields to calculate yield$_7$, and so on.[6]

Actual yields are approximated by taking an average of all trees of the same age (across production years), weighted by the respective mature areas. Thus,

$$\text{Yield}_i = \left(\sum_j \text{Area}_{ij} \times \text{Yield}_{ij}\right) / \sum_j \text{Area}_i$$

where i and j are as above.

The two sets of yields are also compared with yields experienced in Nigeria (where there is a strong dry season) and those found in Malaysia (where there is virtually no dry season). As indicated in the following table, actual yields in recent years have been less than half of what was anticipated in the project report; they are also less than half the yields obtained in Nigeria, and little over one tenth of the yields obtained in Malaysia (4, p. 238):

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[6] That is, since in the first year of production, the plantation consists only of trees that are five years old, therefore,

$$\text{Yield}_5 = \frac{\text{Total Production}_{j=1}}{\text{Area}_{j=1}}$$

and from the second year of production:

$$\text{Yield}_6 = \frac{\text{Total production}_{j=2} - (\text{Area}_{i=5,j=2} \times \text{Yield}_5)}{\text{Area}_{i=6,j=2}}$$

and so on.

Year from planting[a]	--------Yeroor-------- Actual[b]	Predicted	Nigeria (Strong dry season)	Malaysia (No dry season)
	(tons of FFB per hectare)			
3	N.R.	0	0	12.80
4	N.R.	0	6.40	24.50
5	0.44	1.85	7.40	31.30
6	2.12	6.74	10.80	30.50
7	1.99	13.27	8.60	33.10
8	2.69	10.15	10.30	33.10
9	3.31	10.15	10.30	33.10
10	3.69	10.15	10.30	33.10
11	4.61	10.15	10.30	33.10

a: Year of Planting = 0
b: Estimates probably underreport true yields.
N.R. Not Reported.

In addition, there is a high degree of spatial and temporal variability in yields. An examination of fresh fruit bunch yield data by year of planting (Figure 4.5) indicates that the 1971 area has had the highest yields. This is the area that was planted to Malaysian seeds; areas planted to Nigerian seeds (1972 and 1973 areas) have lower yields, but have less variability.[7] The better yield performance of the 1971 area is reflected in the higher average yields of the whole plantation initially. However, as the lower yielding 1972 and 1973 areas began to constitute a larger proportion of total mature area, average yields fell, and then recovered because of increased yields on all the plantings.[8] Nevertheless, even the highest-yielding Malaysian stock are not performing well--yields in India are less than 40 percent of what is commonly obtained in Malaysia.

Apart from droughts which occur once in a while, the region is also subject to a three to four month dry period every year. The

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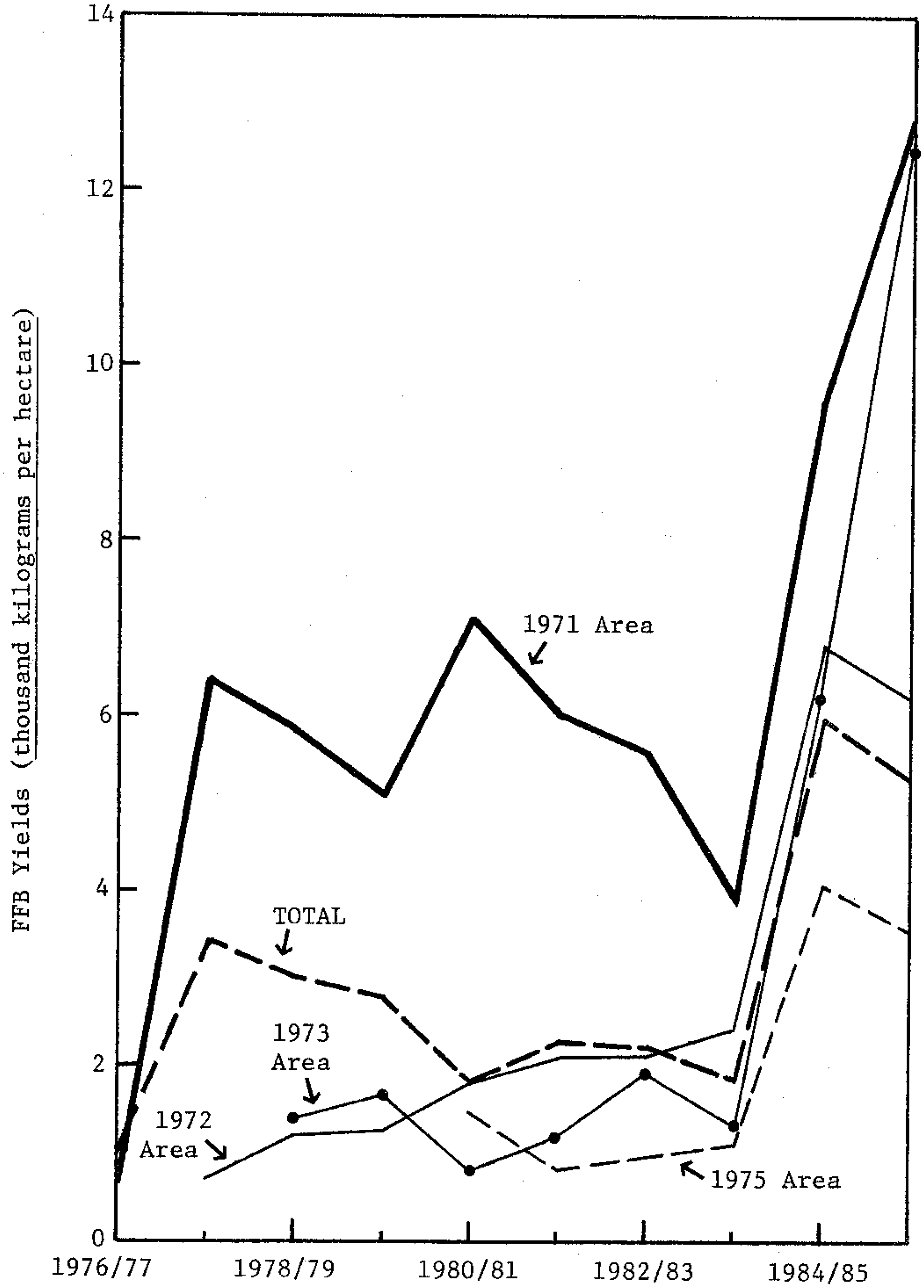
[7] In 1985/86, the 1973 planting yielded an amount as high as the 1971 planting; however, it is not clear whether this high yield will be sustained, or whether it represents a freak performance.

[8] A FAO report cautions against making comparisons between the various planting stock. It indicates that although the original plantings come from different types of seeds, no records have been maitained on the origin of the seeds used for gap filling--replacing unsuccessful palms in the various areas. In addition, it may well be that the Malaysian stock exhibit vigorous yields soon after planting, and that the African stock take longer to achieve the same high yields. The point remains that what ever the reason, the 1971 area has had the highest yields among all the planting areas.

FIGURE 4.5. YEROOR PLANTATION: YIELD OF OIL PALM BY YEAR OF PLANTING, 1976/77-1985/86*



*Source: Appendix III.2.

result is a high variability in yields within the year. The month-to-month variability in production is shown in Figure 4.6.[9] It has been suggested that there is a definite relationship between rainfall and productivity in that the troughs in production occur approximately eight to nine months after the occurrence of troughs in rainfall; this phenomenon appears to be true of the plantations at Yeroor (24). However, the extent to which the variability in rainfall explains variability in production is not known, because yields in any case are not expected to stabilize until the tenth year.

The distribution of production by month is presented in Figure 4.7. March and April are the most productive months, accounting for over 30 percent of the annual production in three of the five years. Only 1981/82 had a roughly equal distribution of yield throughout the year.

The plantation at Yeroor is characterized by low and variable yields which can be traced back to two underlying causes. First, moisture stress at the plantation, both annual and seasonal, has been severe. The poor water retention capacity of the soils, moreover, has only served to exacerbate the moisture deficit. Second, the shortage of good seed material, as evidenced by the low yields of even the Malaysian stock and the apparent disparity between yields of areas planted to Nigerian seeds vis-à-vis those of areas planted to Malaysian seeds, has further contributed to the overall low yields of the plantation. Nevertheless, it is worth noting that these yields are still higher than what would be obtained from groundnut cultivation.

Processing

At the extraction mill, the fruits are first sterilized in a cylindrical vessel through steam heat. This treatment inactivates the enzyme lipase and prevents formation of emulsions in the crude oil. In addition, it serves to loosen the fruits in the bunches and soften the fruit peel. Next, the fruits are stripped from the stalks and fed into a digestor into which steam is injected to convert the fruits into pulp and break down the oil-bearing cells. The digested fruits are then put in a cage-like structure and by the action of a hydraulic piston that presses into the cage, water, oil and some cell debris are released. The oil is poured along with hot water into a clarification unit where the mixture is heated at 85° C, so that the oil floats up on top and is decanted and pumped into storage tanks.

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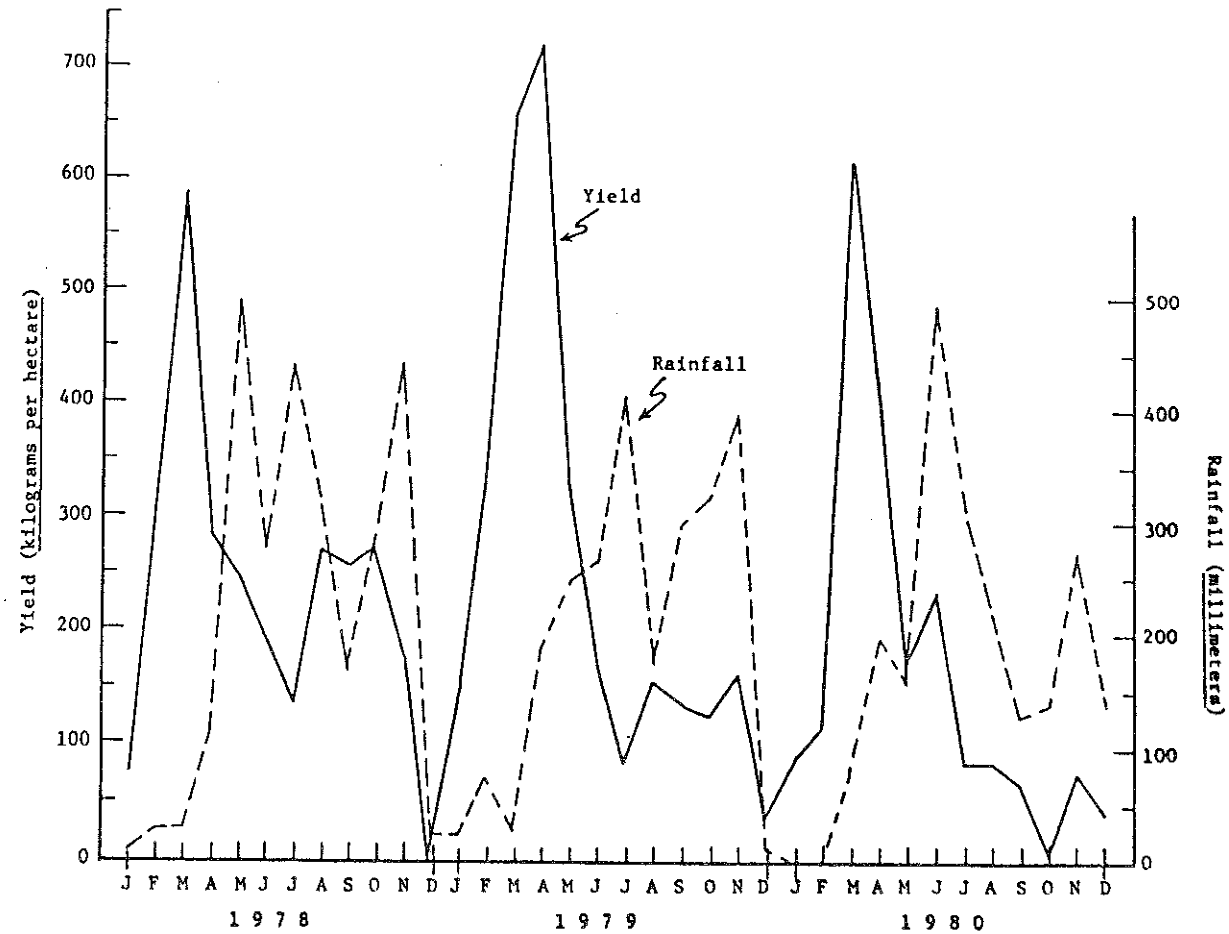
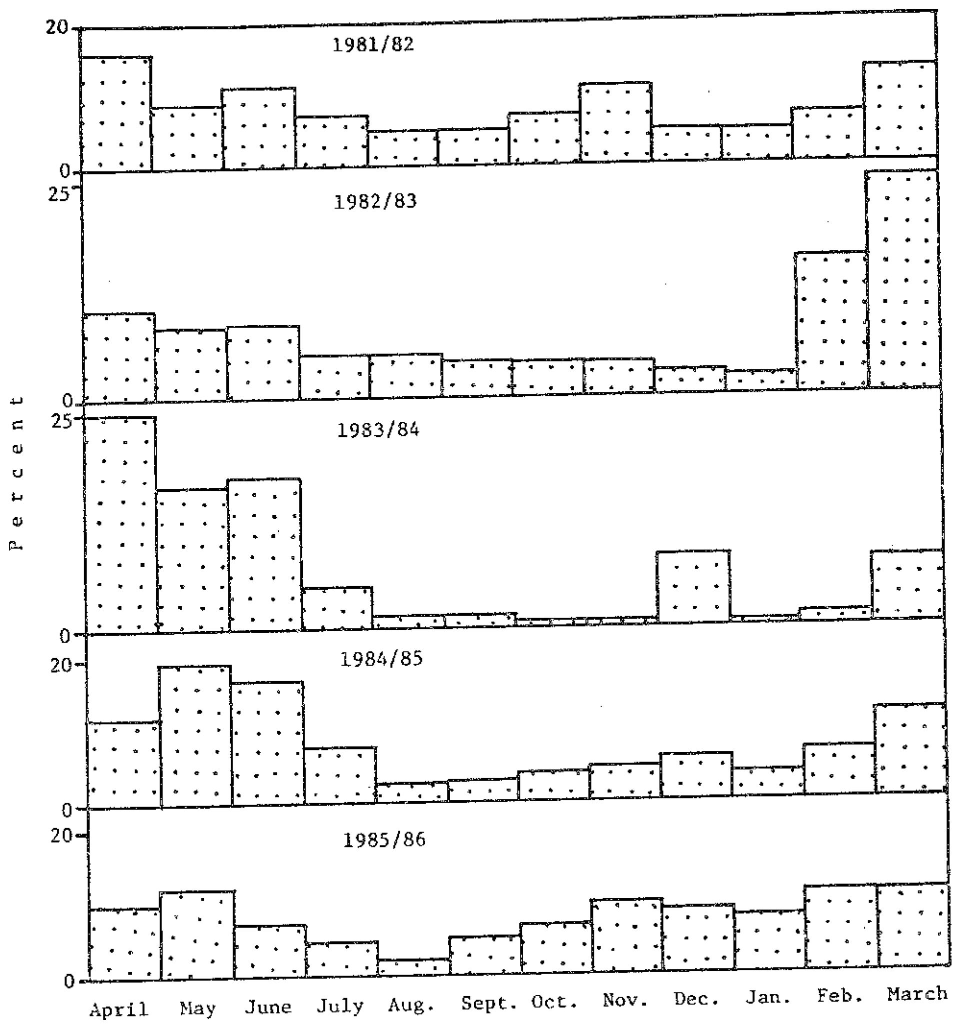
[9] The production year for oil palm is April through March. Increases in mature area are reported at the start of the new production year, and this figure has been used in the computation of month-wise yields throughout the year. Therefore the yield differences between March and April of the same calendar year are exaggerated because a different denominator has been used for each of the two months. Data on increases in mature area by month are not available.

FIGURE 4.6. YEROOR PLANTATION: OIL PALM YIELDS AND RAINFALL, 1978-1980*



*Sources: Appendices III.3, III.4.

FIGURE 4.7. YEROOR PLANTATION: MONTHLY FFB PRODUCTION AS PERCENT OF ANNUAL PRODUCTION, 1981/82-1985/86*



*Source: Appendix III.5.

At present, the unit does not extract palm kernel oil. The extraction unit is only moderately capital intensive which is an appropriate choice of technology given the scale of operation. It has the capacity of processing three tons of FFB per hour, operating three eight-hour shifts per day, depending on the availability of electricity. Full capacity is utilized only in the peak months of March and April. This system is reasonably efficient, and most losses occur prior to extraction. Extraction rates range from 13.8 to 18 percent and correspond closely to what was expected in the Project Report. There are plans to build two more processing units with capacities of 10 and five tons of FFB per hour at a total cost of Rs. 50 million (25).

After extraction, the oil is stored in two 10-ton storage tanks or barrels and awaits marketing. The oil sells for Rs. 137 per barrel, but the buyer is responsible for its transportation. The oil is not edible, and most of it used in the manufacture of soap by Kerala Soaps and Oils, a public sector enterprise.

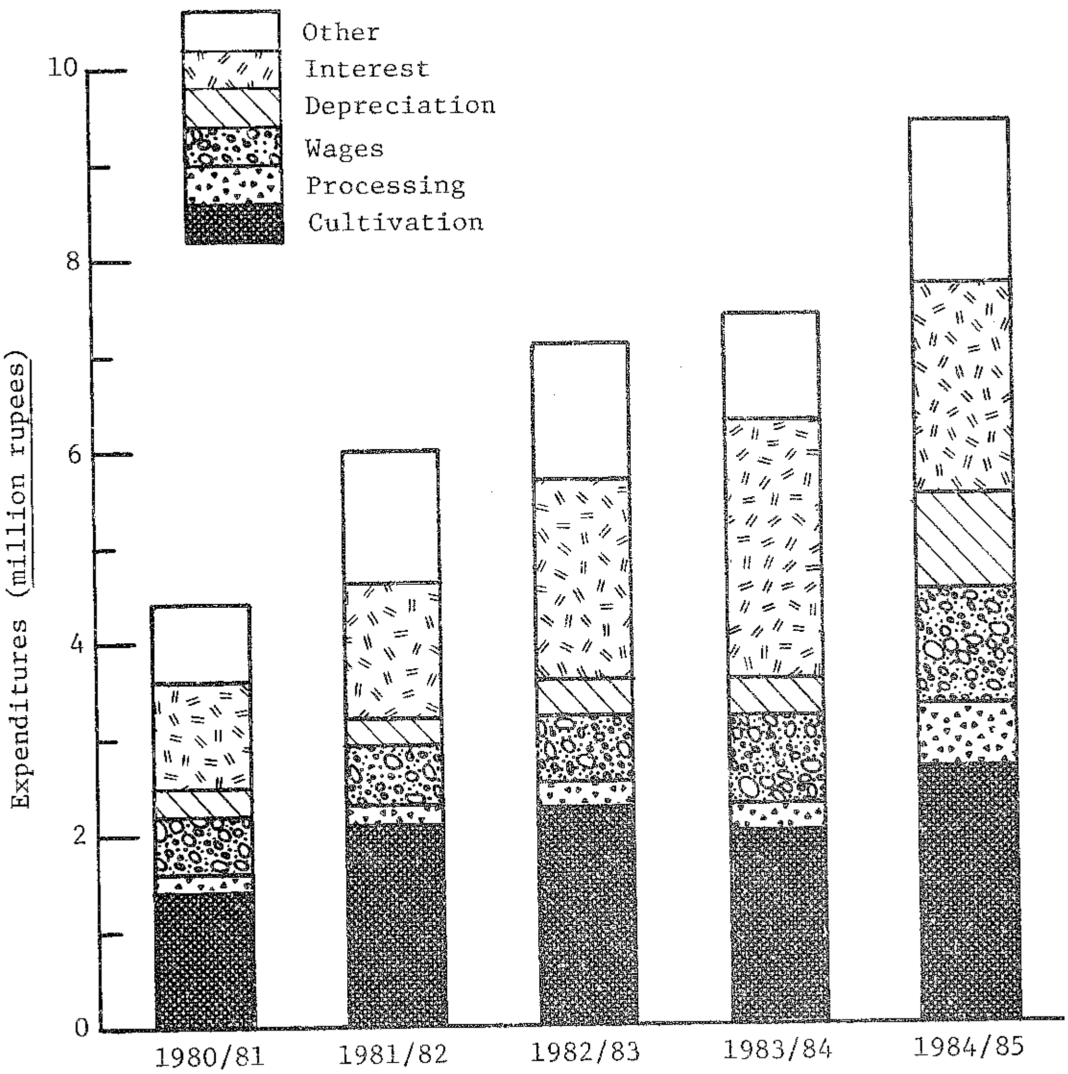
Economics of Cultivation

The pattern of production has had a major impact on the economics of oil palm cultivation: the following discussion reveals that although the cost structure at Yeroor is similar to that found in Malaysia, low yields have meant that all but the area planted to Malaysian stock (and therefore the plantation as a whole) have been operating at a loss.

Figure 4.8 presents the expenditures incurred by Oil Palm India, Limited, as reported in their profit and loss accounts. Total expenditures have grown steadily to over Rs. 9 million in 1984/85. The largest component of this expenditure was the cost of cultivation (averaging 30 percent), followed by interest payments on loans (comprising over 20 percent of total expenditure in most years), and wage payments (typically comprising 11-12 percent of all costs). The three thus constitute nearly two-thirds of total expenditure. Other important components of total cost include processing expenses and depreciation.

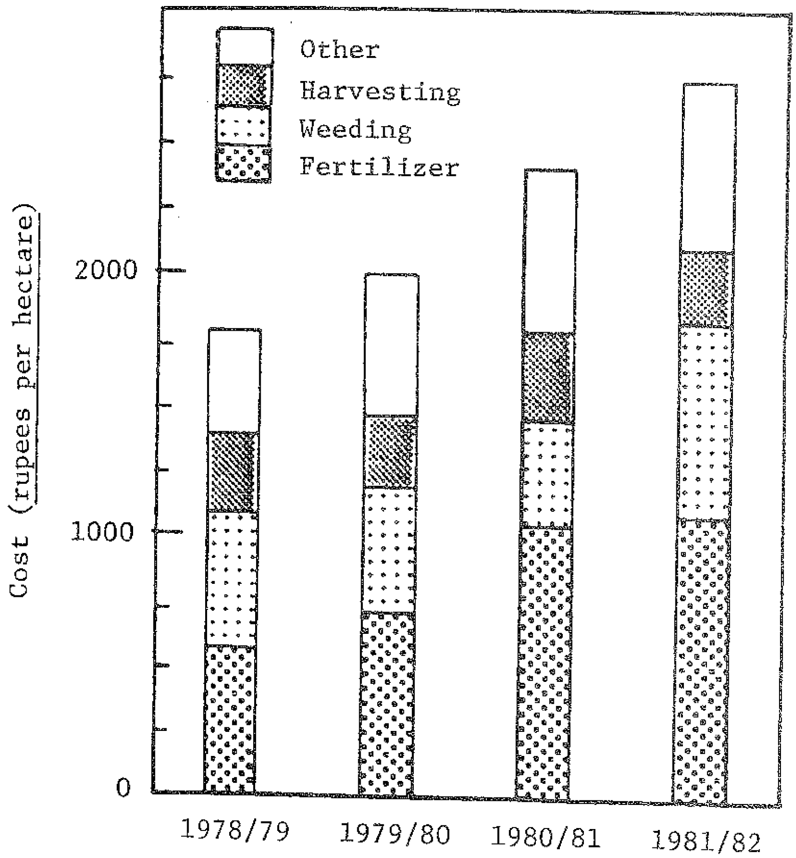
Details of the largest component of total cost, namely, costs of cultivation for mature plantations at Yeroor, are presented in Figure 4.9. Total cultivation costs increased from a little less than Rs. 400,000 in 1978/79 to Rs. 1.4 million in 1981/82. The main component of this cost was fertilization, ranging between 30 and 40 percent, followed by weeding costs, which ranged between 16 and 34 percent of the total, and harvesting costs ranked third, averaging 12 percent of the total cost. This break-down corresponds roughly to that prevalent in Malaysia, where fertilization costs typically constitute over half of total cost, followed by weeding and slashing costs.

FIGURE 4.8. YEROOR PLANTATION: TOTAL EXPENDITURES, 1980/81-1984/85*



Source: Appendix III.6.

FIGURE 4.9. YEROOR PLANTATION: CULTIVATION COSTS OF MATURE OIL PALM, 1978/79-1981/82*



*Source: Appendix III.7.

It is also instructive to compare costs of cultivation by area of planting (Figure 4.10). Mature plantations are typically more expensive to maintain than immature plantations, the difference amounting to nearly Rs. 1,000 per hectare. The 1971 area in both instances has in general higher per hectare costs than the other areas.

The primary source of revenue is the sale of palm oil. Total revenue generated from sales in 1985/86 was Rs. 5 million, well below the maintenance costs incurred for cultivation. Oil Palm India, Limited thus turned in losses for its first eight years of operation; losses in 1984/85 amounted to Rs. 2.6 million. It is expected, however, that the company will break-even within the next two years.

The price of crude palm oil is fixed by Oil Palm India, Limited at around Rs. 8,000 per ton: the price of rice bran oil plus Rs. 600.[10] Rice bran oil is a close substitute for palm oil in use, except that rice bran oil requires hydrogenation, whereas palm oil does not, this is a factor taken into consideration in the determination of the Rs. 600 markup. This price is, nevertheless, less than what the government charges; imported palm oil is sold to wholesalers for Rs. 8,500 per ton. These prices are also less than the wholesale prices for coconut oil and groundnut oil.[11]

A comparison of costs and revenue per hectare for each of the areas reveals, as shown in Figure 4.11, that the 1971 planting, by virtue of its higher yields, consistently had the highest profits.[12] Profit margins for the other areas are low and even negative in some years. These profitability margins do not even take into account processing costs or capital expenditures.

If capital expenditures are incorporated into the analysis through the computation of an internal rate of return, the plantation's financial viability becomes even more problematical. An IRR is only as sound a measure as the assumptions that underlie it. It is therefore reasonable to compute an IRR for a range of yield and price assumptions. A pessimistic projection would be that yields continue to be so low that at peak productivity, the plantation would yield only one ton

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[10] Data refer to 1982-1983.

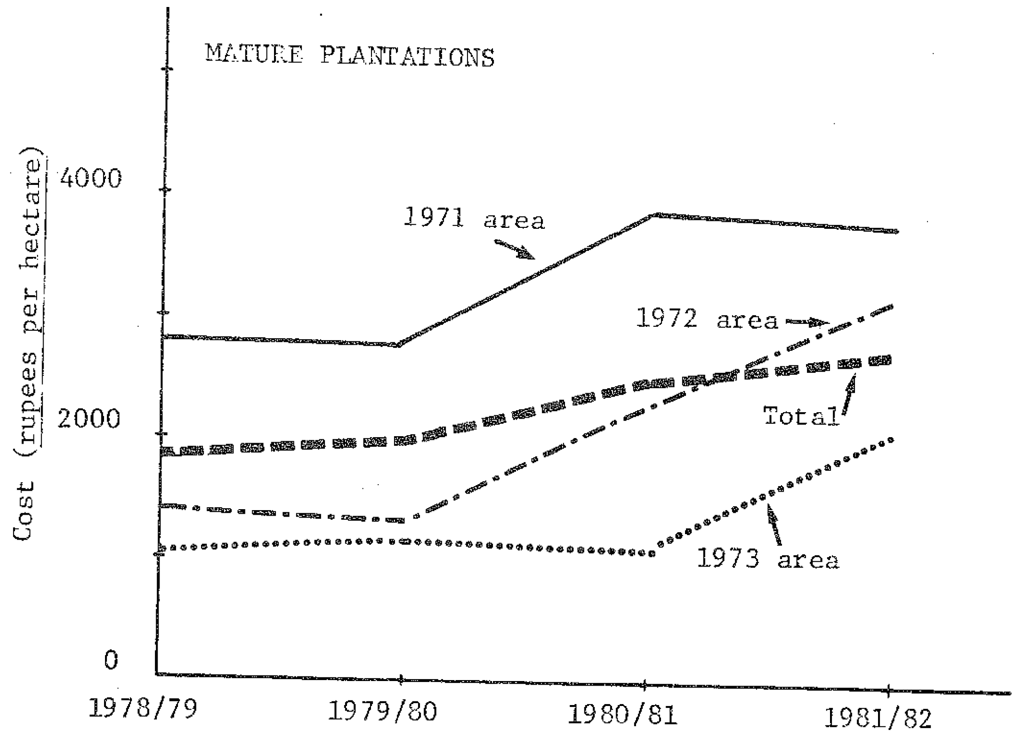
[11] In 1981, the price of coconut oil in Kozhikode, Kerala was Rs. 13,775 per ton and that of groundnut oil in Rajkot, Gujarat was Rs. 10,398 per ton.

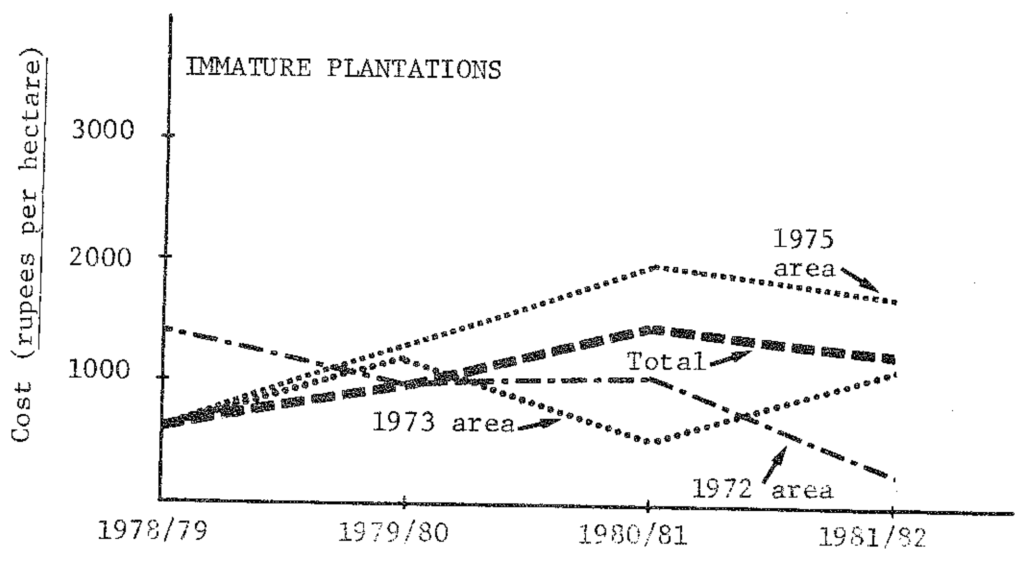
[12] The amount of total revenue generated per hectare on each of the different plantings can be estimated by multiplying the FFB yields with a uniform extraction rate and sale price:

$$\text{Total Revenue/ha}_{\text{area}} = \text{FFB/ha}_{\text{area}} \times \text{extraction rate} \times \text{price per ton}$$

Costs refer to maintenance expenditures only.

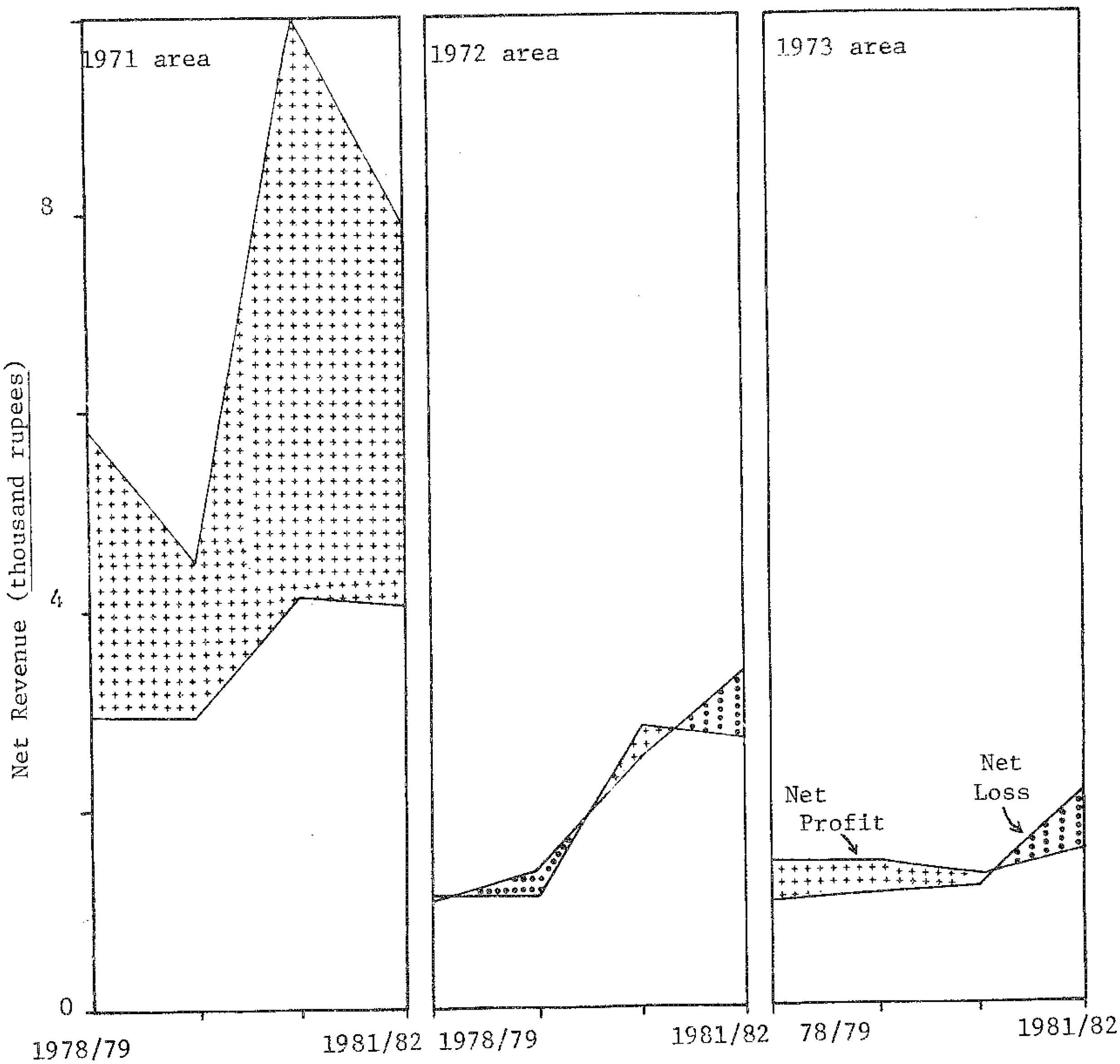
FIGURE 4.10. YEROOR PLANTATION: CULTIVATION COSTS, BY TYPE OF PLANTING STOCK, 1978/79-1981/82*





*Source: Appendix III.8.

FIGURE 4.11. YEROOR PLANTATION: NET REVENUE FROM OIL PALM, BY TYPE OF PLANTING STOCK, 1978/79-1981/82*



*Source: Appendix III.9.

of oil per hectare, and that the sale price of oil remains at Rs. 8 per kilogram. A more optimistic view would be that yields on the plantation will improve through the provision of dry season irrigation and ultimately approach the yields obtained in the area planted to Malaysian seeds of 2 tons of oil per hectare, and that prices rise to Rs. 10 per kilogram (as they did in 1985 and 1986) (25).

In order to derive the cost-benefit stream, since actual data on costs and income are available for the first eleven years, it is appropriate to use these figures, deflated by the consumer price index. For later years, it seems reasonable to assume that production costs per mature hectare will be invariant at the eleventh year level, since harvesting costs typically comprise only 10-15 percent of total cultivation costs and the major costs of fertilization and weeding are unlikely to change with higher yields. Income may be calculated by simply multiplying the yields and prices delineated above. The results are as follows:[13]

Case	IRR (percent)
Current trends persist	
Prices are Rs. 8 per kilogram	
Oil yields are 1 ton per hectare	3
Prices increase	
Prices are Rs. 10 per kilogram	
Oil yields are 1 ton per hectare	11
Yields increase	
Prices are Rs. 8 per kilogram	
Oil yields are 2 tons per hectare	20
Prices and Yields increase	
Prices are Rs. 8.5 per kilogram	
Oil yields are 2 tons per hectare	24

If, once again, one takes the nominal interest rate of 12 percent to be the opportunity cost of obtaining capital, then the above results indicate that persistent low yields will ultimately render the project unprofitable. On the other hand, modest increases in yields would result in significant increases in revenue to the extent that the project would be financially profitable. It is worth noting that the higher yield assumption of 1.5 tons per hectare is not unreasonable and represents in fact only 40 percent of the yields commonly experienced in Malaysia. Some price increases are called for, but this increase is limited by the prices of competing oils.

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[13] Detailed calculations are in Appendix V.5.

Oil Palm in the Andaman and Nicobar Islands[14]

The Andaman and Nicobar Islands (Figure 4.12) are a series of islands aligned North to South in the Bay of Bengal northwest of Malaysia. The Andaman Islands are very hilly and almost entirely covered with dense forests. The Nicobars are also covered with forests but contain some stretches of flat land. While fresh water is a constraint on the Andamans, this is not the case on the Nicobars. They have a combined area of 8,293 square kilometers and comprise a single administrative unit--a union territory, administered by a Chief Commissioner in the Ministry of Home Affairs. Settlers on the Islands come primarily from Bangladesh, Sri Lanka, Burma, and Kerala. Many tribal peoples are also found on the Nicobars (9).

The geographical proximity of the Islands to Malaysia and the nearly identical climatological conditions suggest that they would be an ideal setting for the cultivation of oil palm. Annual rainfall ranges between 2,750 millimeters and 3,250 millimeters and occurs nine months of the year. Temperatures, as the following table indicates, range between 23° C and 33° C (9):

	Maximum ° C	Minimum ° C
January (coldest month)	30	23
April (hottest month)	33	23

In 1972, the National Council of Applied Economic Research concluded that "while it is apparent that it would not be possible to resort to any large scale conversion of land for raising field crops ... the scope for adopting a plantation programme of commercially valuable crops should be fully examined, especially in the Nicobars" (9).

An experimental oil palm plantation was started in 1975 by the Andaman Forest Department with a total of 160 hectares being planted during 1975 and 1976. The project was considered viable, and during 1979/80, the Andaman and Nicobar Island Forest Development Corporation was commissioned to undertake oil palm cultivation on Little Andaman Island on a commercial basis. The anticipated capital cost of the project was Rs. 91 million over a period of 15 years for cultivating a total of 2,400 hectares of oil palm. The Central Government's budgetary allocation in the Sixth Five Year Plan (1980-85) for this purpose was Rs. 30 million (10). As of 1984, 1300 hectares had been planted to oil palm, of which 340 hectares were yielding.

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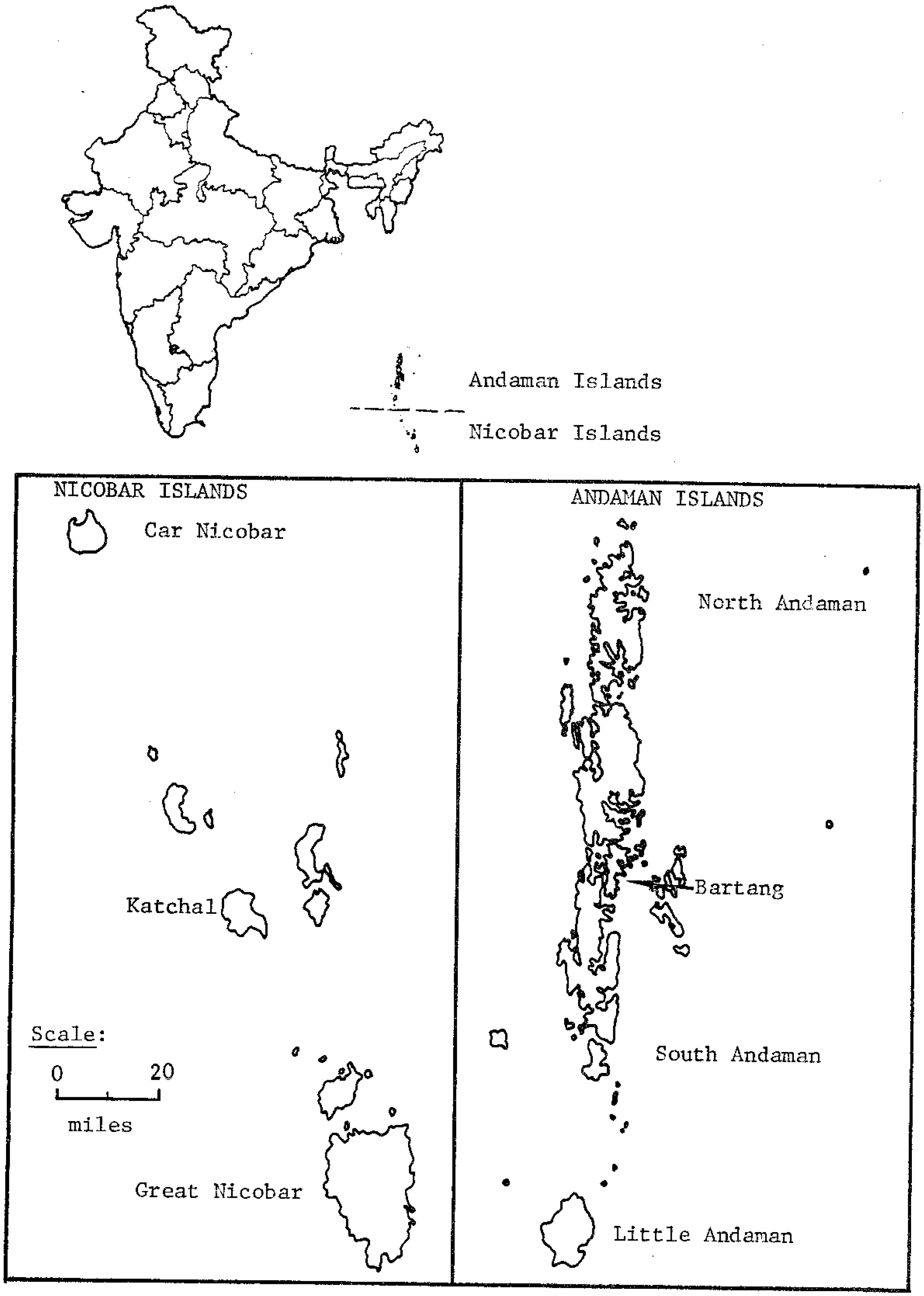
14 The discussion of oil palm cultivation on the Andaman and Nicobar Islands is necessarily limited because a visit to the islands was not possible. The data in this section are based on personal communication with the Divisional Manager of the plantations on the islands, Mr. Chakravarti (34).

FIGURE 4.12. THE ANDAMAN AND NICOBAR ISLANDS*



*Source: National Council of Applied Economic Research, Techno-Economic Survey of the Andaman and Nicobar Islands (New Delhi, 1972).

The FFB and oil yield figures for the islands compare unfavorably with yields obtained in Kerala: by the second year, FFB yields in Kerala were up to 3,404 kilograms per hectare and 3,022 kilograms per hectare in the third year, as opposed to 1,713 and 1,177 kilograms per hectare on the islands. Extraction of oil on Little Andaman Island is done by an "improved country method" and the extraction rates are much lower than those at Yeroor:

Year	FFB/hectare(mature) (kilograms)	Oil/hectare (kilograms)	Extraction rate (percent)
1981/82[a]	944	94	10
1982/83[a]	1,713	156	9
1983/84[b]	1,177	124	11

a: Mature area approximately 160 hectares
b: Mature area approximately 340 hectares

These results are perhaps not quite so surprising in view of the fact that the Andaman and Nicobar Islands have suffered from less than normal rainfall in three of the last five years. It is also hard to draw firm conclusions because yields in the first few years of production are not considered to be indicative of the general pattern.

On the other hand, the costs of cultivation per hectare are, for the most part, comparable with those in Kerala (34):[15]

Year	Total area (hectares)	Total cost (Rs. million)	Costs per hectare (Rs.)
1979/80	160	1.0	6,250
1980/81	340	1.3	3,824
1981/82	640	1.5	2,344
1982/83	640	1.7	2,656
1983/84	940	2.2	2,340

All of the nearly 80 tons of oil produced is sold, but no information is available as to who purchases the palm oil and at what price.

Prospects for Increased Palm Oil Production

Yield Increases

If the performance of the 560 mature hectares in Kerala is any indication of future trends, then clearly efforts to increase yield rates have to be an essential component of any viable expansion

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15 Unfortunately, a detailed breakdown of these costs was not available.

program. The foregoing analysis points to two major avenues through which increases in yields may be brought about.

The first involves the use of better planting material. Portions of Yeroor estate planted to Nigerian stocks have tended to be neither high-yielding nor drought resistant as compared to the areas planted to Malaysian stocks. Therefore, assuming that the current Malaysian ban on the exports of seeds will continue, efforts should be channelized into vegetatively propogating the highest yielding palms on the plantation by means of tissue culture.[16] In the long run, however, Oil Palm India, Limited must have access to high-yielding, drought-resistant varieties of oil palm. For example, although the average yield of palm oil in Malaysia is five tons of oil per hectare, yields as high as 8.5 tons per hectare have been reported in some regions (33).

The second change involves providing dry season irrigation to the plantation so as to reduce annual moisture stress. Studies have shown that such measures can raise productivity significantly. For example, an experiment conducted at the Nigerian Institute for Oil Palm Research, where rainfall patterns are presumably similar to those obtained at Yeroor, found that dry season irrigation resulted in an average 25 percent increase in yields (29):

Year	No irrigation	Irrigation in dry season	Percent increase
	(kilograms per hectare)		
1970	202	245	21.9
1971	378	523	38.4
1972	565	670	18.6
1973	177	215	21.5
1974	234	296	26.5
Average	311	390	25.3

However, in order to be effective, water in the dry season needs to be administered to the plantations consistently. Sporadic applications of water have not succeeded in increasing yields. The plantation at Yeroor has the advantage that an irrigation canal serving the Kallada Irrigation Project runs right through the plantation and can easily serve the lower reaches of the estate. It may be necessary to employ lift irrigation techniques to serve palms at the higher reaches of the plantation. This can be an expensive operation, the costs and benefits of which need to be weighed before being undertaken. The relevant data for such an analysis were not available, however, it is understood that a FAO/Banker's mission that visited India in 1978 at the request of the erstwhile Agricultural Finance

[16] Although tissue culture methods have already been worked out in the laboratory, field application procedures have not yet been established.

Corporation evaluated dry season irrigation and deemed it a worthwhile investment.

In sum, the success with which increases in the yield rate can be brought about will determine the financial profitability of oil palm cultivation, which in turn will influence the rate of its expansion.

Area Limitations

Figure 4.2 broadly delineated regions that are climatologically suited to the cultivation of oil palm. It is understood that the FAO/Banker's Mission made a detailed assessment of the areas in India where oil palm could be grown under rainfed conditions and identified the five southern districts of Kerala, namely, Alleppey, Ernakulam, Kottayam, Quilon and Trivandrum, and the Andaman and Nicobar Islands as suitable, citing high dry-season moisture deficits as the key limiting factor in the selection of sites. Most other regions in India have a six to seven month dry period and while it is conceivable that these regions be brought under oil palm through irrigation systems, it is highly unlikely because providing water for such a long period continuously is extremely difficult and expensive.

In the Kerala districts, acreage under oil palm can be increased by either replacing competing crops such as coconut and paddy, or by clearing forest lands. Evidence indicates, however, that this increase is not likely to occur.

Replacing coconut in Kerala: A case can be made that since the districts suitable for the cultivation of oil palm are also those most affected by the root wilt, the affected coconut palms can be replaced with oil palm trees (assuming that the oil palm tree is not affected by the disease). Such a substitution, however, would only be possible when the perceived economic returns from oil palm cultivation exceed those from coconut cultivation. Table 4.1 compares the costs and returns per hectare from the cultivation of these two crops for a "typical" year of peak production. Despite the fact that capital requirements for coconut differ significantly from those of oil palm (the former being a small holder crop and the latter being a plantation crop), capital costs are ignored in the comparison. Once again, three different scenarios are envisaged.

Under fair conditions, similar to present circumstances, coconuts enjoy a clear superiority over oil palm in terms of net revenue. Under good and ideal conditions, the margin is diminished although coconuts are still the favored crop. This bias, from the farmers' viewpoint, is strengthened by several considerations. First, there is no minimum land requirement for coconut. Second, the coconut tree has a longer life and a smaller capital requirement. Third, the coconut tree can be put to other uses (for example, the fruit can be consumed as food in times of food scarcity, the leaves can be used for thatching roofs and so on) and a value on these uses has not been taken into account in the

TABLE 4.1. COSTS AND RETURNS TO CULTIVATION FOR COCONUT AND OIL PALM

(Rs. per Hectare, 1982 prices)

COCONUTS (WEST COAST TALL)			OIL PALM		
Costs	Revenue	Net Return	Costs	Revenue	Net Return
Fair management:					
1,340[a]	6,825[b]	5,485	6,404[c]	8,000[d]	1,596
Good management:					
3,268[e]	9,750[f]	6,482	6,404[c]	1,2750[g]	6,346
Ideal management:					
7,210[h]	21,000[i]	13,790	6,404[c]	17,000[j]	10,596

a: Only harvesting costs (from CPCRI)
b: Assumes average yield of 4,559 nuts per hectare (state average for 1979/80-1980/81) and sale price of Rs. 1.5 per nut.
c: Maintenance costs per hectare actually experienced.
d: Assumes one ton of oil per hectare and sale price of Rs. 8/kilogram.
e: Assumes only fertilizer and harvesting costs (from CPCRI)
f: With peak productivity of 6,500 nuts per hectare and sale price of Rs. 1.5 per nut.
g: Assumes 1.5 tons of oil per hectare and sale price of Rs. 8.5 per kilogram.
h: Includes irrigation, fertilizer, labor.
i: Peak bearing ability of 80 nuts per palm and 175 palms per hectare with sale price of Rs. 1.5 per nut.
j: Assumes 2.0 tons of oil at peak productivity and a sale price of Rs. 8.5/kilogram.

analysis. The oil palm does not enjoy these advantages, and therefore, it appears unlikely that coconut will be replaced by oil palm. Moreover, the difference in oil yields per hectare between oil palm and coconut actually being experienced is not significant enough to merit any intervention on the part of the government to encourage oil palm cultivation at the expense of coconuts. This conclusion differs markedly from that of the management of Oil Palm India, Limited, who are confident of oil palm's ability to replace coconut once the former's yields stabilize (25).

Clearing forest lands: Kerala and the Andaman and Nicobar Islands are among the few places in India where there are evergreen forests. Attempts to expand acreage in these areas must take into account the environmental impact of such a measure. This analysis presumes that there will be no negative impact.

Among the five southern districts of Kerala suited to oil palm, only two, Quilon and Trivandrum, have any appreciable amounts of forest land (107):

District	Area under forests as a proportion of total geographical area (percent)
Alleppey	0
Ernakulam	4
Kottayam	4
Quilon	50
Trivandrum	23
STATE	28

Of the nearly 236,000 hectares in Trivandrum and 50,000 hectares in Quilon under forests, it is estimated that approximately 20,000 hectares are suited to the cultivation of oil palm. In the Andaman and Nicobar Islands, nearly 60,000 hectares are thought to be appropriate for oil palm. These plantations would be located on the islands of Little Andaman, Katchal, Great Nicobar and Bartang. It is not clear why much of the remaining 600,000 hectares under forests on the islands can not be put to oil palm.

Thus a total of 80,000 hectares can be brought under oil palm, an amount which is only 13 percent more than the annual addition to oil palm area expected in Malaysia over the next fifteen years. However, these forests are protected by the Forest Conservancy Act of 1980 which requires prior approval of the Central Government before virgin forests may be cut down. The Act is said to have created problems in the past: for example, because of it, lands delineated for oil palm cultivation in Kerala were not released in time, and nearly 200,000 seedlings imported from Nigeria got overgrown (27; 49). Although this experience points to the need for better planning on the part of the management of Oil Palm India, Limited, the point remains that this law is serving to limit the expansion of oil palm area.

Supply Projections

Oil palm production in India is a monopoly enterprise of Oil Palm India, Limited. The traditional price-dependent, supply-response model which assumes that the producer is a price taker, is therefore not appropriate in this case because the monopolist is in fact a price setter. The monopolist in theory determines quantity by equating marginal revenue to marginal cost, and then uses the demand function to set price. In practice, the upper limit on quantity is set by the amount of land available for oil palm cultivation, and that on price is set by that of the closest competing oil. Moreover, unlike the pure monopolist, profit maximization is not the sole objective of a government owned monopoly.

It is not possible to adequately consider all of the above factors because of paucity of data; therefore, as with coconuts, the projections of the supply of palm oil have to be based on alternative area and yield assumptions. The three area assumptions are derived as follows. First, if the Forest Conservancy Legislation acts as a block to any expansion in oil palm area, then only the 3,700 hectares already planted would remain under this crop. Alternatively, if all of the area currently allocated for oil palm cultivation is planted, then 12,400 hectares (10,000 in Kerala, and 2,400 in the Andaman and Nicobar Islands) would result. Finally, if all the regions climatically suited to rainfed cultivation are exploited, then 80,000 hectares would be under this crop.

As for yields, a low projection would be to assume that the management of the plantation will not improve and that oil yields would remain at the one ton per hectare actually obtained at Yeroor (25). If however, there is dry season irrigation, and no severe annual droughts are experienced while the plantation is young, then medium yields of 1.5 tons per hectare would be achieved. Furthermore, if there is a greater use of better planting material, then oil yields as high as 2 tons per hectare would be possible. These area and yield assumptions suggest that production in 2000 and 2010 would be:

	2000[a]		2010
	Low area (3,700 ha)	Medium area (12,400 ha) (tons)[c]	High area (80,000 ha)
Low Yields (1 ton/ha)	3,700 (0.07)	12,400 (0.24)	80,000 (1.17)
Medium yields (1.5 tons/ha)	5,550 (0.11)	18,600 (0.35)	120,000 (1.75)
High yields (2 tons/ha)	7,400 (0.14)	24,800 (0.47)	160,000 (2.34)

Notes:

a: Production of all vegetable oils is 5.23 million tons.

b: Production of all vegetable oils is 6.84 million tons.

c: Figures in parentheses refer to percent of total vegetable oil production accounted for by palm oil.

These projections indicate that because of area and water limitations, the production of palm oil under even the most optimistic scenario in India would constitute an insignificant proportion of the total production of vegetable oils in 2000 and 2010, and is not likely to eliminate imports of palm oil in the near or distant futures.

CHAPTER V
IMPORTS VERSUS DOMESTIC PRODUCTION: SOME POLICY IMPLICATIONS

The Indian grain revolution has generally resulted in lower proportions of the gross cropped area being devoted to the oilseeds as compared to the foodgrains. In areas where the grain revolution has not been successful, this result does not hold, but, nevertheless, the oilseeds compete with the foodgrains for land. Therefore, because India is a land-scarce country, any attempts to increase production of annual oilseeds through area expansion would occur at the expense of foodgrains, thereby adversely affecting food self-sufficiency. For this reason, the tree sources of vegetable oil, coconuts and oil palm, were examined. It was found that while oil palm does not compete with any of the cereals, coconut does compete with paddy.

The major constraints to coconut production were identified as the root-wilt disease, aging palm population, and the lack of proper maintenance. However, coconut cultivation is quite profitable in Kerala, and, as indicated by the analysis of mixed coconut and rice farming, given a choice, the farmer is likely to plant more area to coconuts as compared to rice, barring further spread in the root-wilt. With modest increases in yields, the production of coconuts and coconut oil in Kerala alone could rise several fold. However, since the base of production is small relative to the entire vegetable oil economy, this relatively optimistic scenario for coconut oil would leave unaltered the projections of "all other oils" made in Chapter 2.

The primary constraint to oil palm cultivation in India is the lack of suitable areas where it can be grown under rainfed conditions. Only a total of 80,000 hectares located in Kerala and the Andaman and Nicobar Islands have been identified as suitable. In addition, in areas where oil palm is grown, dry season moisture deficits and the lack of quality planting materials have suppressed yields and consequently inhibited production. Even if all the lands suited to the cultivation of oil palm were planted and yields improved, palm oil would not contribute more than two percent to the total expected production of vegetable oil in 2000 or 2010.

Thus the two tree crops would under optimal circumstances contribute only 13 percent to total vegetable oil production in the future. Projections made in this study indicate that total supply is likely to be 5.2 million tons in 2000 and nearly seven million tons in 2010 (Table 5.1). When compared with demand projections, it is evident that if past trends continue, domestic vegetable oil supply will not be sufficient to meet the demand, and the deficit will be 2.8-4.5 million tons in 2000 and 3.4-6.6 million tons in 2010.

TABLE 5.1. INDIA: DEMAND AND SUPPLY PROJECTIONS FOR VEGETABLE OILS TO 2000 AND 2010

(million tons)

	2000	2010
	SUPPLY	
Groundnut	2.06	2.46
Rapeseed-Mustard	1.26	1.74
Sesame	0.26	0.31
Coconut	0.65	0.79
Palm	0.03	0.09
Others	0.86	1.46
Total	5.23	6.84
	DEMAND	
Low estimate	8.0	10.2
High estimate	9.7	13.4
	DEFICIT	
With low demand	2.77	3.40
With high demand	4.50	6.60

Imports or Domestic Production?

The issue remains as to whether it would be cheaper to import vegetable oils or to encourage domestic production. The Government of India has accorded high priority to oilseeds development, and ranked it second in the "Twenty Point Programme" for economic development.[1] The advantages of successfully achieved import substitution are principally three. First, there is the security of self-sufficiency. This security is particularly important in cases where a political price has to be paid for imports.[2] The second benefit lies in the employment generation associated with import substitution. Again, this is not a major concern in India because the perennial crops, due to their low labor requirements, are not good sources for employment, and the oil processing industries do not employ large numbers of people. The third advantage lies in the relative immunity from exchange rate fluctuations, provided none of the inputs used in the production process have to be imported. The costs of import substitution, on the other hand, especially when accompanied by import restrictions, lie in the higher prices that consumers have to pay for the commodity and the associated loss in consumer surplus.

One quick way of evaluating the desirability of imports is through a comparison of the import and domestic prices of each vegetable oil. An import price is calculated by dividing quantity of imports into value. Where an import price is not relevant--as in the case of coconut, rapeseed and groundnut oils, whose imports have been infrequent--the international market price may be used. Such a comparison is made in Figure 5.1 for the period 1970-1982.

Coconut oil prices in India have been nearly twice as high as international prices in most years. The domestic price has also been rising at a rate faster than that of the international price. Moreover, part of the increase in international price is also explained by the devaluating rupee. Similarly, palm oil prices in India for the four years for which data on domestic prices are available have been about half again higher than import prices. In addition, because the costs of production per unit output of palm oil in India have been higher than the sale price, the difference between domestic costs of production and import price is even higher.

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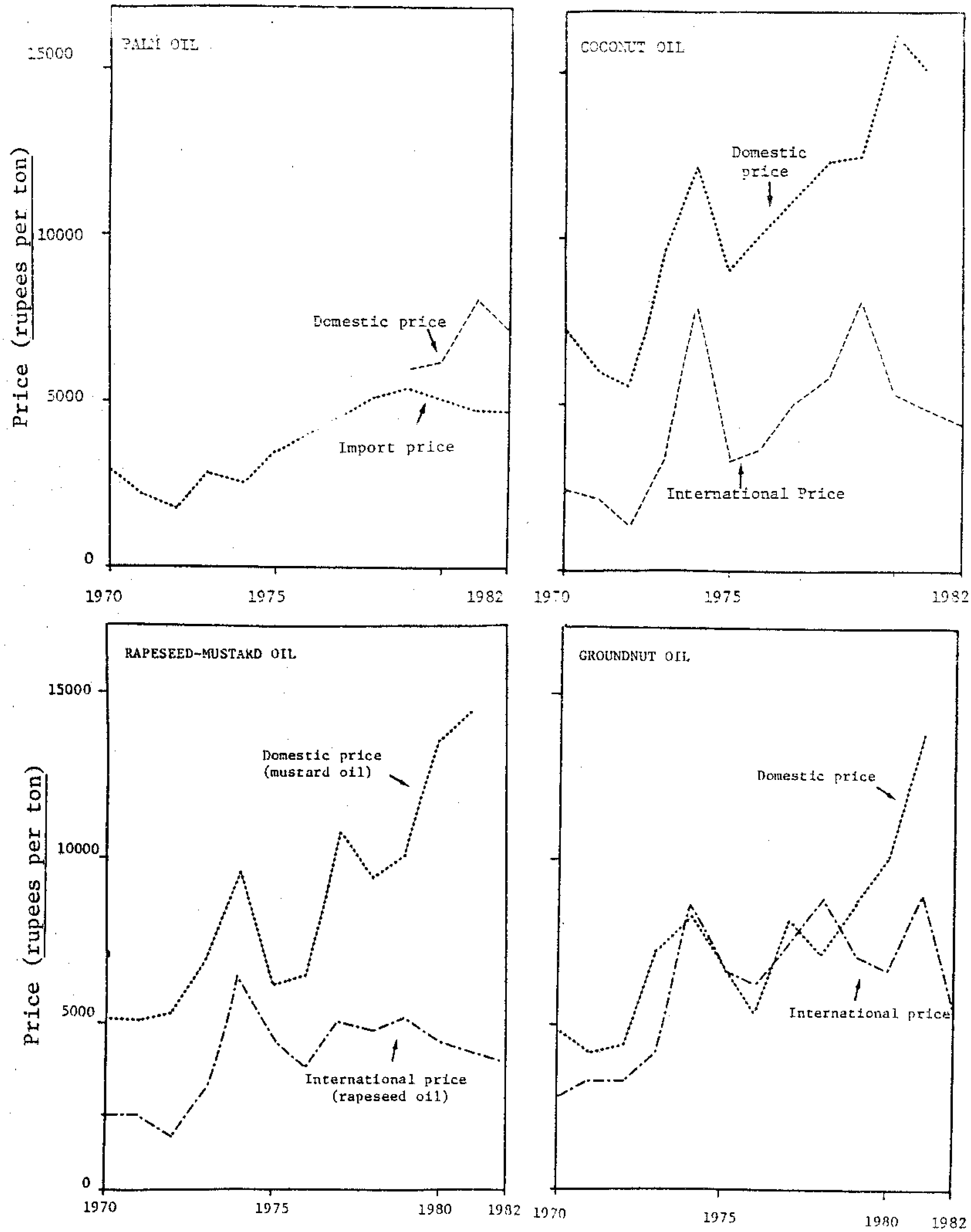
[1] The first priority has been accorded to the expansion of irrigated areas (<u>111</u>).

[2] For example, the Agriculture Minister in 1965, Mr. C. Subramaniam complained that President Johnson's policy of approving P.L. 480 shipments only a month at a time was designed to put pressure on the Indian government to implement programs that were agreed to in a secret "Treaty of Rome" and had created a good deal of political "irritation" in India (<u>22</u>, pp. 53-54).

FIGURE 5.1. IMPORT AND DOMESTIC PRICES OF VEGETABLE OILS, 1970-1982*



*Source: Appendix IV.8.

As for the annual crops, the domestic price of mustard oil has been over one and a half times that of the international price of its close substitute, rapeseed oil. Furthermore, the domestic price of mustard oil has grown at a rate faster than that of the international price; in fact, international prices have fallen since 1978 in rupee (and therefore also in dollar) terms, while domestic prices have continued to rise. Groundnut oil prices in India have also been above international prices except in years when India has imported groundnut oil.[3]

Thus, in every instance, the unit cost of importing oils has been less than the domestic wholesale price, both before and after import liberalization in the late 1970s, and, therefore, one can conclude that ceteris paribus, augmenting domestic supplies with imports would be more economical. Availability of storage facilities at ports and transportation to major demand locations are also not likely to pose problems.

This conclusion would obviously be altered if the price advantage imports currently enjoy were to change. This can happen in several ways. First, if there is a technological breakthrough, the resultant increase in supply could lower the domestic price of the relevant oil. Second, if the rupee were to depreciate with respect to exporting country currencies, then import prices in rupee terms would increase. Third, the world supply and demand of vegetable oils could change such that international prices would go up. This could happen if demand were to increase at a rate faster than that of supply, if supply for some reason (such as disease) fell, or if trade restrictions were imposed.

An examination of the trends in international prices of the two oils that dominate world trade, palm oil and soybean oil (Figure 5.2), indicates that because of increasing supplies, real prices for both oils have generally declined since the mid-1970s (except during 1984 when all oil prices increased). This downward trend has been much more evident in the recent past, as is suggested by the price levels during the first 11 months of 1985. The decreases have occured in the case of soybean oil primarily because of increased EEC demand for meal which has resulted in greater crushings, and in the case of palm oil as a result of higher area and better rainfall in Malaysia. Current indications are that although this precipitous decline will not continue, prices are unlikely to rise in real terms because export availabilites are expected to be higher in the future (50).

World production and exports of vegetable oils have been rising over the past decade (Figure 5.3). Production has increased by nearly one and a half times, while exports have increased two-fold as a result of Malaysian palm oil, soybean oil from Brazil and the United States,

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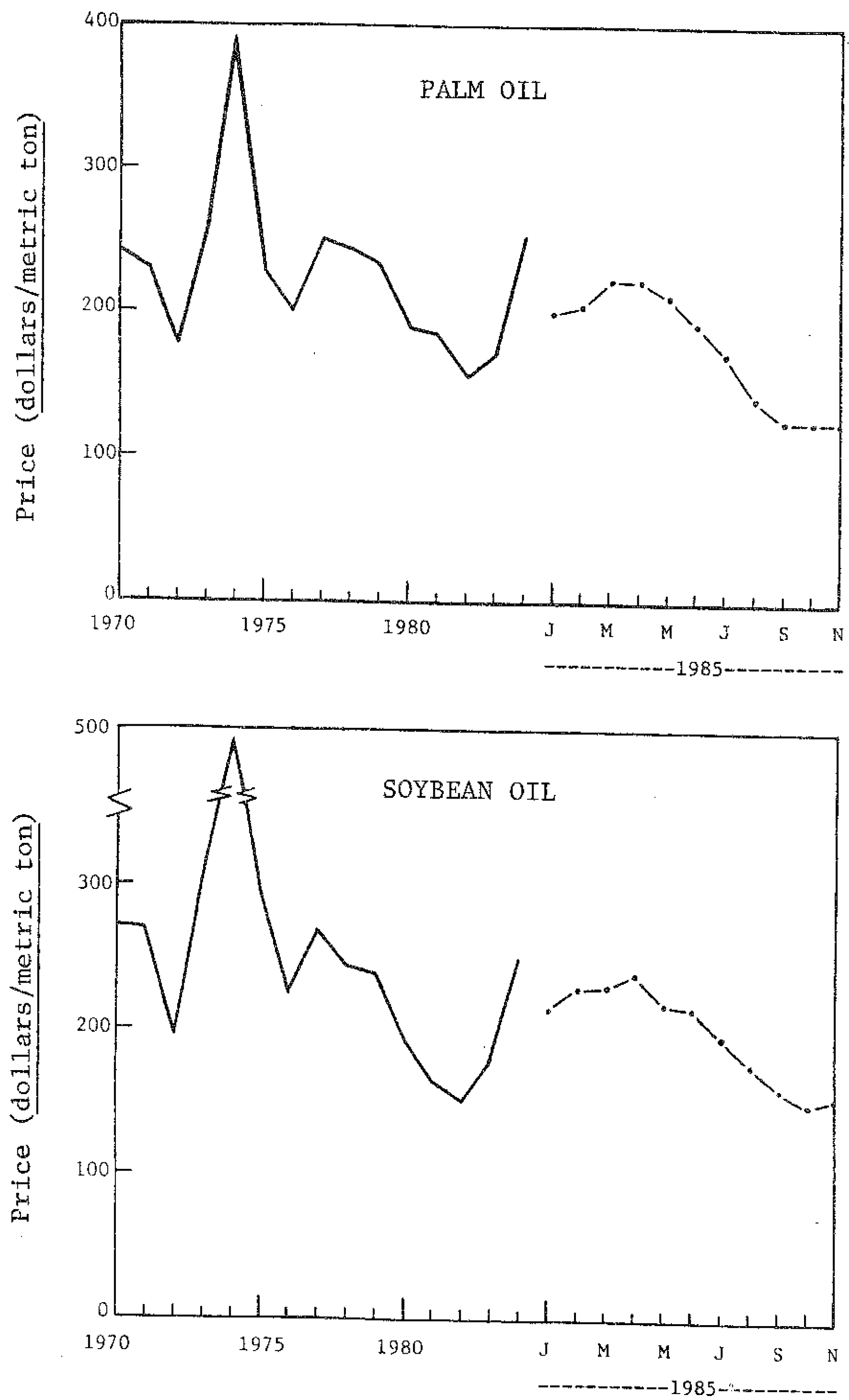
[3] Since data on domestic prices of soybean oil are not available, a similar comparison for soybean oil could not be made.

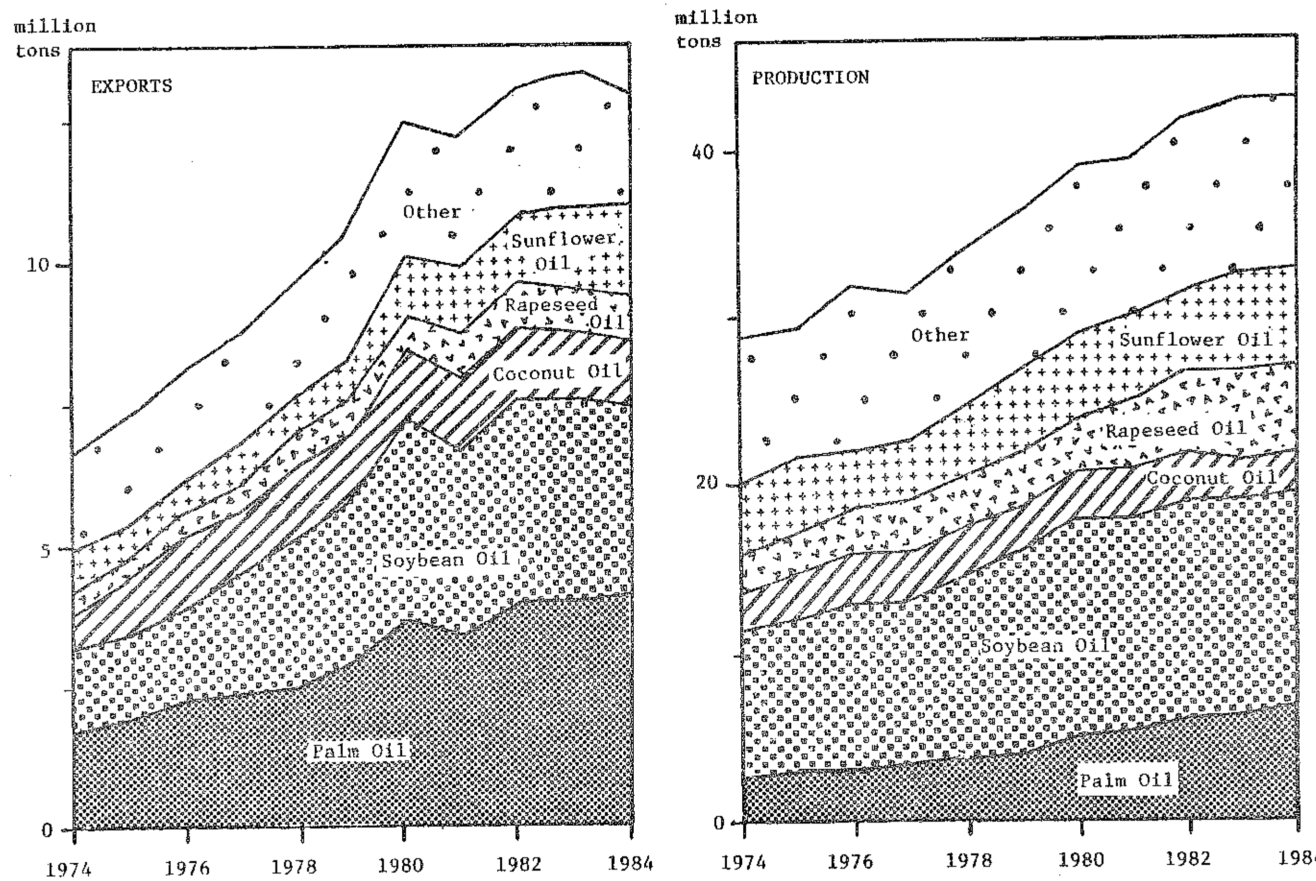
FIGURE 5.2. INTERNATIONAL PRICES OF PALM AND SOYBEAN OILS, 1975-1982*

(1969 U.S. dollars/MT)



*Source: Appendix IV.9.

FIGURE 5.3. WORLD EXPORTS AND PRODUCTION OF MAJOR VEGETABLE OILS, 1974-1984*



*Source: Appendix IV.7.

and to a lesser extent, rapeseed and sunflower oils. There is no reason to expect that future export availabilities will fall. Mediumterm projections made by the Food and Agriculture Organization indicate that the volume of international trade in vegetable oils will continue to increase (although at a slower rate than in the 1970s), led primarily by palm oil, the production of which is expected to grow at seven percent per annum. This increase in palm oil is anticipated because recent developments in cloning, tissue culture and success with weevil pollination are resulting in higher yields (44). Area under oil palm in Malaysia alone is projected to increase by 60,000 hectares per year, reaching two million hectares by the year 2000. Furthermore, there has already been a rapid expansion in new plantings of oil palm in that country which will reach peak productivity in the next five to twenty years: even if not a single additional tree were to be planted, production of palm oil will continue to increase for several years. Therefore, according to the F.A.O., "the issue which is likely to become the most important in the development of the Malaysian oil palm sector is that of finding markets for the increased quantities that will become available for export" (46, p.3). The output of other oils is projected by the F.A.O. to grow at a more modest rate: soybean oil at 2.1 percent per annum; and cotton, groundnut, rapeseed and sunflower oils at between 2.5 and 4.0 percent per annum. Analysts at the U.S.D.A. concur with these projections. Increasing availabilities, combined with a slow-down in the demand for vegetable oils world-wide, are resulting in downward pressure on prices, thereby making vegetable oil imports even more attractive (45; 50).

Moreover, closing the demand-supply deficit of approximately three million tons through imports would not be likely to result in significantly pushing up the world prices of vegetable oils. This is because Indian imports currently account for only ten percent of the total trade in vegetable oils; and a deficit of three million tons in the next 15 years would account for no more than 20 percent of _current_ world trade. In addition, import values of edible oils constitute only about five percent of the total value of imports into India (121). If there are no real increases in the prices of vegetable oils, then a doubling of imports would result in an increase in the share of edible oils in the total value of current imports to no more than ten percent.

Policy Implications

At present, India does not enjoy a comparative advantage in oilseeds. Importing vegetable oil would be economical, but requires the expenditure of scarce foreign exchange. However, India will be operating in a buyers' market and can minimize foreign exchange expenditure by entering into long-term bilateral barter agreements. It can make use of the fact that most future increases in trade are likely to come from developing countries (41), and export commodities in which it does enjoy a comparative advantage, in exchange for vegetable oils. For both countries, the gains from such trade are likely to be higher than those from trade on a commercial basis, particularly if lower transportation costs (because of geographical proximity) are involved or if protection from wide swings in exchange rates is sought. Malaysia is a country with whom trade on a barter basis could be particularly of mutual benefit. Over sixty percent of Malaysia's imports consists of manufactured commodities and investment goods such as machinery, items that India currently exports (40). India's Seventh Plan for economic development recognizes the need for industrial exports, and identifies engineering goods as one of the major sources of increased export earnings (11). Given India's large pool of skilled labor, there should be no problem in meeting Malaysia's specific requirements in exchange for palm oil. India can also offer its traditional export items such as coffee, tea and textiles in barter. Already, the Government of India has reached an agreement with the Government of the Philippines to import oil in exchange for textiles and iron ore (84). Indonesia is yet another nation which may be amenable to long-term barter exchange arrangements.

As for countries with whom barter agreements are not feasible (because the benefit from barter does not accrue to the other nation), India can at least hedge against sudden changes in exchange rates by engaging in long-term contracts with trading agencies of exporting countries. Furthermore, India can augment foreign exchange earnings by actively encouraging the export of oilcake and meal (the domestic prices of which are lower than international prices) until such time as their use within India becomes popular.

These recommendations are not intended to undermine the importance of improvements in oilseed production. There is a need for better coordination of research information. Regular contact and exchange of knowledge with international centers may well assist in the development of better yielding oilseeds. Within the country, oilseeds should be fully integrated into crop research and extension programs of the Agricultural Universities and the State Agricultural Departments. The requisite institutions are in place; what is necessary is to mobilize and utilize them efficiently.

But while research to achieve technological breakthroughs in the traditional oilseeds and endeavors to identify and tap nontraditional oilseeds should continue, greater imports of vegetable oils are inevitable and not necessarily undesirable.

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APPENDIX I.
STATISTICS RELATING TO THE COMPETITION BETWEEN CEREALS AND OILSEEDS

APPENDIX I.1.
INDIA: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
GUJARAT

(thousand hectares)

Year	Groundnut	Bajra	Cotton	Gross Cropped Area
1956/57	863	2,005	1,897	9,791
1957/58	1,515	2,009	1,902	9,791
1958/59	1,571	1,997	1,836	9,791
1959/60	1,876	1,632	1,544	9,934
1960/61	1,982	1,728	1,863	9,768
1961/62	1,865	1,734	1,755	10,127
1962/63	2,344	1,576	1,777	9,977
1963/64	1,847	1,439	1,743	9,887
1964/65	2,143	1,482	1,846	10,134
1965/66	2,024	1,652	1,751	10,188
1966/67	1,992	1,582	1,739	10,200
1967/68	2,009	1,790	1,650	10,420
1968/69	1,798	1,640	1,608	10,182
1969/70	1,748	1,784	1,646	10,045
1970/71	1,758	1,782	1,582	10,492
1971/72	1,778	1,776	1,847	10,479
1972/73	1,741	1,716	1,790	10,259
1973/74	1,582	2,034	1,863	10,492
1974/75	1,493	1,430	1,596	8,850
1975/76	1,641	1,916	1,778	10,499
1976/77	1,887	1,563	1,726	10,353
1977/78	1,971	1,369	1,829	10,389
1978/79	2,047	1,461	1,759	10,459
1979/80	2,040	1,257	1,717	10,605
1980/81	2,125	1,380	1,572	10,695

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.1.
INDIA: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
TAMIL NADU

(thousand hectares)

Year	Groundnut	Paddy	Bajra	Gross Cropped Area
1956/57	737	2,314	542	7,748
1957/58	777	2,263	486	6,756
1958/59	808	2,270	501	6,918
1959/60	836	2,314	508	7,043
1960/61	871	2,515	501	7,320
1961/62	835	2,536	489	7,270
1962/63	945	2,666	486	7,290
1963/64	914	2,619	489	7,192
1964/65	901	2,626	440	7,176
1965/66	896	2,501	466	7,066
1966/67	911	2,629	466	7,305
1967/68	909	2,670	446	7,309
1968/69	883	2,573	402	6,914
1969/70	982	2,696	459	7,162
1970/71	1,000	2,686	490	7,384
1971/72	1,117	2,691	494	7,642
1972/73	1,061	2,851	428	7,699
1973/74	1,136	2,704	401	7,649
1974/75	977	2,238	373	6,640
1975/76	935	2,564	450	7,235
1976/77	890	2,284	456	7,147
1977/78	926	2,782	437	7,768
1978/79	983	2,757	409	7,684
1979/80	998	2,906	370	7,717
1980/81	789	2,230	319	6,469

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.1.
INDIA: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
ANDHRA PRADESH

(thousand hectares)

Year	Groundnut	Jowar	Paddy	Gross Cropped Area
1956/57	1,336	2,509	2,936	12,444
1957/58	1,280	2,579	2,530	12,002
1958/59	966	2,657	3,010	12,089
1959/60	823	2,602	3,078	11,947
1960/61	802	2,727	2,962	10,816
1961/62	888	2,670	3,164	12,712
1962/63	898	2,660	3,474	12,842
1963/64	982	2,619	3,567	12,752
1964/65	1,092	2,494	3,459	12,756
1965/66	1,239	2,454	3,137	12,091
1966/67	1,189	2,537	3,322	12,676
1967/68	1,370	2,484	3,052	12,794
1968/69	1,187	2,682	3,298	12,456
1969/70	1,375	2,725	3,521	13,145
1970/71	1,481	2,567	3,521	13,347
1971/72	1,524	2,532	3,041	12,652
1972/73	1,415	2,848	2,928	12,314
1973/74	1,387	2,743	3,378	13,238
1974/75	1,471	2,538	3,554	13,283
1975/76	1,331	2,395	3,895	12,958
1976/77	1,051	2,043	3,565	11,863
1977/78	1,099	2,309	3,662	12,536
1978/79	1,277	2,345	3,979	13,121
1979/80	1,346	2,400	3,469	12,281
1980/81	1,304	2,053	3,600	12,281

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.1.
INDIA: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
MAHARASHTRA

(thousand hectares)

Year	Groundnut	Bajra	Jowar	Gross Cropped Area
1956/57	1,048	1,904	5,814	18,683
1957/58	1,142	1,856	5,826	18,683
1958/59	1,162	1,844	6,058	18,683
1959/60	1,138	1,780	6,053	18,797
1960/61	1,083	1,675	6,395	18,823
1961/62	1,059	1,729	6,262	19,094
1962/63	1,145	1,721	6,239	18,963
1963/64	1,136	1,706	6,152	19,174
1964/65	1,122	1,740	6,070	19,216
1965/66	1,053	1,828	6,053	18,972
1966/67	1,056	1,727	6,129	18,191
1967/68	1,044	1,822	6,245	19,197
1968/69	915	1,891	6,291	19,367
1969/70	945	2,256	6,088	19,435
1970/71	953	1,929	5,784	18,737
1971/72	751	1,135	6,169	18,115
1972/73	763	1,278	4,994	16,980
1973/74	675	2,239	6,102	19,486
1974/75	755	1,905	6,057	19,506
1975/76	839	1,853	6,152	19,663
1976/77	925	1,768	6,439	19,786
1977/78	848	1,759	6,639	19,860
1978/79	814	1,575	6,524	19,914
1979/80	747	1,428	6,825	20,129
1980/81	833	1,709	6,438	20,270

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.1.
INDIA: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
KARNATAKA

(thousand hectares)

Year	Groundnut	Paddy	Jowar	Gross Cropped Area
1956/57	899	1,015	2,686	10,400
1957/58	979	1,032	2,809	10,495
1958/59	944	1,077	2,892	10,534
1959/60	964	1,088	2,989	10,595
1960/61	915	1,107	3,078	10,588
1961/62	846	1,137	3,056	10,643
1962/63	870	1,169	3,161	10,761
1963/64	892	1,108	3,016	10,852
1964/65	916	1,171	2,978	10,793
1965/66	804	1,149	2,876	10,430
1966/67	779	1,123	2,723	10,467
1967/68	778	1,134	2,664	10,417
1968/69	808	1,192	3,070	10,555
1969/70	833	1,106	3,153	10,794
1970/71	837	1,160	2,594	10,887
1971/72	985	1,120	2,420	10,988
1972/73	720	1,010	1,794	10,410
1973/74	925	1,150	2,140	10,893
1974/75	895	1,173	2,178	10,997
1975/76	961	1,194	2,016	11,159
1976/77	838	963	1,729	9,864
1977/78	863	1,096	2,013	11,036
1978/79	886	1,098	1,994	11,133
1979/80	879	1,174	1,932	11,112
1980/81	765	1,101	1,648	10,660

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.2.

GUJARAT: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY DISTRICT
1961/62 - 1973/74
(thousand hectares)

Year	Groundnut	Bajra	Gross Cropped Area
		AMRELI	
1961/62	200	84	492
1962/63	210	92	493
1963/64	223	105	502
1964/65	248	89	509
1965/66	233	109	519
1966/67	235	115	510
1967/68	238	122	514
1968/69	231	123	516
1969/70	230	133	517
1970/71	235	133	524
1971/72	228	101	526
1972/73	210	106	508
1973/74	217	115	516
		RAJKOT	
1961/62	338	77	759
1962/63	378	61	733
1963/64	351	95	746
1964/65	372	84	736
1965/66	358	85	756
1966/67	373	88	741
1967/68	376	97	768
1968/69	339	106	778
1969/70	337	121	760
1970/71	346	105	787
1971/72	362	91	791
1972/73	362	89	752
1973/74	315	122	755

Sources: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume II (Delhi, various issues) and Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Bulletin on Groundnut Statistics (District-Wise) (Delhi, 1976). Published data for years subsequent to 1973/74 are not available.

APPENDIX I.2.

GUJARAT: AREA UNDER GROUNDNUT AND ITS COMPETING CROPS, BY DISTRICT 1961/62 - 1973/74

(thousand hectares)

Year	Groundnut	Bajra	Gross Cropped Area
	JUNAGARH		
1961/62	292	82	630
1962/63	334	56	579
1963/64	340	57	588
1964/65	354	49	625
1965/66	330	66	641
1966/67	335	79	608
1967/68	337	85	642
1968/69	325	83	638
1969/70	329	87	639
1970/71	343	74	666
1971/72	331	64	666
1972/73	339	56	636
1973/74	306	53	620
	JAMNAGAR		
1961/62	303	64	584
1962/63	357	53	587
1963/64	144	48	491
1964/65	234	85	588
1965/66	353	77	605
1966/67	339	92	613
1967/68	355	97	633
1968/69	298	96	616
1969/70	280	114	608
1970/71	299	104	632
1971/72	325	100	617
1972/73	350	97	615
1973/74	291	102	618

Sources: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume II (Delhi, various issues) and Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Bulletin on Groundnut Statistics (District-Wise) (Delhi, 1976). Published data for years subsequent to 1973/74 are not available.

APPENDIX I.3.
INDIA: AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
UTTAR PRADESH

(thousand hectares)

Year	Rapeseed-mustard	Wheat	Barley	Gross Cropped Area
1956/57	1,469	4,031	1,997	21,353
1957/58	1,280	3,740	1,777	21,058
1958/59	1,294	3,861	1,857	21,769
1959/60	1,866	3,869	1,845	21,733
1960/61	1,852	3,930	1,847	21,730
1961/62	1,958	4,091	1,825	22,147
1962/63	1,856	4,031	1,678	21,964
1963/64	1,806	3,910	1,684	22,051
1964/65	1,809	3,958	1,502	22,223
1965/66	1,856	4,107	1,482	22,074
1966/67	1,895	5,385	1,512	22,082
1967/68	2,051	4,962	1,614	22,709
1968/69	1,992	5,228	1,412	22,360
1969/70	2,120	5,369	1,486	22,969
1970/71	2,164	5,907	1,323	23,207
1971/72	2,244	6,046	1,312	23,024
1972/73	1,935	6,135	1,288	22,927
1973/74	1,933	6,009	1,268	23,007
1974/75	2,035	6,152	1,232	22,788
1975/76	2,008	6,302	1,202	23,098
1976/77	2,015	6,624	1,075	23,152
1977/78	2,007	6,760	863	23,349
1978/79	2,058	7,391	869	24,300
1979/80	1,994	7,532	786	23,642
1980/81	2,276	8,112	779	24,574

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.3.
INDIA: AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
RAJASTHAN

(thousand hectares)

Year	Rapeseed-mustard	Wheat	Barley	Gross Cropped Area
1956/57	266	1,355	585	13,701
1957/58	246	1,067	505	12,907
1958/59	301	1,182	538	13,727
1959/60	206	1,230	554	14,467
1960/61	204	1,068	474	14,013
1961/62	266	1,293	557	15,045
1962/63	321	1,248	479	14,833
1963/64	305	1,129	420	14,464
1964/65	208	1,183	433	15,501
1965/66	222	966	390	14,971
1966/67	252	961	439	15,447
1967/68	198	1,264	651	16,657
1968/69	121	1,163	500	14,257
1969/70	183	1,254	473	14,267
1970/71	254	1,478	524	16,729
1971/72	383	1,514	445	16,773
1972/73	294	1,399	434	16,097
1973/74	374	1,673	591	17,886
1974/75	424	1,421	713	15,711
1975/76	253	1,762	803	17,164
1976/77	231	1,799	590	16,899
1977/78	353	1,833	468	16,924
1978/79	315	1,991	406	17,496
1979/80	349	2,073	423	16,371
1980/81	363	1,635	410	17,350

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.3.
INDIA: AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS, BY STATE
1956/57 - 1980/81
MADHYA PRADESH

(thousand hectares)

Year	Rapeseed-mustard	Wheat	Barley	Gross Cropped Area
1956/57	153	3,241	206	17,633
1957/58	93	2,544	122	16,581
1958/59	153	2,800	174	17,730
1959/60	146	3,163	188	18,183
1960/61	149	3,085	125	18,194
1961/62	169	3,170	203	18,506
1962/63	153	3,238	176	18,407
1963/64	163	3,322	159	18,743
1964/65	168	3,166	158	18,963
1965/66	149	2,401	133	17,786
1966/67	97	2,129	137	18,336
1967/68	144	2,661	170	19,653
1968/69	157	3,056	170	20,001
1969/70	183	3,176	176	20,298
1970/71	204	3,403	157	20,561
1971/72	234	3,665	173	20,892
1972/73	213	3,277	180	20,742
1973/74	236	3,274	191	21,212
1974/75	265	2,788	211	20,512
1975/76	242	3,360	204	21,356
1976/77	180	3,144	159	20,857
1977/78	253	3,554	177	21,508
1978/79	239	3,778	186	21,747
1979/80	185	3,085	219	20,826
1980/81	236	3,365	198	21,402

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.3.
INDIA: AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS, BY STATE
1964/65 - 1979/80
HARYANA

(thousand hectares)

Year	Rapeseed-mustard	Wheat	Barley	Gross Cropped Area
1964/65	167	723	92	2,779
1965/66	148	685	118	2,816
1966/67	198	738	161	2,863
1967/68	245	846	302	2,907
1968/69	66	895	166	2,728
1969/70	120	1,017	141	2,773
1970/71	129	1,129	107	2,793
1971/72	163	1,177	91	2,889
1972/73	211	1,270	144	3,020
1973/74	169	1,178	154	3,076
1974/75	198	1,117	226	3,104
1975/76	137	1,226	177	3,176
1976/77	105	1,348	103	3,311
1977/78	177	1,360	97	3,239
1978/79	118	1,481	90	3,239
1979/80	126	1,471	81	3,239

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1979/80 are not available. Data prior to 1964/65 is not available because Haryana state was created in 1966.

APPENDIX I.4.

UTTAR PRADESH: AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS BY DISTRICT, 1961/62 - 1973/74

(thousand hectares)

Year	Rapeseed-mustard	Wheat	Barley	Gross Cropped Area
		ETAWAH		
1961/62	15	59	26	361
1962/63	15	54	23	361
1963/64	15	53	21	361
1964/65	16	59	20	368
1965/66	19	63	23	360
1966/67	13	70	19	359
1967/68	16	89	23	380
1968/69	12	85	20	383
1969/70	15	93	19	390
1970/71	17	100	15	391
1971/72	26	93	17	391
1972/73	20	102	15	385
1973/74	23	95	17	385
		NAINITAL		
1961/62	14	53	7	255
1962/63	14	53	4	255
1963/64	15	46	3	229
1964/65	15	46	3	231
1965/66	16	48	3	257
1966/67	22	54	3	270
1967/68	22	58	3	272
1968/69	18	66	3	265
1969/70	24	67	2	271
1970/71	18	74	2	277
1971/72	22	81	2	277
1972/73	18	83	1	289
1973/74	20	81	1	289

Sources: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume II (Delhi, various issues) and Uttar Pradesh Department of Agriculture, Statistical Division, Uttar Pradesh ke Krishi Ankade [Agricultural Statistics of Uttar Pradesh] (Lucknow, various issues). Published data for years subsequent to 1973/74 are not available.

APPENDIX I.4.
UTTAR PRADESH: AREA UNDER RAPESEED-MUSTARD AND ITS COMPETING CROPS BY DISTRICT, 1961/62 - 1973/74

(thousand hectares)

Year	Rapeseed-mustard	Wheat	Barley	Gross Cropped Area
		AGRA		
1961/62	11	77	40	430
1962/63	14	72	32	409
1963/64	15	72	23	420
1964/65	14	77	27	425
1965/66	16	79	24	422
1966/67	20	83	23	418
1967/68	15	104	27	445
1968/69	12	106	23	429
1969/70	19	119	23	437
1970/71	28	129	18	443
1971/72	43	127	20	443
1972/73	26	145	21	455
1973/74	33	130	25	455
		KANPUR		
1961/62	28	102	58	534
1962/63	23	89	50	521
1963/64	21	90	48	524
1964/65	19	88	41	523
1965/66	23	100	45	534
1966/67	15	100	41	507
1967/68	24	118	50	531
1968/69	19	107	45	521
1969/70	25	111	47	526
1970/71	25	118	43	527
1971/72	30	120	43	527
1972/73	28	127	40	524
1973/74	29	132	42	524

Sources: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume II (Delhi, various issues) and Uttar Pradesh Department of Agriculture, Statistical Division, Uttar Pradesh ke Krishi Ankade [Agricultural Statistics of Uttar Pradesh] (Lucknow, various issues). Published data for years subsequent to 1973/74 are not available.

APPENDIX I.5.
INDIA: AREA UNDER SESAME AND ITS COMPETING CROPS, BY STATE
1960/61 - 1980/81
ORISSA

(thousand hectares)

Year	Sesame	Jowar	Gross Cropped Area
1960/61	92	7	6,482
1961/62	93	8	6,267
1962/63	111	7	6,947
1963/64	103	7	7,221
1964/65	103	5	7,446
1965/66	88	4	7,446
1966/67	116	9	7,954
1967/68	103	9	7,954
1968/69	109	14	6,813
1969/70	122	17	6,761
1970/71	91	17	6,875
1971/72	94	19	6,936
1972/73	102	21	7,285
1973/74	94	22	7,134
1974/75	104	24	7,733
1975/76	119	24	7,209
1976/77	112	33	7,931
1977/78	141	35	7,931
1978/79	163	33	8,275
1979/80	181	23	8,166
1980/81	157	37	8,746

Note: Data prior to 1960/61 are unavailable. Area under bajra in this state is negligible and has therefore been omitted.

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.5.
INDIA: AREA UNDER SESAME AND ITS COMPETING CROPS, BY STATE
1956/56 - 1980/81
UTTAR PRADESH

(thousand hectares)

Year	Sesame	Jowar	Bajra	Gross Cropped Area
1956/57	470	894	1,126	21,353
1957/58	451	856	1,085	21,058
1958/59	472	915	1,080	21,769
1959/60	459	911	1,076	21,733
1960/61	652	895	1,081	21,730
1961/62	621	856	969	22,147
1962/63	699	885	1,023	21,964
1963/64	747	889	1,013	22,051
1964/65	755	872	1,064	22,223
1965/66	708	858	986	22,074
1966/67	705	902	1,012	22,082
1967/68	687	902	1,063	22,709
1968/69	656	824	1,050	22,360
1969/70	619	722	1,020	22,969
1970/71	662	734	1,121	23,207
1971/72	538	621	949	23,025
1972/73	711	729	1,086	22,927
1973/74	693	704	1,063	23,007
1974/75	678	718	909	22,788
1975/76	674	710	1,008	23,098
1976/77	791	703	1,013	23,152
1977/78	766	674	982	23,349
1978/79	730	658	930	24,300
1979/80	793	680	1,043	23,642
1980/81	751	678	995	24,574

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.5.
INDIA: AREA UNDER SESAME AND ITS COMPETING CROPS, BY STATE
1956/56 - 1980/81
RAJASTHAN

(thousand hectares)

Year	Sesame	Jowar	Bajra	Gross Cropped Area
1956/57	479	854	3,764	13,701
1957/58	443	1,055	3,888	12,907
1958/59	491	1,104	4,001	13,727
1959/60	554	1,055	3,959	14,467
1960/61	421	1,025	4,558	14,013
1961/62	513	1,231	4,388	15,045
1962/63	626	1,182	4,163	14,833
1963/64	484	1,030	4,324	14,464
1964/65	579	1,195	4,855	15,501
1965/66	630	1,025	4,881	14,971
1966/67	729	1,135	5,017	15,447
1967/68	666	1,169	4,893	16,657
1968/69	525	946	4,565	14,257
1969/70	428	1,167	4,347	14,267
1970/71	499	1,179	5,130	16,729
1971/72	630	923	5,100	16,773
1972/73	455	989	5,235	16,097
1973/74	476	1,115	5,731	17,886
1974/75	399	811	4,224	15,711
1975/76	367	713	3,717	17,164
1976/77	378	840	3,615	16,899
1977/78	363	724	4,066	16,924
1978/79	423	826	4,533	17,496
1979/80	318	848	4,266	16,371
1980/81	428	1,002	5,032	17,350

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX I.5.
INDIA: AREA UNDER SESAME AND ITS COMPETING CROPS, BY STATE
1956/56 - 1980/81
MAHARASHTRA

(thousand hectares)

Year	Sesame	Jowar	Bajra	Gross Cropped Area
1956/57	120	5,814	1,904	18,683
1957/58	127	5,826	1,858	18,683
1958/59	147	6,059	1,845	18,683
1959/60	118	6,052	1,780	18,797
1960/61	128	6,396	1,675	18,823
1961/62	116	6,262	1,729	19,094
1962/63	133	6,239	1,721	18,963
1963/64	126	6,152	1,706	19,174
1964/65	121	6,070	1,740	19,216
1965/66	118	6,053	1,828	18,972
1966/67	128	6,128	1,727	18,191
1967/68	142	6,245	1,822	19,197
1968/69	150	6,291	1,891	19,367
1969/70	159	6,088	2,258	19,435
1970/71	160	5,785	1,929	18,737
1971/72	127	6,169	1,135	18,115
1972/73	123	4,994	1,278	16,980
1973/74	154	6,103	2,239	19,486
1974/75	137	6,057	1,905	19,506
1975/76	171	6,152	1,977	19,663
1976/77	177	6,439	1,768	19,786
1977/78	175	6,639	1,759	19,860
1978/79	179	6,524	1,575	19,860
1979/80	205	6,825	1,428	19,914
1980/81	191	6,438	1,709	20,129

Sources: Crop area data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues). For gross cropped area: data up to 1976/77 from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Indian Agricultural Statistics, Volume I (Delhi, various issues); and subsequent data from Directorate of Economics and Statistics' unpublished Land Use Classification data. Data on gross cropped area at the state level after 1980/81 are not available.

APPENDIX II.
STATISTICS RELATING TO COCONUT

APPENDIX II.1.
INDIA: AREA, PRODUCTION AND YIELD OF COCONUTS, 1956/57 - 1982/83

Year	Area (thousand hectares)	Production (million nuts)	Yield (nuts per hectare)
1956/57	657	4,383	6,671
1957/58	666	4,455	6,689
1958/59	690	4,589	6,651
1959/60	715	4,734	6,621
1960/61	717	4,639	6,470
1961/62	723	4,478	6,194
1962/63	798	5,017	6,288
1963/64	798	4,725	5,921
1964/65	848	5,043	5,947
1965/66	884	5,035	5,696
1966/67	893	5,192	5,814
1967/68	924	5,321	5,759
1968/69	988	5,546	5,613
1969/70	1,033	5,859	5,672
1970/71	1,046	6,075	5,808
1971/72	1,088	6,124	5,629
1972/73	1,099	5,997	5,457
1973/74	1,102	5,851	5,309
1974/75	1,116	6,030	5,403
1975/76	1,070	5,829	5,448
1976/77	1,075	5,765	5,363
1977/78	1,057	5,413	5,121
1978/79	1,055	5,730	5,431
1979/80	1,076	5,636	5,238
1980/81	1,083	5,720	5,282
1981/82	1,091	5,573	5,190
1982/83	1,113	5,664	5,088

Note: 1982/83 data are estimates subject to revision.

Source: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX II.2.
INDIA: AREA, PRODUCTION AND YIELD OF COCONUTS, BY STATE
1956/57 - 1982/83

KERALA

Year	Area (thousand hectares)	Production (million nuts)	Yield (nuts per hectare)
1956/57	460	3,182	6,917
1957/58	463	3,199	6,909
1958/59	463	3,199	6,909
1959/60	476	3,248	6,823
1960/61	476	3,248	6,823
1961/62	505	3,247	6,430
1962/63	539	3,304	6,130
1963/64	545	3,262	5,985
1964/65	559	3,278	5,864
1965/66	586	3,293	5,620
1966/67	610	3,425	5,615
1967/68	639	3,593	5,623
1968/69	686	3,834	5,589
1969/70	708	3,956	5,588
1970/71	719	3,981	5,537
1971/72	730	4,054	5,553
1972/73	745	3,921	5,263
1973/74	745	3,703	4,971
1974/75	748	3,719	4,972
1975/76	693	3,440	4,964
1976/77	695	3,348	4,817
1977/78	674	3,053	4,530
1978/79	661	3,237	4,897
1979/80	665	3,032	4,559
1980/81	666	3,036	4,559
1981/82	667	3,006	4,507
1982/83	659	2,444	3,710

Note: 1982/83 data are estimates subject to revision.

Source: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX II.2.
INDIA: AREA, PRODUCTION AND YIELD OF COCONUTS, BY STATE
1956/57 - 1982/83

TAMIL NADU

Year	Area (thousand hectares)	Production (million nuts)	Yield (nuts per hectare)
1956/57	51	416	8,157
1957/58	51	415	8,137
1958/59	51	416	8,157
1959/60	54	437	8,093
1960/61	54	437	8,093
1961/62	55	445	8,091
1962/63	73	912	12,493
1963/64	75	668	8,907
1964/65	83	791	9,530
1965/66	90	844	9,378
1966/67	82	867	10,573
1967/68	83	867	10,446
1968/69	89	735	8,258
1969/70	98	873	8,908
1970/71	95	942	9,916
1971/72	114	977	8,570
1972/73	105	932	8,876
1973/74	105	943	8,981
1974/75	109	1,091	10,009
1975/76	110	1,099	9,991
1976/77	109	1,095	10,046
1977/78	110	1,039	9,445
1978/79	110	1,123	10,209
1979/80	115	1,154	10,035
1980/81	116	1,132	9,859
1981/82	116	1,019	8,774
1982/83	143	1,650	11,538

Note: 1982/83 data are estimates subject to revision.

Source: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX II.2.
INDIA: AREA, PRODUCTION AND YIELD OF COCONUTS, BY STATE
1956/57 - 1982/83

KARNATAKA

Year	Area (thousand hectares)	Production (million nuts)	Yield (nuts per hectare)
1956/57	85	417	4,906
1957/58	87	440	5,057
1958/59	87	446	5,126
1959/60	97	487	5,021
1960/61	98	463	4,725
1961/62	97	437	4,505
1962/63	108	400	3,704
1963/64	107	353	3,299
1964/65	114	460	4,035
1965/66	115	362	3,148
1966/67	106	446	4,208
1967/68	108	449	4,157
1968/69	117	485	4,145
1969/70	128	610	4,766
1970/71	130	732	5,631
1971/72	132	638	4,833
1972/73	138	659	4,775
1973/74	140	730	5,214
1974/75	145	721	4,972
1975/76	151	767	5,080
1976/77	154	803	5,214
1977/78	156	810	5,192
1978/79	164	855	5,213
1979/80	168	873	5,196
1980/81	171	884	5,170
1981/82	176	918	5,216
1982/83	179	930	5,196

Note: 1982/83 data are estimates subject to revision.

Source: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX II.2.
INDIA: AREA, PRODUCTION AND YIELD OF COCONUTS, BY STATE
1956/57 - 1982/83

ANDHRA PRADESH

Year	Area (thousand hectares)	Production (million nuts)	Yield (nuts per hectare)
1956/57	36	307	8,528
1957/58	35	316	9,029
1958/59	35	291	8,314
1959/60	36	325	9,028
1960/61	36	325	9,028
1961/62	34	179	5,265
1962/63	35	192	5,486
1963/64	34	302	8,882
1964/65	33	269	8,152
1965/66	33	288	8,727
1966/67	34	222	6,529
1967/68	34	181	5,324
1968/69	36	248	6,889
1969/70	36	159	4,417
1970/71	37	157	4,243
1971/72	38	157	4,132
1972/73	39	171	4,385
1973/74	39	163	4,179
1974/75	40	173	4,325
1975/76	41	167	4,073
1976/77	39	162	4,154
1977/78	40	165	4,125
1978/79	40	165	4,125
1979/80	41	171	4,171
1980/81	42	175	4,167
1981/82	43	179	4,163
1982/83	45	179	3,978

Note: 1982/83 data are estimates subject to revision.

Source: Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX II.3.
KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

TRIVANDRUM

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	55,039	354	6,432
1961/62	55,326	356	6,435
1962/63	55,815	342	6,127
1963/64	55,684	340	6,106
1964/65	58,711	342	5,825
1965/66	61,150	376	6,149
1966/67	61,800	380	6,145
1967/68	70,400	433	6,150
1968/69	73,800	454	6,156
1969/70	76,100	468	6,152
1970/71	76,500	470	6,150
1971/72	77,300	476	6,151
1972/73	76,194	440	5,775
1973/74	77,000	445	5,774
1974/75	77,270	446	5,772
1975/76	74,074	428	5,777
1976/77*	74,074	428	5,777
1977/78	79,335	402	5,069
1978/79	75,806	320	4,222
1979/80	72,775	373	5,127
1980/81	73,485	350	4,767

Note:
* Previous year's figures.

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.3.

KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

QUILON

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	64,713	416	6,428
1961/62	64,865	417	6,429
1962/63	70,261	431	6,134
1963/64	70,431	422	5,992
1964/65	73,455	436	5,936
1965/66	74,019	418	5,647
1966/67	77,700	438	5,641
1967/68	80,000	452	5,644
1968/69	85,000	479	5,640
1969/70	91,700	517	5,642
1970/71	92,500	522	5,641
1971/72	104,300	588	5,639
1972/73	106,798	607	5,684
1973/74	106,800	528	4,946
1974/75	107,409	531	4,944
1975/76	98,073	485	4,946
1976/77*	98,073	485	4,946
1977/78	93,465	391	4,186
1978/79	87,563	357	4,080
1979/80	81,381	314	3,858
1980/81	84,488	333	3,936

Note:
* Previous year's figures.

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, <u>Agricultural Statistics in Kerala</u> (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.3.

KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

ALLEPPEY

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	75,829	488	6,435
1961/62	77,064	496	6,436
1962/63	68,425	419	6,124
1963/64	69,059	413	5,980
1964/65	70,784	514	7,262
1965/66	75,599	505	6,680
1966/67	77,600	518	6,678
1967/68	79,700	532	6,676
1968/69	81,500	545	6,683
1969/70	82,500	551	6,675
1970/71	82,000	547	6,675
1971/72	82,100	549	6,681
1972/73	79,941	510	6,380
1973/74	79,900	443	5,549
1974/75	79,963	444	5,553
1975/76	72,824	404	5,547
1976/77*	72,824	404	5,547
1977/78	64,338	334	5,197
1978/79	59,354	283	4,770
1979/80	61,814	349	5,645
1980/81	62,907	325	5,169

Note:
* Previous year's figures.

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.3.
KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

KOTTAYAM, ERNAKULAM, IDIKKI

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	102,967	671	6,517
1961/62	103,834	668	6,433
1962/63	108,656	665	6,120
1963/64	111,101	665	5,986
1964/65	114,031	624	5,472
1965/66	123,364	649	5,261
1966/67	129,100	685	5,305
1967/68	130,200	690	5,298
1968/69	141,100	746	5,288
1969/70	139,500	740	5,301
1970/71	139,500	741	5,310
1971/72	140,500	751	5,346
1972/73	145,617	729	5,006
1973/74	142,100	731	5,142
1974/75	142,376	732	5,141
1975/76	120,366	567	4,716
1976/77	119,203	612	5,133
1977/78	124,653	528	4,238
1978/79	122,861	508	4,135
1979/80	129,789	548	4,225
1980/81	127,571	550	4,312

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.3.
KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

PALGHAT, KOZHIKOKE, MALLAPPURAM

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	117,829	758	6,433
1961/62	118,249	761	6,436
1962/63	134,695	826	6,132
1963/64	134,806	807	5,986
1964/65	135,231	871	6,441
1965/66	141,235	828	5,863
1966/67	146,300	854	5,835
1967/68	158,700	926	5,837
1968/69	165,700	955	5,762
1969/70	172,700	998	5,781
1970/71	180,500	998	5,527
1971/72	182,800	1,007	5,509
1972/73	188,787	954	5,053
1973/74	190,900	910	4,765
1974/75	191,550	913	4,766
1975/76	184,711	891	4,824
1976/77*	184,711	891	4,824
1977/78	191,446	991	5,174
1978/79	185,411	857	4,624
1979/80	186,970	928	4,965
1980/81	186,327	870	4,668

Note:
* Previous year's figures.

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.3.
KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

TRICHUR

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	35,977	231	6,421
1961/62	37,020	238	6,429
1962/63	34,673	213	6,143
1963/64	35,497	212	5,972
1964/65	36,835	222	6,027
1965/66	37,236	235	6,311
1966/67	41,000	259	6,315
1967/68	41,100	260	6,328
1968/69	48,900	309	6,323
1969/70	50,400	319	6,327
1970/71	54,900	347	6,317
1971/72	54,700	346	6,319
1972/73	56,869	346	6,084
1973/74	56,900	335	5,893
1974/75	57,328	338	5,896
1975/76	50,699	299	5,896
1976/77*	50,699	299	5,896
1977/78	50,530	346	6,844
1978/79	49,641	311	6,259
1979/80	51,704	327	6,331
1980/81	53,549	326	6,095

Note:
* Previous year's figures.

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.3.
KERALA: AREA, PRODUCTION AND YIELD OF COCONUT, BY DISTRICT
1960/61 - 1980/81

CANNANORE

Year	Area (hectares)	Production (million nuts)	Yield (nuts per hectare)
1960/61	48,414	311	6,424
1961/62	48,472	311	6,416
1962/63	66,744	409	6,128
1963/64	67,239	403	5,994
1964/65	69,944	287	4,103
1965/66	73,716	282	3,826
1966/67	76,100	291	3,823
1967/68	78,600	301	3,824
1968/69	90,400	346	3,825
1969/70	94,900	363	3,826
1970/71	93,200	357	3,826
1971/72	88,600	339	3,824
1972/73	91,223	335	3,672
1973/74	91,200	312	3,419
1974/75	92,277	315	3,414
1975/76	92,198	315	3,418
1976/77	94,964	325	3,418
1977/78	95,352	374	3,924
1978/79	98,026	439	4,477
1979/80	85,541	346	4,044
1980/81	77,889	282	3,623

Sources: Kerala Department of Agriculture, Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Coconut Development Board, Ernakulam, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1977/78

(hectares)

TRIVANDRUM

Year	Rice	Coconut	Gross Cropped Area
1960/61	37,417	55,039	196,610
1961/62	36,411	55,326	197,742
1962/63	38,531	55,815	198,106
1963/64	38,789	56,864	196,086
1964/65	38,602	58,711	197,222
1965/66	38,734	61,150	206,144
1966/67	39,036	61,762	215,550
1967/68	39,583	70,401	240,750
1968/69	39,962	73,885	235,230
1969/70	39,489	67,137	235,921
1970/71	39,496	76,515	242,996
1971/72	39,496	77,326	249,454
1972/73	39,486	76,194	249,023
1973/74	39,765	76,956	244,294
1974/75	39,926	77,270	246,663
1975/76	37,447	74,074	237,048
1976/77	37,976	74,074*	241,670
1977/78	34,529	79,335	241,670*

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND
GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1976/77

(hectares)

QUILON

Year	Rice	Coconut	Gross Cropped Area
1960/61	46,143	64,713	257,111
1961/62	44,989	64,865	257,688
1962/63	49,691	70,261	271,043
1963/64	49,605	70,431	277,001
1964/65	49,469	73,455	278,711
1965/66	49,637	74,019	287,522
1966/67	50,057	77,718	297,182
1967/68	50,378	80,052	333,639
1968/69	51,785	85,000	345,561
1969/70	51,884	91,732	352,063
1970/71	51,884	92,512	341,281
1971/72	51,729	104,272	356,309
1972/73	51,155	106,798	359,281
1973/74	51,189	106,798	371,407
1974/75	51,686	107,409	377,448
1975/76	53,053	98,073	345,349
1976/77	49,657	98,073*	336,049

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1976/77

(hectares)

ALLEPPEY

Year	Rice	Coconut	Gross Cropped Area
1960/61	79,389	75,829	221,902
1961/62	76,125	77,064	221,361
1962/63	82,302	64,825	221,460
1963/64	82,320	69,059	220,207
1964/65	81,911	70,784	219,781
1965/66	81,603	75,599	222,282
1966/67	81,087	77,595	226,140
1967/68	81,708	79,675	230,013
1968/69	86,713	81,557	235,875
1969/70	85,240	82,463	236,165
1970/71	85,162	81,962	232,156
1971/72	85,162	82,139	233,167
1972/73	91,131	79,941	237,003
1973/74	92,039	79,941	239,965
1974/75	96,459	79,963	244,713
1975/76	96,316	72,824	236,766
1976/77	88,591	72,824*	226,393

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1977/78

(hectares)

KOTTAYAM, ERNAKULAM AND IDIKKI

Year	Rice	Coconut	Gross Cropped Area
1960/61	117,859	102,967	532,877
1961/62	112,856	103,834	531,891
1962/63	124,359	108,656	547,438
1963/64	124,251	111,101	560,786
1964/65	123,815	114,031	564,828
1965/66	123,990	123,358	581,749
1966/67	123,904	129,141	612,478
1967/68	126,995	130,138	627,391
1968/69	143,880	141,056	648,735
1969/70	143,772	139,463	653,034
1970/71	143,724	139,526	648,940
1971/72	143,725	140,472	651,723
1972/73	144,255	145,617	660,215
1973/74	133,324	142,082	661,555
1974/75	145,481	142,376	668,409
1975/76	159,049	120,366	653,782
1976/77	164,298	119,203	653,752
1977/78	156,576	124,653	653,752*

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, <u>Agricultural Statistics in Kerala</u> (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1977/78

(hectares)

PALGHAT, KOZHIKODE AND MALLAPPURAM

Year	Rice	Coconut	Gross Cropped Area
1960/61	300,223	117,829	676,036
1961/62	296,654	118,249	676,182
1962/63	305,681	134,695	697,467
1963/64	305,904	134,806	693,112
1964/65	304,510	135,231	704,400
1965/66	305,314	141,235	717,603
1966/67	303,632	146,348	737,638
1967/68	308,262	158,736	778,627
1968/69	336,507	165,256	813,381
1969/70	341,710	172,662	834,794
1970/71	340,605	180,525	855,224
1971/72	341,076	182,792	863,723
1972/73	339,228	188,787	873,322
1973/74	339,379	190,819	879,493
1974/75	340,987	191,550	890,023
1975/76	319,265	184,711	878,046
1976/77	314,328	184,711*	872,526
1977/78	309,688	191,446	872,526*

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND
GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1977/78

(<u>hectares</u>)

TRICHUR

Year	Rice	Coconut	Gross Cropped Area
1960/61	102,197	35,977	196,842
1961/62	93,435	37,020	189,094
1962/63	108,218	34,673	204,034
1963/64	108,493	35,497	202,456
1964/65	107,586	36,835	207,531
1965/66	108,807	37,236	208,552
1966/67	108,844	40,958	214,050
1967/68	108,967	41,148	220,007
1968/69	114,371	48,196	230,579
1969/70	113,311	50,451	236,405
1970/71	115,267	54,861	245,741
1971/72	115,267	54,684	245,297
1972/73	110,492	56,869	243,782
1973/74	109,914	56,869*	247,801
1974/75	108,966	57,328	246,357
1975/76	126,426	50,699	247,086
1976/77	118,065	50,699*	232,573
1977/78	119,768	50,530	232,573

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, <u>Agricultural Statistics in Kerala</u> (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.4.
KERALA: AREA UNDER RICE, COCONUT AND GROSS CROPPED AREA, BY DISTRICT, 1960/61 - 1977/78

(hectares)

CANNANORE

Year	Rice	Coconut	Gross Cropped Area
1960/61	95,698	48,414	267,514
1961/62	92,434	48,472	267,283
1962/63	83,895	66,744	307,222
1963/64	95,738	67,239	312,056
1964/65	95,228	69,944	316,974
1965/66	94,244	73,716	322,492
1966/67	92,878	76,071	318,933
1967/68	93,651	78,571	333,012
1968/69	97,653	90,393	343,402
1969/70	98,653	93,931	367,706
1970/71	98,692	93,235	366,205
1971/72	98,702	88,575	358,683
1972/73	97,957	91,223	363,852
1973/74	98,065	91,223	350,038
1974/75	97,961	92,277	354,512
1975/76	84,486	92,198	383,202
1976/77	81,459	94,964	370,487
1977/78	78,523	95,352	370,487*

Note:
* Previous year's figures.

Sources: Kerala Bureau of Economics and Statistics, Agricultural Statistics in Kerala (Trivandrum, Kerala, 1975) and unpublished data from the Central Plantation Crops Research Institute, Kasaragod, Kerala.

APPENDIX II.5.
KERALA: PRICES OF COCONUT OIL AND COCONUTS, 1963-1981

Year	Wholesale (Rs/quintal of oil)	Retail[a] (Rs/quintal of oil)	Farm Harvest[b] (Rs/1000 nuts)	Consumer Price Index[c]
1963	286.4	293	243.8	110
1964	279.1	301	233.3	132
1965	438.4	406	351.3	150
1966	455.4	484	367.9	161
1967	503.1	546	422.6	172
1968	490.4	548	423.8	195
1969	507.0	549	420.7	202
1970	702.1	755	587.4	214
1971	570.4	624	474.1	211
1972	523.3	549	430.1	221
1973	892.5	896	707.0	276
1974	1,153.3	1,169	932.3	383
1975	836.4	903	722.6	366
1976	942.5	1,007	813.0	326
1977	1,048.8	1,130	948.0	317
1978	1,169.6	1,267	1,020.9[d]	324
1979	1,144.6	1,244	1,142.7[d]	345
1980	1,502.9	1,637	1,200.1[d]	379
1981	1,377.5	1,531	1,257.5	419

Sources and Notes:

a: Ministry of Agriculture, Directorate of Economics and Statistics, Agricultural Prices in India, 1963-74 (Delhi, 1976) and Ministry of Agriculture, Directorate of Economics and Statistics, Agricultural Prices in India, 1975-82 (Delhi, 1983)

b: Kerala Department of Planning, Economic Review, 1982 (Trivandrum, 1983) and unpublished data from Kerala Department of Agriculture, Bureau of Economics and Statistics.

c: Refers to the general consumer price index for Kerala (base 1960/61 = 100); data relate to crop year, that is, 1963 refers to 1963/64 and so on. Source: Ministry of Agriculture, Directorate of Economics and Statistics, Agricultural Prices in India, 1963-74 (Delhi, 1976) and Agricultural Situation in India, January, 1984

d: Refers to crop year. Figure for 1980 is interpolated from those of 1979 and 1981.

APPENDIX III.
STATISTICS RELATING TO OIL PALM

APPENDIX III.1.
YEROOR PLANTATION: AREA, PRODUCTION AND YIELD OF OIL PALM, 1976/77-1985/86

Year	Mature Area (ha.)	Production: FFB[a] (metric tons)	Production: Oil (metric tons)	Yield: FFB (kilograms/hectare)	Yield: Oil (kilograms/hectare)	Extraction Rate (percent)
1976/77	72	80.6	10.9	119.5	151.7	13.6
1977/78	174	592.2	99.5	3403.5	571.7	16.8
1978/79	210	634.6	101.2	3021.9	481.7	15.9
1979/80	210	588.4	81.2	2801.9	386.5	13.8
1980/81	477	886.2	158.1	1857.9	333.6	18.0
1981/82	514	1163.0	204.5	2297.7	397.8	17.3
1982/83	560	1112.6	180.2	2164.6	350.6	16.2
1983/84	560	1056.5	195.2	1887.5	348.6	18.5
1984/85	560	3291.0	538.7	5876.8	962.0	16.4
1985/86	1087	5630.0	973.4	5179.4	895.2	17.3

Note: a. Fresh fruit bunch production includes minor amounts from "other areas," for example, the Central Plantation Crops Research Institute, therefore, FFB yields are slightly overstated.

Source: Oil Palm India, Ltd., Kottayam, Kerala.

APPENDIX III.2.
YEROOR PLANTATION: MATURE AREA, PRODUCTION AND YIELD OF OIL PALM BY YEAR OF PLANTING 1976/77-1985/86

A: Mature area in hectares.
P: Production of fresh fruit bunch (FFB) in metric tons.
Y: Yields (FFB) in kilograms per hectare.

Crop Year	1971 Area			1972 Area			1973 Area			1975 Area		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1976/77	72	69.5	965									
1977/78	81	521.3	6436	93	62.5	672						
1978/79	81	470.6	5810	105	129.3	1231	24	34.7	1446			
1979/80	81	409.0	5049	105	138.6	1320	24	41.3	1721			
1980/81	81	577.7	7132	105	190.8	1817	68	58.1	854	188	28.4	1511
1981/82	100	599.9	5999	149	312.9	2100	71	83.0	1169	194	167.2	862
1982/83	100	460.5	4605	149	317.7	2132	71	136.8	1927	194	175.0	902
1983/84	92	364.0	3960	136	297.0	2180	63	82.0	1300	269	307.0	1140
1984/85	92	885.0	9620	136	927.0	6820	63	394.0	6250	269	1085.0	4030
1985/86	92	1177.0	12790	189	1149.0	6080	63	804.0	12760	503	1816.0	3610

Source: Oil Palm India, Ltd., Kottayam, Kerala.

APPENDIX III.3
YEROOR PLANTATION: MONTHLY RAINFALL, 1976/77 - 1980/81

(millimeters)

Month	1976/77	1977/78	1978/79	1979/80	1980/81
April	336	140	115	184	201
May	164	438	495	248	158
June	142	359	272	267	494
July	373	386	438	414	315
August	254	198	318	175	219
September	133	213	171	303	127
October	369	332	292	326	140
November	316	283	442	395	272
December	12	11	25	15	137
January	0	12	25	0	3
February	0	29	73	0	49
March	254	31	25	78	65

Source: Oil Palm India, Ltd., Kottayam, Kerala

APPENDIX III.4
YEROOR PLANTATION: FRESH FRUIT BUNCH YIELDS, BY MONTH
1976/77 - 1980/81

(kilograms per hectare)

Month	1976/77	1977/78	1978/79	1979/80	1980/81
Mature area (hectares)	72	174	210	210	442
April	100	131	288	728	433
May	102	137	248	343	168
June	174	208	194	174	242
July	15	257	137	93	90
August	28	240	275	156	87
September	59	270	259	140	70
October	97	556	274	132	8
November	42	583	185	162	78
December	7	41	-	39	46
January	52	83	159	90	-
February	147	308	338	125	255
March	300	592	665	625	394

Note: The production year for oil palm in April through March. Increases in mature area are reported at the start of the new production year, and this figure has been used in the computation of month-wise yields throughout the year. Therefore, the yield differences between March and April of the same calender year are exaggerated because a different denominator has been used for each of the two months. Data on monthwise increases in mature area were not available.

Source: Oil Palm India, Ltd., Kottayam, Kerala.

APPENDIX III.5
YEROOR PLANTATION1: FRESH FRUIT PRODUCTION BY MONTH
1981/82 - 1985/86

(tons)

Month	1981/82	1982/83	1983/84	1984/85	1985/86
April	207.6	133.8	312.4	421.7	546.6
May	108.1	109.3	233.8	693.0	658.8
June	132.2	113.7	244.5	578.4	417.9
July	84.3	64.8	70.2	272.2	250.9
August	59.6	62.4	19.4	103.5	116.0
September	58.3	50.6	23.8	95.1	316.7
October	77.5	53.7	14.7	127.6	356.1
November	124.1	53.2	8.3	150.6	539.4
December	58.8	35.9	112.8	192.8	509.2
January	58.7	30.7	5.7	133.4	461.1
February	77.9	102.1	16.3	221.5	727.6
March	147.7	285.1	107.7	419.8	730.9
TOTAL	1,194.8	1,095.3	1,169.6	3,409.6	5,631.2

Source: Oil Palm India, Limited, Kottayam, Kerala.

APPENDIX III.6
OIL PALM INDIA, LIMITED: TOTAL EXPENDITURES, 1980/81 - 1984/85

(million rupees)

Item	1980/81	1981/82	1982/83	1983/84	1984/85
Cultivation	1.45	2.12	2.26	2.04	2.62
Processing	0.22	0.16	0.22	0.27	0.73
Wages and related expenditures[a]	0.50	0.66	0.76	0.88	1.18
Depreciation	0.34	0.31	0.39	0.42	0.98
Interest on loans	1.01	1.40	2.04	2.67	2.21
Other	0.88	1.38	1.42	1.12	1.62
TOTAL	4.40	6.03	7.09	7.40	9.34

Note: a. Expenditures include pay, leave encashment, gratuity paid, employer's contribution to Provident Fund, deposit-linked insurance, and welfare expenses.

Source: Oil Palm India, Limited, Annual Report, various issues.

APPENDIX III.7
YEROOR PLANTATION: COSTS OF CULTIVATION OF MATURE PLANTATIONS
1978/79 TO 1981/82

(Rupees per hectare)

Item	1978/79	1979/80	1980/81	1981/82
Pitting	0.9	-	-	37.2
Terracing	229.4	15.3	39.8	60.1
Cover Crops	-	8.0	217.7	19.5
Fertilization	558.4	651.9	1,034.1	1,086.9
Weeding	521.2	577.1	407.8	930.6
Pruning	54.8	105.5	166.0	203.4
Harvesting	204.6	277.8	314.5	274.7
Pollination	104.8	163.1	135.4	34.7
Other	113.1	145.5	191.3	96.5
TOTAL	1,787.2	1,944.2	2,506.6	2,743.6

Source: Oil Palm India, Ltd., Kottayam, Kerala.

APPENDIX III.8
YEROOR PLANTATION: COSTS OF CULTIVATION OF MATURE VERSUS IMMATURE PLANTATIONS 1978/79 - 1981/82

(Rupees per hectare)

Year	1978/79	1979/80	1980/81	1981/82
		MATURE PLANTATIONS		
1971	2,844.4	2,797.9	3,924.9	3,777.9
1972	1,144.6	1,328.9	2,309.6	3,281.1
1973	1,030.9	1,141.2	1,120.0	2,032.7
1975	-	-	a	2,057.8
TOTAL	1,787.2	1,944.2	2,506.2	2,743.6
		IMMATURE PLANTATIONS		
1972	1,420.3	991.1	1,045.4	247.8
1973	573.6	1,195.7	518.9	1,085.8
1975	466.0	1,307.3	2,026.5	1,701.6
1979	-	332.1	1,006.3	1,300.0
1980	-	-	2,416.4	1,413.0
TOTAL	608.6	928.4	1,527.4	1,356.0

Note: a: Although 188 hectares of the 1975 planting were mature in 1980/81, their costs have not been reported

Source: Oil Palm India, Ltd., Kottayam, Kerala

APPENDIX III.9
YEROOR PLANTATION: NET REVENUE FROM OIL PALM CULTIVATION, BY TYPE OF PLANTING STOCK, 1978/79 - 1981/82

(Rupees per hectare)

Year		1971 Area	1972 Area	1973 Area
1978/79	Revenue	5,582.5	1,183.2	1,389.3
	Cost	2,844.4	11,44.6	1,030.9
	Income	2,738.1	38.7	358.4
1979/80	Revenue	4,333.9	1,164.0	1,323.2
	Cost	2,797.9	1,328.9	1,141.2
	Income	1,536.0	(-) 164.8	182.1
1980/81	Revenue	10,718.8	2,780.9	1,248.6
	Cost	3,924.9	2,309.6	1,119.9
	Income	6,783.9	471.3	128.7
1981/82	Revenue	7,507.9	2,628.2	1,463.0
	Cost	3,777.9	3,281.1	2,032.7
	Income	3,730.0	(-) 652.9	(-) 569.7

Source: Oil Palm India, Ltd., Kottayam, Kerala

APPENDIX IV.

MISCELLANEOUS STATISTICS RELATING TO OILSEEDS AND VEGETABLE OILS

APPENDIX IV.1.
INDIA: AREA, PRODUCTION AND YIELD OF GROUNDNUT, 1956/57 - 1983/84

Year	Area (million hectares)	Production (million tons)	Yield (kgs/hectare)
1950/51	4.50	3.32	738
1951/52	4.92	3.05	620
1952/53	4.80	2.79	567
1953/54	4.25	3.28	772
1954/55	5.55	4.05	730
1955/56	5.14	3.68	716
1956/57	5.55	4.17	751
1957/58	5.57	4.50	808
1958/59	6.26	4.88	780
1959/60	6.45	4.45	690
1960/61	6.47	4.70	726
1961/62	6.90	4.74	687
1962/63	7.29	4.94	678
1963/64	6.89	5.17	750
1964/65	7.37	6.00	814
1965/66	7.70	4.26	554
1966/67	7.30	4.41	604
1967/68	7.55	5.73	759
1968/69	7.09	4.63	653
1969/70	7.13	5.13	720
1970/71	7.33	6.11	834
1971/72	7.51	6.18	823
1972/73	6.99	4.09	585
1973/74	7.02	5.93	845
1974/75	7.06	5.11	724
1975/76	7.22	6.75	935
1976/77	7.04	5.26	747
1977/78	7.03	6.09	866
1978/79	7.43	6.21	835
1979/80	7.16	5.76	805
1980/81	6.80	5.01	736
1981/82	7.43	7.22	972
1982/83	7.21	5.28	732
1983/84	7.64	7.28	953

Note: 1982/83 data are revised estimates; 1983/84 data are subject to revision.

Source: Ministry of Food and Agriculture, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX IV.2.
INDIA: AREA, PRODUCTION AND YIELD OF RAPESEED-MUSTARD
1956/57 - 1983/84

Year	Area (million hectares)	Production (million tons)	Yield (kgs/hectare)
1950/51	2.08	0.77	370
1951/52	2.40	0.94	392
1952/53	2.10	0.86	409
1953/54	2.24	0.87	388
1954/55	2.44	1.04	426
1955/56	2.55	0.86	337
1956/57	2.53	1.04	411
1957/58	2.41	0.93	386
1958/59	2.44	1.04	426
1959/60	2.92	1.06	363
1960/61	2.85	1.35	474
1961/62	3.16	1.34	424
1962/63	3.12	1.30	417
1963/64	3.04	0.91	299
1964/65	2.91	1.47	505
1965/66	2.91	1.30	446
1966/67	3.01	1.23	408
1967/68	3.24	1.57	483
1968/69	2.87	1.35	469
1969/70	3.17	1.56	493
1970/71	3.32	1.98	594
1971/72	3.61	1.43	396
1972/73	3.32	1.81	545
1973/74	3.46	1.70	493
1974/75	3.68	2.25	612
1975/76	3.34	1.94	580
1976/77	3.13	1.55	496
1977/78	3.58	1.65	460
1978/79	3.54	1.86	525
1979/80	3.47	1.43	411
1980/81	4.11	2.00	487
1981/82	4.40	2.38	541
1982/83	3.83	2.21	577
1983/84	3.89	2.57	659

Note: 1982/83 data are revised estimates; 1983/84 data are subject to revision.

Source: Ministry of Food and Agriculture, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX IV.3.
INDIA: AREA, PRODUCTION AND YIELD OF SESAME, 1956/57 - 1983/84

Year	Area (million hectares)	Production (million tons)	Yield (kgs/hectare)
1950/51	2.23	0.42	188
1951/52	2.43	0.43	177
1952/53	2.41	0.44	183
1953/54	2.60	0.53	204
1954/55	2.64	0.56	212
1955/56	2.31	0.44	191
1956/57	2.18	0.41	188
1957/58	2.10	0.36	171
1958/59	2.26	0.51	225
1959/60	2.18	0.37	170
1960/61	2.18	0.32	147
1961/62	2.23	0.37	166
1962/63	2.55	0.49	192
1963/64	2.41	0.44	183
1964/65	2.49	0.48	193
1965/66	2.51	0.42	169
1966/67	2.79	0.42	149
1967/68	2.65	0.45	168
1968/69	2.42	0.42	174
1969/70	2.31	0.45	194
1970/71	2.43	0.56	231
1971/72	2.39	0.45	188
1972/73	2.29	0.39	168
1973/74	2.39	0.49	203
1974/75	2.23	0.39	176
1975/76	2.17	0.48	221
1976/77	2.28	0.42	185
1977/78	2.38	0.52	218
1978/79	2.39	0.51	215
1979/80	2.38	0.35	146
1980/81	2.47	0.45	180
1981/82	2.59	0.59	228
1982/83	2.22	0.55	249
1983/84	2.18	0.62	283

Note: 1982/83 data are revised estimates; 1983/84 data are subject to revision.

Source: Ministry of Food and Agriculture, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX IV.4.
INDIA: PRODUCTION OF VEGETABLE OILS, 1960/61 - 1983/84[a]

(thousand tons)

Year	Ground-nut	Rapeseed-mustard	Sesame	Coconut	Other	Total[b]
1960/61	1,089	431	99	188	277	2,084
1961/62	1,131	431	115	185	282	2,144
1962/63	1,146	417	153	197	284	2,197
1963/64	1,214	275	136	182	271	2,078
1964/65	1,394	458	150	175	341	2,518
1965/66	961	393	132	165	283	1,934
1966/67	1,006	378	129	164	279	1,956
1967/68	1,324	489	138	164	358	2,473
1968/69	1,044	418	131	175	316	2,084
1969/70	1,171	489	139	184	372	2,355
1970/71	1,413	633	175	190	400	2,811
1971/72	1,429	456	140	187	381	2,593
1972/73	918	590	120	181	452	2,261
1973/74	1,345	545	150	173	591	2,804
1974/75	1,157	715	119	178	668	2,837
1975/76	1,503	616	136	172	606	3,033
1976/77	1,158	476	129	173	517	2,453
1977/78	1,400	500	162	165	620	2,847
1978/79	1,427	569	159	190	652	2,997
1979/80	1,318	439	104	167	542	2,570
1980/81	1,129	708	138	174	603	2,752
1981/82	1,656	731	180	165	734	3,466
1982/83	1,216	675	172	188	724	2,975
1983/84	1,676	785	192	174	781	3,608

Notes:
a. 1975/76 - 1983/84 data are provisional estimates only.
b. Other oils consist of safflower, soybean, sunflower, nigerseed, cottonseed, linseed and castor oils.

Sources: For data up to 1974/75, James Harrison, Jon Hitchings and John Wall, Supply and Demand Prospects for Indian Agriculture (World Bank Staff Working Paper Number 500, Washington, D.C., 1981). The remaining data are from the Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics.

APPENDIX IV.5.
INDIA: NET IMPORTS OF FOODGRAINS AND VEGETABLE OILS, 1961-1984

Year	Quantity (thousand tons)		Value (million rupees)	
	Foodgrains	Vegetable oils	Foodgrains	Vegetable oils
1961	3,488	4	1,291	- 6
1962	3,630	- 32	1,403	- 50
1963	4,538	- 87	1,820	-133
1964	6,252	- 60	2,651	- 97
1965	7,449	43	2,888	55
1966	10,325	30	5,191	46
1967	8,659	47	5,302	143
1968	5,671	- 9	3,578	- 25
1969	3,824	61	2,456	132
1970	3,547	59	1,961	166
1971	2,010	57	1,168	146
1972	411	20	183	21
1973	3,587	103	3,144	125
1974	4,826	24	4,401	-169
1975	7,383	- 56	10,460	148
1976	6,917	15	11,440	226
1977	629	378	1,056	1,817
1978	- 572	281	- 719	1,432
1979	- 204	651	- 528	3,610
1980	- 351	948	- 990	6,551
1981	-	1,074	-	5,160
1982	-	998	-	4,497
1983	-	1,150	-	5,045
1984	-	1,634	-	13,190

Note: Net imports have been computed by subtracting total exports from imports. For foodgrains, import data subsequent to 1975 include pulses and imports on private account.

Source: Ministry of Agriculture, Directorate of Economics and Statistics, _Bulletin on Food Statistics_ (Delhi, various issues) for data up to 1980, and subsequent data are unofficial figures from the Department of Civil Supplies, New Delhi.

APPENDIX·IV.6.
INDIA: IMPORTS OF VEGETABLE OIL, BY TYPE, 1960/61 - 1983/84[a]

(thousand tons)

Year	Palm[b]	Soybean	Rapeseed	Groundnut	Total[c]
1960/61	33.7	0.5	-	N.S.	34.5
1961/62	37.8	1.7	-	0.1	41.7
1962/63	29.2	0.7	-	N.S.	34.1
1963/64	35.5	2.1	0.1	N.S.	38.8
1964/65	24.6	17.6	0.4	-	44.7
1965/66	6.9	42.9	0.4	-	56.3
1966/67	10.6	31.9	0.3	-	42.8
1967/68	5.0	49.8	0.3	-	55.1
1968/69	0.6	50.7	0.1	-	51.4
1969/70	0.3	74.1	0.1	-	75.8
1970/71	0.5	84.6	N.S.	-	89.1
1971/72	0.7	88.7	N.S.	-	89.7
1972/73	24.2	52.8	7.1	-	84.3
1973/74	72.3	49.0	21.0	-	142.5
1974/75	14.9	12.0	1.5	0.5	29.2
1975/76	21.4	24.6	10.0	6.2	62.6
1976/77	145.0	152.4	113.2	35.2	459.0
1977/78	444.4	347.0	352.6	66.9	1,257.6
1978/79	375.0	331.2	213.2	8.1	953.3
1979/80	537.0	631.0	123.0	-	1,291.0
1980/81	453.0	639.0	109.0	-	1,318.0
1981/82	426.0	460.0	44.0	-	944.0
1982/83	621.0	537.0	72.0	-	1,244.0
1983/84	450.0	700.0	300.0		1,520.0

Notes: a. The amount of total imports of vegetable oils in this table are from a different source than that in Appendix IV.3.
b. Includes palm kernel oil.
c. Other oils include coconut, cottonseed and sunflowerseed oils.
N.S. Not significant.

Sources: James Harrison, Jon Hitchings and John Wall, India: Demand and Supply Prospects for Agriculture (World Bank Staff Working Paper Number 500, Washington, D.C., October, 1981) for data through 1978/79, and United States Department of Agriculture, Foreign Agriculture Circular: Oilseeds and Products (October, 1984) for subsequent data.

APPENDIX IV.7.
WORLD PRODUCTION AND EXPORTS OF VEGETABLE OILS, 1973/74 - 1983/84

(thousand tons)

Year	Soybean	Palm	Coco-nut	Rape-seed	Sun-flower	Total[a]
			PRODUCTION			
1973/74	8,528	2,651	1,964	2,522	4,308	29,291
1974/75	7,903	2,984	2,617	2,520	3,896	29,420
1975/76	9,677	3,159	3,157	2,716	3,437	32,004
1976/77	9,580	3,479	2,861	2,838	3,599	31,346
1977/78	10,909	3,708	2,869	2,747	4,388	34,111
1978/79	11,772	4,267	2,579	3,327	4,569	36,143
1979/80	13,235	4,829	2,638	3,365	5,010	38,743
1980/81	12,796	5,170	2,908	4,042	4,726	39,386
1981/82	13,016	6,006	2,842	4,617	5,138	41,970
1982/83	13,467	5,593	2,552	5,387	5,827	43,466
1983/84	13,007	6,483	2,549	5,168	5,892	42,897
			EXPORTS			
1973/74	1,464	1,699	676	356	765	6,782
1974/75	1,545	1,943	1,000	360	639	7,379
1975/76	1,713	2,209	1,337	411	601	8,196
1976/77	2,148	2,363	1,091	531	662	8,804
1977/78	2,653	2,447	1,265	570	725	9,721
1978/79	2,919	2,935	1,092	598	838	10,622
1979/80	3,620	3,723	1,204	643	1,088	12,579
1980/81	3,389	3,416	1,341	824	1,175	12,302
1981/82	3,615	3,962	1,266	816	1,186	13,191
1982/83	3,572	3,962	1,223	800	1,548	13,534
1983/84	3,370	4,100	1,192	799	1,603	13,129

Note: a. Includes, in addition, groundnut, olive, palm kernel, cotton and fish oils.

Source: United States Department of Agriculture, Foreign Agriculture Circular: Oilseeds and Products (Washington, D.C., March 1984).

APPENDIX IV.8.
INTERNATIONAL AND DOMESTIC PRICES OF VEGETABLE OIL, 1970 - 1982

(Rupees per ton)

Year	Groundnut		Rapeseed	Mustard	Palm		Coconut	
	Int[a]	Dom[b]	Int[c]	Dom[d]	Int[e]	Dom[f]	Int[g]	Dom[h]
1970	2,860	4,831	2,217	5,139	3,027	.	2,414	7,302
1971	3,356	4,148	2,257	5,104	2,227	.	2,212	6,054
1972	3,228	4,353	1,694	5,275	1,777	.	1,443	5,554
1973	4,204	7,271	3,058	6,900	2,880	.	3,329	9,421
1974	8,685	8,319	6,360	9,558	2,601	.	8,029	12,158
1975	6,701	6,979	4,615	6,225	3,518	.	3,267	9,067
1976	6,317	5,430	3,719	6,496	4,041	.	3,754	10,183
1977	7,419	8,296	5,103	10,894	4,597	.	5,086	11,158
1978	8,955	7,070	4,867	9,532	5,129	.	5,702	12,296
1979	7,240	8,610	5,168	10,150	5,436	6,028	8,110	12,467
1980	6,739	10,058	4,490	13,554	5,111	6,220	5,308	16,142
1981	9,040	13,804	4,182	14,467	4,762	8,137	4,901	15,173
1982	5,531	15,497	3,943	12,663	4,718	7,230	4,368	21,017

Notes:

. Not applicable.

a. Up to 1973, c.i.f. Europe, from 1974, c.i.f. Rotterdam.

b. Price at Bombay. 1982 data are for November-October, 1982/83.

c. Up to 1972, ex-tank Rotterdam, from 1973, f.o.b. ex-mill Dutch.

d. Price at Calcutta. 1982 data are for April-March, 1982/83.

e. Import price, calculated by dividing value of imports by quantity.

f. Price at Yeroor (refers to crop year).

g. c.i.f. Rotterdam/Hamburg.

h. Price at Bombay. 1982 data are for Cochin, Kerala.

Sources:

Domestic palm oil prices are from Oil Palm India, Limited, Annual Report (various issues). Other domestic prices are from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Agricultural Prices in India (Delhi, various issues) and Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Agricultural Situation in India (various issues). Import prices are computed from FAO Trade Yearbook. International prices are from FAO, Committee on Commodity Problems, Inter-governmental Group on Oilseeds, Oils and Fats, "International Market Price Information" (Rome, 1985). The conversion into rupees have been made using the IMF average of year exchange rates provided in the technical notes.

APPENDIX IV.9.
INTERNATIONAL PRICES OF PALM AND SOYBEAN OILS, 1970-1985

Year	Palm oil[a] (Current U.S. $/ton)	Soybean oil[b] (Current U.S. $/ton)	Percent Change in MUV[c]	MUV Index[d] (1969=1)
1970	259	290	6.1	1.06
1971	262	304	5.3	1.12
1972	218	243	8.6	1.22
1973	372	439	14.7	1.42
1974	674	832	19.7	1.72
1975	435	563	10.6	1.92
1976	396	438	1.4	1.94
1977	530	576	9.4	2.13
1978	600	607	14.0	2.46
1979	654	663	12.4	2.78
1980	583	598	9.2	3.05
1981	569	506	0.5	3.06
1982	445	447	-1.4	3.02
1983	501	527	-2.6	2.95
1984	729	723	-1.8	2.89
1985			0.8	2.91

1985 Prices by Month[e]
(Current U.S.$/ton)

Month	Palm oil	Soybean oil
January	583	630
February	595	664
March	650	667
April	653	693
May	610	652
June	556	630
July	487	568
August	404	518
September	360	469
October	356	448
November	358	455

Appendix IV.9. (continued)

Notes:

a Up to May 1977, Malaysian c.i.f. Europe, from June 1977, Sumatra/Malaysia c.i.f. N W Europe.

b Up to 1971, any origin, ex-tank Rotterdam, from 1972, crude f.o.b. ex-mill.

c MUV refers to Manufactured Unit Value. It represents the value of exports from the United States, Great Britain, France, Japan and West Germany to all lesser developed countries. Percent changes are over previous year's levels and are in logarithmic terms.

d The MUV index has been derived from the MUV growth rates as follows:
Let the price level in 1969 = 1. Then $\ln(P70) - \ln(1) = 0.061$, where P70 is the price level in 1970. Therefore, the index number in 1970 is $e^{0.061} = 1.06$.
Similarly, $\ln(P71) - \ln(1) = 0.061+0.053 = 0.114$, and the index number in 1971 is $e^{0.114} = 1.12$, and so on.

e Prices by month have been deflated using the 1985 index number.

Sources:

Price data from FAO, Committee on Commodity Problems, Inter-governmental Group on Oilseeds, Oils and Fats, "International Market Price Information" (Rome, 1985). MUV deflator from Economic Projections Department, The World Bank.

APPENDIX IV.10.
INDIA: MINOR TREE-CROP OILSEEDS

Name	Botanical name	Production in 1979/80	Production in 1980/81	Production in 1981/82	Realizable Potential[a]
		(- - - thousand tons			- - -)
Mahua	Madhuca indica/ Madhuca longifolia	28	24	64	34
Neem	Azadirachta indica	17	39	34	40
Sal	Shorea robusta	21	6	19	138
Karanj	Pongamia pinnata/ Pongamia glabra	4	7	7	7
Kusum	Schleichera oleosa	2	5	4	6
Rubberseed	Hevea brasiliensis	4	4	4	6
Others[b]		4	5	7	18
Total		80	90	139	249

Notes:

a. This takes into account harvesting difficulties and represents approximately 20 percent of total potential.

b. These consist of Mango Kernel (Mangifera indica), Kokum (Garcina indica), Dhupa (Vateria indica), Undi (Calophyllum inophyllum), Maroti (Hydnocarpus wightania), Pisa (Actinodaphne hookeri), Nahor (Mesua ferrea) and Khakan (Salvadora cleides).

Source: Ministry of Agriculture and Irrigation, Directorate of Oilseeds Development, Oilseeds in India (Hyderabad, India, 1983)

APPENDIX V.
MISCELLANEOUS CALCULATIONS

APPENDIX V.1.
CALCULATION OF THE RELATIVE CONTRIBUTION OF PRICE, YIELD AND INTERACTION EFFECTS TO CHANGES IN TOTAL REVENUES OF OILSEEDS AND COMPETING CEREALS

	1959/60-1961/62			1977/78-1979/80		
	Real Price (Rs/kg)	Yield (kg/ha)	Total Revenue (Rs/ha)	Real Price (Rs/kg)	Yield (kg/ha)	Total Revenue (Rs/ha)
			GUJARAT			
Groundnut	0.61	596	360	0.84	891	745
Bajra	0.40	298	120	0.40	956	384
			UTTAR PRADESH			
Rapeseed-mustard	0.70	536	374	0.89	463	414
Wheat	0.41	956	389	0.33	1,442	482
			UTTAR PRADESH			
Sesame	0.90	145	131	1.17	96	112
Jowar	0.29	476	136	0.28	598	167
Bajra	0.38	455	171	0.32	549	176

Notes:

a. The change in total revenue can be decomposed into price, yield and interaction effects as follows:
Total revenue (TR) can be calculated by multiplying price (P) and Yield (Y). Letting subscript 1 denote the period 1978/79-1980/81 and the subscript 0 denote the period 1959/60-1961/62, one can write the change in total revenue as:

$$\Delta TR = TR_1 - TR_0 = P_1 X Y_1 - P_0 X Y_0$$

But since $P_1 = P_0 + \Delta P$ and $Y_1 = Y_0 + \Delta Y$,

$$\Delta TR = (P_0 + \Delta P) X (Y_0 + \Delta Y) - (P_0 X Y_0)$$

Expanding this expression yields

$$\Delta\ TR = (\Delta\ Y\ X\ P_0) + (\Delta\ P\ X\ Y_0) + (\Delta\ P\ X\ \Delta\ Y)$$

where $\Delta\ Y\ X\ P_0$ is the yield effect,
$\Delta\ P\ X\ Y_0$ is the price effect, and
$\Delta\ P\ X\ \Delta\ Y$ is the interaction effect.

b. Nominal harvest prices are deflated by the consumer price index for agricultural laborers for each state; the base is 1960/61 = 100. It is assumed that the deflation factor for the average of prices centered on 1960/61 is also 100.

c. Multiplying prices and yields may not amount to total revenue due to rounding.

Sources: Harvest price data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Farm (Harvest) Prices (Delhi, various issues); consumer price index information from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Agricultural Situation in India (Delhi, various issues); and production data from Ministry of Agriculture and Irrigation, Directorate of Economics and Statistics, Estimates of Area and Production of Principal Crops in India (Delhi, various issues).

APPENDIX V.2.
CALCULATION OF THE INTERNAL RATE OF RETURN FOR COCONUTS

(1983 Rupees/hectare)

Year	Capital Costs[a]	Maintenance Costs[b]	Income[c]	Cash flow[d]
1	2,489	-	-	-2,489
2	75	185	-	- 260
3	-	185	-	- 185
4	-	185	-	- 185
5	-	185	-	- 185
6	-	1,375	4,800	3,425
7	-	1,450	5,100	3,650
8	-	1,525	5,400	3,875
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
30	-	1,525	5,400	3,875

Internal Rate of Return = 36.6 percent

Notes:

a. Capital Costs consist of clearing land and making pits, planting seedlings, and fencing.

b. Maintenance costs include organic fertilization and harvesting costs.

c. Income is calculated by multiplying yield per hectare with farm harvest price of Rs 1.2 per nut. Sixth year yields are assumed at 4,000 nuts per hectare, seventh year yields at 4,250 nuts per hectare, eighth year yields at 4,500 nuts per hectare.

Source: Cost data from the Central Plantation Crops Research Institute, Kerala.

APPENDIX V.3.
CALCULATION OF THE PRESENT WORTH OF INCOME GENERATED FROM PADDY CULTIVATION COMPARED TO THAT FROM MIXED PADDY AND COCONUT CULTIVATION

(at 1983 prices)

Discount factor = 12 percent

Revenue is derived by multiplying average yields and prices for the early eighties and subtracting half the result in the case of paddy and one-fourth of the result in the case of coconuts to take into account costs.

R: Net revenue generated from rice cultivation = Rs 1,029 per hectare
C1: Net revenue generated from six year old coconuts = Rs 3,482 per hectare
C2: Net revenue generated from seven year old coconuts = Rs 3,700 per hectare
C3: Net revenue generated from eight year old coconuts = Rs 3,918 per hectare

Present worth of paddy = Rs. 8,289

Case 1. 60 percent to rice
10 percent to coconuts in years 1,2,3,and 4

Year		Income	Discounted income
		(Rupees)	
1	0.9R	= 926.1	827.0
2	0.8R	= 823.2	656.1
3	0.7R	= 720.3	512.9
4	0.6R	= 617.4	392.7
5	0.6R	= 617.4	350.1
6	0.6R + 0.1C1	= 965.6	489.6
7	0.6R + 0.1C1 + 0.1C2	= 1,335.6	603.7
8	0.6R + 0.1C1 + 0.1C2 + 0.1C3	= 1,727.4	697.9
9	0.6R + 0.1C1 + 0.1C2 + 0.2C3	= 2,119.2	765.0
10	0.6R + 0.1C2 + 0.3C3	= 2,162.8	696.4
11	0.6R + 0.4C3	= 2,184.6	627.0
12	0.6R + 0.4C3	= 2,184.6	561.4
13	0.6R + 0.4C3	= 2,184.6	500.3
14	0.6R + 0.4C3	= 2,184.6	
	..	..	

Appendix V.3 (continued)

.	..	..	
.	..	..	
.			
30	0.6R + 0.4C3	= 2,184.6	3,563.1

Present worth = Rs. 11,243.2

Case 2. 60 percent to rice
20 percent to coconuts in years 1 and 2

Year		Income	Discounted income
		(Rupees)	
1	0.8R	= 823.2	735.1
2	0.6R	= 617.4	492.1
3	0.6R	= 617.4	439.6
4	0.6R	= 617.4	392.7
5	0.6R	= 617.4	350.1
6	0.6R + 0.2C1	= 1,313.8	666.1
7	0.6R + 0.2C1 + 0.2C2	= 2,053.8	928.3
8	0.6R + 0.2C2 + 0.2C3	= 2,141.0	865.0
9	0.6R + 0.4C3	= 2,184.6	788.6
10	0.6R + 0.4C3	= 2,184.6	703.4
11	0.6R + 0.4C3	= 2,184.6	627.0
12	0.6R + 0.4C3	= 2,184.6	561.4
13	0.6R + 0.4C3	= 2,184.6	500.3
14	0.6R + 0.4C3	= 2,184.6	
.	..	..	
.	..	..	
.	..	..	
30	0.6R + 0.4C3	= 2,184.6	3,563.1

Present Worth = Rs 11,612.74

Case 3. 30 percent of land to rice
10 percent to coconuts in years 1 through 7

Year		Income	Discounted income
		(Rupees)	
1	0.9R	= 926.1	827.0
2	0.8R	= 823.2	656.1
3	0.7R	= 720.3	512.9
4	0.6R	= 617.4	392.7
5	0.5R	= 514.5	291.7
6	0.4R + 0.1C1	= 759.8	385.2

Appendix V.3 (continued)

7	0.3R + 0.1C1 + 0.1C2	= 1,026.9	464.2
8	0.3R + 0.1C1 + 0.1C2 + 0.1C3	= 1,418.7	573.2
9	0.3R + 0.1C1 + 0.1C2 + 0.2C3	= 1,810.5	653.6
10	0.3R + 0.1C1 + 0.1C2 + 0.3C3	= 2,202.3	709.1
11	0.3R + 0.1C1 + 0.1C2 + 0.4C3	= 2,594.1	744.5
12	0.3R + 0.1C1 + 0.1C2 + 0.5C3	= 2,985.9	767.4
13	0.3R + 0.1C2 + 0.6C3	= 3,029.5	693.8
14	0.3R + 0.7C3	= 3,051.3	
.	..	..	
.	..	..	
.	..	..	
30	0.3R + 0.7C3	= 3,051.3	4,976.7

Present worth = Rs 12,648.1

Case 4. 30 percent of land to rice
20 percent of land to coconuts in years 1,2,3, and
10 percent of land to coconuts in year 4.

Year		Income	Discounted income
		(Rupees)	
1	0.8R	= 823.2	735.7
2	0.6R	= 617.4	492.1
3	0.4R	= 411.6	293.1
4	0.3R	= 308.7	196.3
5	0.3R	= 308.7	175.0
6	0.3R + 0.2C1	= 1,005.1	509.6
7	0.3R + 0.2C1 + 0.2C2	= 1,745.1	788.8
8	0.3R + 0.2C1 + 0.2C2 + 0.2C3	= 2,528.7	1,021.6
9	0.3R + 0.1C1 + 0.2C2 + 0.4C3	= 2,964.1	1,070.0
10	0.3R + 0.1C2 + 0.6C3	= 3,029.5	975.5
11	0.3R + 0.7C3	= 3,051.3	875.7
12	0.3R + 0.7C3	= 3,051.3	784.2
13	0.3R + 0.7C3	= 3,051.3	698.8
14	0.3R + 0.7C3	= 3,051.3	
.	..	..	
.	..	..	
.	..	..	
30	0.3R + 0.7C3	= 3,051.3	4,976.7

Present worth = Rs 13,593.1

APPENDIX V.4.
CALCULATION OF KERALA RICE IMPORT REQUIREMENTS
(ROUGH APPROXIMATIONS)

Position in 1983

(1)	Area under coconuts	664	1000 hectares
(2)	Area under rice	802	1000 hectares
(3)	Yield of rice	1,586	kgs per hectare
(4)	Production of rice	1,272	1000 tons
(5)	Imports of rice	1,575	1000 tons
(6)	=> Total availability (4)+(5)	2,847	1000 tons
(7)	Population	25.45	million
(8)	Population growth per annum	1.77	percent
(9)	=> Total per capita avaialability (6)/(7)	112	kgs per annum
(10)	Rural population (0.81)X(25.45)	20.62	million
(11)	Rural per capita production (4)/(10)	61	kgs per annum
(12)	=> Proportion of rural rice requirements purchased [(9) - (11)]/(9)	46	Percent

Position in 2000 and 2010

		2000	2010	
(13)	Population	35.51	42.31	million
(14)	Total per capita availability (9)	112	112	kgs per annum
(15)	=> Total requirements (13)x(14)3,979	4,742	1000	tons
(16)	Projected area under coconuts	690	705	1000 hectares
(17)	Net area diverted from paddy (16) - (1) 26	39	1000	hectares
(18)	Total area diverted from paddy (including effect of cropping intensity (17)X 1.3)	34	54	1000 hectares
(19)	Area under rice (2)-(18)	768	749	1000 hectares
(20)	Yield of rice (20)	1,586	1,586	kgs per hectare
(21)	Production of rice (19)X(20)	1,218	1,118	1000 tons
(22)	Proportion of total rice requirements that needs to be imported [(15)-(21)]/(15)	70	75	percent
(23)	Rural population (13)X0.81	28.76	34.27	million
(24)	Rural requirements (23)X(14)	3,221	3,838	1000 tons
(25)	Proportion of rural rice requirements that needs to be imported [(24)-(21)]/(24)	62	70	percent

Appendix V.4 (continued)

Sources: Area, production and yield data from Ministry of Agriculture and Irrigation, Estimates of Area, Production and Yield of Principal Crops in India (Delhi, 1985); population data from Padmanabha, Census of India, 1981: Key Population Statistics (Bombay, 1983); imports data from India, Kerala State Planning Board, Economic Review, 1983 (Trivandrum, 1983).

APPENDIX V.5.
CALCULATION OF THE INTERNAL RATE OF RETURN FOR OIL PALM

(1983 million rupees)

Year	Capital cost	Operating cost	Income1	Income2	Income3	Income4
1	1.247	-	-	-	-	-
2.	1.197	-	-	-	-	-
3.	0.958	-	-	-	-	-
4.	0.687	-	-	-	-	-
5.	0.725	-	-	-	-	-
6.	0.813	-	-	-	-	-
7.	0.832	1.003	0.502	0.502	0.502	0.502
8.	2.851	2.580	1.213	1.213	1.213	1.213
9.	0.580	3.050	1.080	1.080	1.080	1.080
10.	1.840	4.507	1.654	1.654	1.654	1.654
11.	0.680	6.410	1.860	1.860	1.860	1.860
12.	-	6.290	3.810	4.760	5.933	7.417
13.	-	6.970	5.270	6.580	9.147	11.433
14.	-	7.830	7.220	9.025	13.587	16.983
15.	-	8.890	9.810	12.263	19.613	24.517
16.	-	10.210	12.190	15.238	24.387	30.483
17.	-	11.220	14.020	17.525	28.027	35.033
.	..	..	..	..	..	..
.	..	..	..	..	..	..
.	..	..	..	..	..	..
30.		11.220	14.020	17.525	28.027	35.033

Notes:
Income1: Oil yield is one ton per hectare, price is Rs 8,000 per ton.
Income2: Oil yield is one ton per hectare, price is Rs 10,000 per ton.
Income3: Oil yield is two tons per hectare, price is Rs 8,000 per ton.
Income4: Oil yield is two tons per hectare, price is Rs 10,000 per ton.

Peak productivity is assumed to be attained in year 17. Cash flow is calculated by subtracting from each income, capital and operating costs.

Sources: Cost data are from the Annual Reports of Oil Palm India, Ltd., and have been deflated to 1983 prices using the consumer price index for agricultural laborers in Kerala. Income data up to Year 11 are actual and are derived from the Annual Reports. These have also been deflated.

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