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# INDIAN SCHOOL OF POLITICAL ECONOMY



JOURNAL OF INDIAN SCHOOL OF POLITICAL ECONOMY is devoted to a study of the Indian Economy, Polity and Society. Emphasis is on reviewing developments since Independence with roots in the British administration where relevant. When a review is based on statistical data, as far as possible, full statistical base data are presented. The Journal is intended to be a quarterly. However, in the first year, we brought out only two issues, January-June and July -December 1989. In 1990, we brought out three issues January-April, May-August, and September-December 1990. Beginning 1991, we shall bring out four quarterly issues. This is the fourth issue of 1991.

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JOURNAL
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# AUTHORS - PLEASE NOTE

In the INSTRUCTIONS FOR AUTHORS normally published on this page, we have inter alia the following condition: Mention any special circumstance concerning the paper, such as its earlier presentation at a meeting or a conference. We will assume that papers submitted to this Journal are not under consideration elsewhere. We regret to say that we have been proved wrong. One is the case of the article titled 'Demand for Labour in Indian Manufacturing Industry: 1960-84' by Dr. A.K. Seth and Dr. V.K. Seth published in the July-September, 1991 issue of this Journal. The other is the article titled 'Maintenance of Highways - An Evaluation' by Sudha Mahalingam published in the April-June 1991 issue of this Journal. In the following, we offer our explanation and hope that this will not happen again. As will be evident, the two cases fall in two quite different categories.

CASE OF DR. A.K. AND DR. V.K. SETH
RELEVANT CORRESPONDENCE

October 30, 1991

Dear Dr. Seth,

This has reference to the article titled 'Demand for Labour in Indian Manufacturing Industry: 1960-84' by yourself jointly with Dr. Ashok K. Seth, which appeared in the July-September, 1991 issue of the Journal of the Indian School of Political Economy. I was surprised to find substantially the same article now appearing in the July, 1991 issue of the Indian Journal of Industrial Relations, which I received only today. The two versions are substantially the same except that the one appearing in our Journal is considerably edited by myself including its title.

You will remember that you first sent your paper to me by your letter dated 16th April, 1991. By my letter dated 4th July, 1991, I wrote to you saying that your paper was acceptable and that it would appear in the July-September, 1991 issue of the Journal. I also wrote that it would require some editing. Since then we corresponded several times because of my editorial requirements. I wrote my last letter to you dated 9th September, 1991.

As much as I can see, during this period you never informed me that you had also submitted your paper to the Indian Journal of Industrial Relations. I find this very surprising and, to put it very mildly, contrary to all norms of academic behaviour. I shall be obliged to publish my explanation in the forthcoming (October-December, 1991) issue of our Journal. If you have any explanation to offer, please write to me urgently so that I may incorporate it in my own note.

Unless you have any valid explanation, I think decency requires that you return the amount of Rs. 1300/- which we paid for your paper. Please send the amount by a Demand Draft, payable to Indian School of Political Economy, drawn on any bank in Pune, as we did in your case.

I am sorry that so much correspondence and the editorial labour spent by me on your paper should end in this manner. I feel very unhappy.

I am sending a copy of this letter to the Editor, Indian Journal of Industrial Relations, New Delhi-110 055.

Yours sincerely,
(Sd/)V.M. DANDEKAR

J.S. SODHI, Professor & Editor
Indian Journal of Industrial Relations

13th November, 1991

Dear Dr. Dandekar,

I am in receipt of the copy of your letter addressed to Dr. V.K. Seth in connection with the publication of his paper in the Journal of the Indian School of Political Economy as well as the Indian Journal of Industrial Relations.

The paper with the title of 'Labour Absorption in the Indian Manufacturing Sector' was submitted to the IJIR by Dr. V.K. Seth vide his letter dated 21st June, 1991. I had acknowledged the receipt of his paper on the same date and given him my acceptance orally, subject to the editorial changes, some time in late July. I had, of course, no knowledge of the fact that the paper was also submitted elsewhere for publication.

With personal regards,

Yours sincerely,
(Sd/-) J.S. SODHI

Dr. Seth has not acknowledged my letter.

CASE OF SUDHA MAHALINGAM

I first received Sudha Mahalingam's paper titled 'Maintenance of Highways - An Evaluation' as a Working Paper No. 9/1990 of the National Institute of Public Finance and Policy with a covering letter of the Editor of NIPFP dated October 22, 1990. By my letter dated November 6, 1990, I asked the Editor whether I could consider this paper for publication in our Journal. After consulting the author, the Editor, by his letter dated January 24, 1991, conveyed her permission to publish the paper and her request that if I wanted to make any changes in the paper, I should write to her directly at her address in Calcutta. Evidently, she had by that time left the NIPFP. After due editing and approval of the author, the paper was published in April-June 1991 issue of our Journal. Recently, I saw the same paper, except for my editing, published in the December 7, 1991 issue of the Economic and Political Weekly. Before this came to my notice and I could write to her, I received the following letter from her.

Dec. 28, 1991

Dear Prof. Dandekar,

I was dismayed to find my paper on National Highways in the Dec. 7 issue of EPW. When I gave you the consent (through NIPFP) for publishing the same piece in your Journal (April-June 1991), I simultaneously wrote to Prof. Krishna Raj of this development. I had sent him this paper in May 1990 and had not heard of its fate since then. Therefore, I presumed that EPW was not interested in publishing my piece. Now, they have used it, full 19 months after it was sent. There seems to have been some communication gap somewhere and I felt I owed you an explanation. Hence, this letter by Speed Post. I do hope you will not let this lapse cast an aspersion on my integrity as a scholar, because the fault is not mine.

Wish you a Happy New Year,

With regards,

Yours,
(Sd/-) SUDHA MAHALINGAM

The contrast in propriety and probity of the two cases is too obvious to need further comment.

# GROWTH PERFORMANCE IN INDIAN AGRICULTURE

Deepak Ahluwalia

*The paper evaluates growth trends in Indian agriculture, at various levels of disaggregation, over the past four decades. A standard area-yield decomposition exercise also investigates the sources of production growth at the state level for all the main crops. The results show that overall production growth remains modest compared to other developing nations in the Asia region. Further, there has been no statistically significant shift in this growth during any period within the post-Independence era. But, it seems that a shift to a higher growth path is underway in parts of East and Central India.*

Initial drafts of the Eighth Five Year Plan (1990-95) as well as of the Agricultural Policy Resolution reflect the current emphasis being assigned to the agricultural sector of the Indian economy. The emphasis, as such, is not misplaced. Performance in this vast and diverse sector, which accounts for roughly a third of GDP and two-thirds of the total labour force, has far reaching reverberations throughout the economy affecting key macroeconomic variables such as GDP growth, and poverty levels. It is being increasingly realized that many of the issues relating to unemployment, to variations in income and nutrition levels, and to the provision of a better standard of living for a large and growing population cannot be tackled without a large and concerted increase in agricultural production.

Recognizing this, both the Eighth Plan and the Agricultural Policy Resolution have targeted future production growth in the agricultural sector at 4 to 4.5 per cent per annum. This is substantially higher than the less than 3 per cent per annum (the actual figure depends on the data and coverage) trend growth that has characterized agriculture in the past. The key question is -- how realistic and attainable is this target? Do past trends justify it? What initiatives will be necessary to attain this rate of growth? These are complex questions and answers depend as much on the resources available (which are not finalized yet) and the policies that are now formulated as on assumptions about factors notoriously difficult to foresee, such as future technological breakthroughs.

This paper, although with an eye on these central questions, limits itself to a discussion of past trends in agricultural growth. Growth rates of production, at various levels of aggregation, are delineated; the sources of output growth are empirically identified in terms of the standard area-yield components and some attempts are also made at comparing the Indian performance to performance in neighbouring Asian countries. Lessons from this exercise provide some probable directions for the future.

More specifically, in this paper, the most recent data available are used to analyze: (a) past trends in the rates of growth of production in agriculture; given the wide regional and cropwise disparities that exist in Indian agriculture the analysis is conducted both at the all-India and at the state/region level for all the principal crop groups and for selected important crops; some comparisons with neighbouring Asian countries are also presented and (b) the sources of intertemporal growth of production in terms of the contributions from changes in area and increases in per hectare yields. Lessons from (a) and (b) are then used to draw some probable courses that the agricultural sector will take in the future.

## TRENDS IN GROWTH OF PRODUCTION

This section estimates growth rates[1] of agricultural production for different crops/crop groups at the state/region/country levels for various periods within the last four decades. The section is arranged in four parts with successively increasing level of detail. Part A looks at indicators of overall agricultural production at the all-India level. Part B looks at overall production trends at the state and region levels. Part C explores growth trends in the principal crops and crop groups at the all-India level while Part D investigates region level growth in the main crops.

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The author acknowledges numerous editorial suggestions by Prof. V. M. Dandekar. The author is solely responsible for the analysis and opinions expressed in the paper. The World Bank shares no responsibility in the matter.

*A. Aggregate Production Growth at the All-India Level*

Indian agriculture has come a long way since Independence. The virtual stagnation in output in the pre-Independence years has given way to steady growth in the post-Independence era[2]. Nevertheless, the rate of growth in the post-Independence period, though substantially higher than in the past, has still been modest[3]. The actual rate itself varies according to the indicator chosen, but is below 3 per cent per annum for most of the plausible indicators between the period 1950-51 to 1988-89. For instance, GDP originating in agriculture (proper) increased at 2.3 per cent per annum, the value of output of all crops measured by the official Index of Production of all crops increased at 2.5 per cent per annum while foodgrain output (probably the most often used indicator of agricultural performance, even though foodgrains have a weight of only 62.9 per cent in the index of all crop production) increased at 2.6 per cent per annum. These rates are lower than the growth rates in the industrial and services sectors; GDP originating in the industrial sector grew at 5.2 per cent per annum and GDP from services grew at 4.6 per cent per annum. Correspondingly, there has been a gradual decline in the share of agriculture and allied activities in all-India GDP (at current prices) from 55.8 per cent in 1950-51 to 33.0 per cent in 1988-89.

The rates of growth of agricultural production can be termed as modest on at least three counts. First, many other developing nations in the Asia region have performed better. Comparable data on eleven countries, including India, for the period 1968-1988 (this corresponds to the post-green revolution era) shows that the per annum growth in GDP originating in agriculture was faster in Burma, China, Malaysia, Thailand (all 4 per cent or above), Indonesia, Philippines, and Sri Lanka (between 3 and 4 per cent) as compared to India (2.3 per cent). Only Bangladesh (2 per cent) and Nepal (1.9 per cent) recorded a smaller growth (Table 1).

TABLE 1. GROWTH RATES OF GDP ORIGINATING IN AGRICULTURE

(per cent per annum)

| | 1968-88 | 1968-77 | 1978-88 | Statistically significant break between 1978-88 and 1968-77 at a 5% level |
|---|---|---|---|---|
| Bangladesh | 2.0 | 0.6 | 2.0 | Yes at 6% |
| Burma | 4.8 | 2.8 | 5.6 | Yes |
| China | 4.3 | 3.1 | 6.2 | Yes |
| Nepal | 1.9 | 1.4 | 3.8 | Yes |
| Pakistan | 3.6 | 2.4 | 4.6 | Yes |
| Sri Lanka | 3.0 | 1.6 | 2.9 | Yes |
| India | 2.3 | 2.3 | 2.5 | No |
| Indonesia | 3.9 | 4.0 | 3.5 | No |
| Malaysia | 4.0 | 5.7 | 3.5 | Yes |
| Philippines | 3.7 | 4.4 | 2.3 | Yes |
| Thailand | 4.0 | 4.1 | 3.4 | Yes at 6% |

Notes: For Burma data till 1986. For Malaysia data from 1970. The year specified refers to the initial year of the fiscal year wherever data are according to fiscal year. Thus for India 1988 refers to 1988-89.
Source: World Bank, *World Tables, 1989-90*

A sub-division of the entire period shows the Indian performance during the second decade (1978-88) in an even poorer light. First, during 1978-88, only in Bangladesh did GDP originating in agriculture grow slower than in India (2 per cent compared to 2.5 per cent for India). Growth in Nepal during this period was at 3.8 per cent per annum. Second, both in Bangladesh and Nepal, as also in Burma, China, Pakistan, and Sri Lanka (the six immediate neighbours of India) there is evidence of a significant upward break with trend in the 1978-88 decade compared to the trend in the 1968-77 decade[4]. This has not occurred in India (Table 1)[5]. Overall growth in

the post-green revolution period is not significantly different than in the pre-green revolution period. Growth in the 1980s is not significantly different from that in the 1970s. Neither is there a difference if any other cut-off point is chosen (this issue is further elaborated upon in section IIC). Much of the initial promise of the new technology seems to have been belied, with gains accruing only in selected crops and regions; overall there has not been any acceleration.

Finally, the rapid increase of population in India (at about 2.1 per cent per annum over the last four decades) has meant that the modest aggregate growth rates of production have translated into even more modest increases in per capita agricultural production. Given the virtually closed nature of the Indian agricultural economy, this has led to very small increases in per capita availability of food as compared to other countries (Pakistan, China, Sri Lanka) in the region.

*B. Aggregate Production Growth at the State/Region Level*

The all-India picture suppresses regional imbalances that are so much a part of Indian agriculture. Some regions have performed much better than others. Hence, it is necessary to look at the performance at a more disaggregated level and the level most amenable to analysis, in terms of data availability, is the state level. At the state level, the only complete and comparable set of data that provide an overview of total agricultural production are data on State Domestic Products (SDPs). These are available for after 1960-61 which corresponds to the period when the major part of the reorganization of states had been completed.

Fifteen main states account for about 85 per cent of the total all-India domestic product that originates in agriculture (Table 2). They can be regionally organized in various ways. Most traditional classifications use either a four-fold or a five-fold organization: north, east, south, and centre/west. However, Uttar Pradesh, which is geographically the largest state in India, poses a problem when classifying along these traditional lines. The western part of Uttar Pradesh is agriculturally akin to the northern states of Punjab and Haryana while eastern Uttar Pradesh is similar to the states in the eastern region. Including the entire state in either the north or the east (or in the centre for that matter) distorts the regional results unduly.

To overcome this problem, a six-fold regional classification of the fifteen states is used in this paper. Uttar Pradesh is treated as a separate region in itself. The other regions are organized as follows: the northern region is made up of Punjab and Haryana; the eastern region embraces Assam, Bihar, Orissa and West Bengal; the central region constitutes Madhya Pradesh and Rajasthan; the western region consists of Gujarat and Maharashtra and the southern region comprises Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

The first column in Table 2 shows the relative importance of each state (and region) to the agricultural economy of India. Uttar Pradesh, the largest state, is appropriately enough also the most important state in agricultural terms; Assam and Tamil Nadu are relatively the least important. Across regions, the east is the most significant while the north brings up the tail end.

Within each state, agriculture remains a primary activity in terms of its contribution to total State Domestic Product (SDP) (col. 2). In Orissa, Rajasthan, Bihar, Haryana, Punjab, Assam and, Madhya Pradesh, it is over 40 per cent in late 1980s. In Tamil Nadu, Maharashtra, and Gujarat, it is less than 25 per cent. Elsewhere, it lies between 25 and 40 per cent.

Table 3 shows the state level growth rates of SDP originating in agriculture for the period 1960-61 to 1986-87 (data after 1986-87 are not available for all states) as well as for two sub-periods within: 1960-61 to 1975-76 (initial and terminal years are both above trend in all-India GDP from agriculture) and 1976-77 to 1986-87 (both end points are somewhat below all-India trend)[6].

TABLE 2. RELATIVE IMPORTANCE OF THE MAIN STATES IN INDIAN AGRICULTURE AND THE RELATIVE IMPORTANCE OF AGRICULTURE WITHIN EACH STATE

| | Per cent share in All-India Domestic Product originating in Agriculture (average 1984-87) | Per cent share of Agriculture in State Domestic Product (average 1984-87) |
|---|---|---|
| *North* | 8.4 | 43.8 |
| Haryana | 3.3 | 43.8 |
| Punjab | 5.1 | 43.8 |
| *Uttar Pradesh* | 12.8 | 38.0 |
| *East* | 23.0 | 41.9 |
| Assam | 2.8 | 41.9 |
| Bihar | 8.0 | 45.3 |
| Orissa | 4.2 | 55.2 |
| West Bengal | 7.9 | 34.8 |
| *Centre* | 11.3 | 42.9 |
| Madhya Pradesh | 6.2 | 40.1 |
| Rajasthan | 5.2 | 46.7 |
| *West* | 11.5 | 22.8 |
| Gujarat | 4.2 | 25.0 |
| Maharashtra | 7.3 | 21.7 |
| *South* | 17.6 | 30.6 |
| Andhra Pradesh | 6.6 | 36.9 |
| Karnataka | 5.0 | 36.9 |
| Kerala | 3.1 | 35.9 |
| Tamil Nadu | 3.0 | 16.9 |
| Total Above | 84.6 | 35.0 |
| All India | 100.0 | 34.5 |

Note: Data are from the current price series of State Domestic Products.
Source: GOI, CSO, Estimates of State Domestic Products, various issues.

TABLE 3. GROWTH RATES OF STATE DOMESTIC PRODUCT ORIGINATING IN AGRICULTRE

(per cent per annum)

| | 1960-87 | 1960-76 | 1976-87 | Significant break between 1960-76 and 1976-87 at a 5% level |
|---|---|---|---|---|
| *North* | 4.0 | 4.1 | 4.3 | No |
| Haryana | 3.7 | 4.1 | 3.2 | No |
| Punjab | 4.2 | 4.2 | 4.9 | No |
| *Uttar Pradesh* | 2.3 | 1.4 | 3.2 | Yes at 6% |
| *East* | 2.2 | 2.0 | 2.7 | No |
| Assam | 1.3 | 0.4 | 1.9 | Yes |
| Bihar | 1.4 | 0.9 | 2.3 | No |
| Orissa | 4.2 | 6.5 | 3.2 | Yes |
| West Bengal | 2.5 | 2.0 | 3.0 | No |
| *Centre* | 2.5 | 2.2 | 3.6 | No |
| Madhya Pradesh | 1.7 | 1.5 | 3.8 | No |
| Rajasthan | 3.6 | 3.3 | 3.4 | No |
| *West* | 2.0 | 1.0 | -0.9 | No |
| Gujarat | 2.2 | 1.3 | -1.2 | No |
| Maharashtra | 2.0 | 0.7 | -0.7 | No |
| *South* | 1.5 | 1.8 | 1.1 | No |
| Andhra Pradesh | 1.8 | 1.8 | 2.2 | No |
| Karnataka | 2.7 | 3.0 | 2.8 | No |
| Kerala | 0.9 | 2.0 | 0.1 | Yes |
| Tamil Nadu | -0.03 | 0.5 | -2.3 | Yes |
| All India | 2.3 | 1.9 | 2.7 | No |

Notes: All data are at constant (1970/71) prices.
Source: Data from CSO, Estimates of State Domestic Product, various issues.

The rate of growth of all-India GDP from agriculture is 2.3 per cent per annum during the period from 1960-61 to 1986-87 with no significant break in trend between the first and second sub-period. However, at the state level, in five of the fifteen states, there is a statistically significant break in trend between the two sub-periods. The rate of growth increased significantly in Assam and Uttar Pradesh after the mid-1970s while it decreased in Orissa, Kerala, and Tamil Nadu[7].

Comparing across regions, growth performance in the north (above 4 per cent per annum) has been well above the performance elsewhere in each of the sub-periods considered. The eastern, central, and Uttar Pradesh regions have performed well in the 1976-87 decade with evidence of an upward break in trend in at least Uttar Pradesh. Growth has been slow in the southern region, primarily because of the stagnation in Tamil Nadu and Kerala, while in the western region agricultural SDPs actually declined over the 1976-87 decade.

Within regions, output in Haryana, in the north, grew at a somewhat lower rate than in Punjab and the difference widened during the last decade. While it is still too early to judge whether growth in Haryana has shifted to a lower trend line, the slowdown is ominous. Of course, by the same token, the shift to a higher growth path in Uttar Pradesh is a welcome development. Also welcome are signs of quickening growth in some of the eastern and central states. In the east, Assam has already taken to a higher growth path since the mid-seventies (although the rate of growth in Assam is still low; higher only than in Gujarat, Maharashtra, Kerala, and Tamil Nadu, all of which performed very poorly) while indications are that Bihar and West Bengal might well be following soon. In the centre, Madhya Pradesh too has shown signs of an improved performance since the mid-seventies. Not so welcome is the poor performance in the west and the south with evidence of an absolute fall in output in Gujarat, Maharashtra, and Tamil Nadu and stagnant output in Kerala during the 1976-87 decade. In all of the western and southern regions, only Andhra Pradesh and Karnataka have performed moderately well in the second sub-period, 1976-87.

There are many explanations for these disparate performances which may be broadly classified under four heads: agro-climatic, technological, incentive structure, and institutional. One may also distinguish 'natural' factors from 'man-made' factors such as better irrigation infrastructure, better access to the new inputs and so on which are also responsibile for the disparate growth trends. Whatever they be, assuming these growth trends continue into the future, the regions with maximum growth potential will be the east, the centre, and Uttar Pradesh. A combination of factors such as a large rural population, relatively high irrigation potential, and good rainfall appear to favour agricultural growth in these parts. The need now is to consolidate and build on the gains that have come about so as not to let the momentum fritter away.

While comparing across states or regions within India is one way to assess comparative growth performance, an alternative and informative exercise, is to compare regions with adjoining countries. The advantage of such comparisons is that areas with roughly similar agro-climatic conditions can be compared. Variations in agro-climatic conditions may be partly responsible for the disparate growth rates within India; for instance, it may be alleged that soil conditions or weather patterns favour agricultural production in the north, more than say, in the south. If so, the northern region can be compared to Pakistan; the south to Sri Lanka; the east to Bangladesh and/or Burma and so on. Such comparisons, for the decade 1976-87, show that on the whole, many of the regions in India did not do as well as the neighbouring countries. The 4.3 per cent per annum growth in north India is less than the 4.6 per cent per annum achieved in Pakistan (this is average for Pakistan as a whole - in regions immediately adjacent to India, say, Pakistan Punjab, it may be more); the negative growth in the west is nowhere comparable to Pakistan; growth in the south (1.1 per cent) is much less than in Sri Lanka (4.1 per cent); the east (2.7 per cent) compares unfavourably to Burma (5.9 per cent) and China (5.9 per cent) although it does hold its own against Nepal (2.8 per cent) and does somewhat better than Bangladesh (2.3 per cent). Uttar Pradesh (3.2 per cent) does better than

Nepal which is the only country this region borders. The central region does not border any countries, but growth there in the 1976-87 decade was 3.6 per cent per annum which is better than both in Bangladesh and Nepal but not as good as, say, Pakistan or Sri Lanka[8].

In sum, the international comparisons also highlight the poor agricultural growth in the western and southern regions of India, while in the north, Uttar Pradesh, and the east, differences with neighbouring countries are not so marked. But, overall agricultural growth in India clearly leaves much to be desired and policies will have to focus on consolidating the recent gains achieved in the eastern and central parts of the country.

### *C. Production Growth in the Principal Crops and Crop Groups at the All-India Level*

Table 4 shows the growth rates in the all-India indices of production of principal crop groups for various periods within 1949-50 to 1988-89.

TABLE 4. GROWTH RATES OF PRODUCTION OF PRINCIPAL CROP GROUPS

(per cent per annum)

| Crop Group | Weight in Index of Ag. Prdn. | Entire period 1949-89 | Pre-Green Revolution 1949-65 | Post-Green Revolution 1967-89 | Significant change between pre and post Green Revolution at 5% level | Post-Green Revolution Decade I 1967-78 | Post-Green Revolution Decade II 1978-89 | Significant change between Decade I & Decade II at 5% level |
|---|---|---|---|---|---|---|---|---|
| All Crops | 100.00 | 2.5 | 3.1 | 2.5 | No | 2.3 | 2.8 | No |
| Foodgrains | 62.92 | 2.4 | 2.8 | 2.5 | No | 2.2 | 2.8 | No |
| All Cereals | 54.98 | 2.8 | 3.2 | 2.8 | No | 2.6 | 2.9 | No |
| Coarse Cereals | 10.79 | 1.2 | 2.2 | 0.5* | Yes | 0.7* | -0.3* | No |
| All Pulses | 7.94 | 0.4 | 1.4 | 0.7 | No | 0.3* | 2.1** | No |
| Non-Foodgrains | 37.08 | 2.6 | 3.7 | 2.6 | Yes | 2.6 | 3.0 | No |
| All Oilseeds | 12.64 | 2.1 | 3.2 | 2.2 | No | 1.3* | 4.1 | Yes at 6% |
| Sugarcane | 8.11 | 2.9 | 4.2 | 2.7 | Yes | 4.0 | 3.1 | No |
| All Fibres | 5.09 | 2.1 | 4.5 | 1.8 | Yes | 1.9** | 0.01* | No |
| All Fruits & Vegs. | 4.90 | 5.4 | 7.3 | 3.8 | Yes | 3.9 | 3.2 | No |
| All Condiments & Spices | 2.59 | 1.8 | 1.2 | 3.0 | Yes | 1.0* | 3.4 | Yes |
| All Plantation Crops | 2.29 | 3.4 | 2.9 | 3.5 | Yes | 4.6 | 3.3 | Yes at 6% |

Notes: * not significant at 10% level; ** significant at between 5% and 10% levels; all others are significant at less than 5% level. Data are from the new series of All-India index numbers of agricultural production (base: triennium ending 1981-82=100). Years 1965-66 and 1966-67 are dropped when comparing pre- and post-green revolution periods because these were severe drought years. New seed varieties were first used in wheat, following these two drought years. A list of the crops in each group is given in Annex Table 1.
Source: *All India Index Numbers of Area, Production and Yield of Principal Crops, 1990.*

Various periods are considered and statistical tests employed to check for significant changes in trend across periods. One set of results contrasts growth in the pre-green revolution years (1949-65) to growth in the post-green revolution years (1967-89). A second set focuses on the post-green revolution era and contrasts growth in the first decade following the introduction of the new technology (Decade I: 1967-78) to growth in the second decade (Decade II: 1978-89). All the end points chosen (1949-50, 1964-65, 1967-68, 1977-78, 1978-79, and 1988-89) are above the trend line for all crop production. Hence, the comparisons are statistically justified.

The results show that, in most of the crop groups, growth rates are lower in the post-green revolution period than in the pre-green revolution period; the only exceptions are the relatively minor groups of condiments and spices and plantation crops. However, in statistical terms, the downward break in trend is significant only for coarse cereals within foodgrains, for non-foodgrains as a whole, and for sugarcane, fibres, and fruits and vegetables within the non-foodgrains group. On the whole, the green-revolution has not led to any acceleration in the growth of production at the all-India level. Rather, a decrease in growth in some important segments is suggested. The overall picture is of important crop groups continuing to grow at a less

than 3 per cent per annum that seems to have been the hallmark of agriculture in India.

The same is true between the first and second decades of the post-green revolution era. There is no significant change in the trend growth of production of all crops, foodgrains or non-foodgrains. The only significant upward break in Indian agriculture in Decade II as compared to Decade I occurred in condiments and spices and in oilseeds (at a 6 per cent level of significance). On the other hand, growth in plantation crops slowed significantly (again at a 6 per cent level of significance) in Decade II. There is no change in the other crop groups.

Within each of the crop group, there are differences and these are explored by extending the analysis to the principal crops in the post-green revolution period. Table 5 shows the trend growth rates in 14 major crops for the entire post-green revolution period (1967-90) as well as for two decades 1967-78 and 1978-90. The first ten crops (rice to bajra) are chosen according to their relative importance in Indian agriculture which is measured by the weight they are assigned in the index of all crop production. Four additional crops are included to get additional representation for some important groups: tur (from the pulses group), sesamum (oilseeds group), jute (fibres group) and tobacco.

TABLE 5. GROWTH OF PRODUCTION OF PRINCIPAL CROPS

(per cent per annum)

| Crop | Weight in Index of Agricultural Production | Post-Green Revolution 1967-90 | Decade I: 1967-78 | Decade II: 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| Rice | 29.74 | 2.7 | 2.1 | 3.5 | No |
| Wheat | 14.45 | 4.9 | 5.4 | 4.0 | No |
| Sugarcane | 8.11 | 2.8 | 4.1 | 3.4 | No |
| Groundnut | 5.60 | 1.4 | 1.1* | 2.5* | No |
| Jowar | 4.43 | 1.3 | 1.6* | -0.02* | No |
| Cotton | 4.37 | 2.2 | 2.1** | 1.6* | No |
| Gram | 3.07 | -0.6* | -0.1* | -0.3* | No |
| Rape/Mustard | 2.41 | 4.2 | 1.7* | 8.1 | Yes |
| Maize | 2.41 | 1.4 | 0.4* | 2.7 | No |
| Bajra | 1.87 | 0.2* | 0.04* | 0.8* | No |
| Tur | 1.58 | 2.0 | 0.4* | 3.4 | Yes |
| Tobacco | 1.12 | 1.5 | 2.1* | -0.9* | No |
| Sesamum | 0.65 | 1.5 | 0.3* | 3.3 | No |
| Jute | 0.55 | 2.2 | 0.7* | 1.1* | No |

Notes: * significant at 10% level; ** significant at between 5% and 10% levels; all others are significant at less than 5% level. Preliminary crop level estimates for 1989-90 are now available (though not yet for the index of agricultural production) and these are included. Hence, the second period 1978-90 is actually 11 years; nevertheless, for convenience of expresssion, it is still referred to as a decade.
Source: Data from GOI, MOA.

An immediate observation from Table 5 is the number of crops that do not show any growth (statistically significant) during Decade I. Excepting for rice, wheat, and sugarcane, growth in other crops is not statistically significant at a 5 per cent level. Growth in cotton is significant at a 10 per cent level; but growth in other crops is not significant even at this level. This may be partly due to the short time period considered (eleven observations), but even so, it does highlight the very limited initial impact of the new technology. New seed varieties, initially in wheat and later in rice, access to irrigation for wheat, rice, and sugarcane, along with a support price policy, subsidized modern inputs, and consequent area increases, were responsible for reasonable growth occurring in these three crops. In other crops, because of lack of technological and price incentives, there were no large increases in production. The overall growth performance improved somewhat in Decade II with more crops, notably, rape/mustard, maize, tur, and sesamum showing significant growth. Growth in cotton was not significant. Other important crops such as groundnut, jowar, gram, tobacco, and jute continued to languish.

In sum, growth trends during the post-green revolution period show that among the main crops only the output of rice, wheat, sugarcane and rape/mustard grew faster than the all-crops average. These four crops, accounting for 54.7 per cent of total value of output (in the triennium ending 1981/82) can be termed as the engines of growth in Indian agriculture. In the remaining principal crops, growth has been less than the all-crops average and they have acted as drags on overall growth.

### *D. Growth in the Principal Crops at the Regional Level*

To keep the discussion within manageable limits, the analysis is restricted to just six regions and to eight most important crops in Indian agriculture. State level trends for each crop give far too many growth rates for any underlying patterns to be readily comprehended especially since for each crop three periods are investigated: the entire post-green revolution period (1967-90), and the two sub-periods 1967-78 and 1978-90.

The eight crops considered are rice and wheat, jowar from among the coarse cereals, groundnut and rape/mustard among oilseeds, gram from the pulses group, cotton from the fibres, and sugarcane. Growth rates, by crop, are presented in Tables 6 through 13. After briefly discussing the salient features of each Table, a summation of the growth performance, by region, is attempted. Taking each crop in turn, the growth picture at the regional level is as follows:

TABLE 6. GROWTH IN PRODUCTION OF RICE BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 10.6 | 11.5 | 14.7 | 6.0 | Yes |
| Uttar Pradesh | 12.7 | 5.0 | 4.0 | 7.1 | No |
| East | 35.1 | 1.5 | 0.7* | 4.0 | Yes |
| Centre | 7.1 | 1.9 | 1.3 | 4.6 | No |
| West | 4.3 | 2.7 | 4.4** | 0.3* | No |
| South | 27.4 | 1.8 | 1.6 | 1.4 | No |
| Total above | 97.1 | | | | |
| All India | 100 | 2.7 | 2.1 | 3.5 | No |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Rice*: Among the four main rice growing regions (north, Uttar Pradesh, east and south), the introduction of the new technology led to large increases in output in the north, Uttar Pradesh and, in decade II, in the east. The pattern of growth between the north, and Uttar Pradesh and the east, is dissimilar -- growth decelerated in the north during decade II as compared to decade I (although in numerical magnitude it is still high at 6 per cent per annum), whereas the reverse has been the case with Uttar Pradesh and the east (although the acceleration in Uttar Pradesh is not statistically significant).

The reasons for these dissimilar performances are not hard to identify. Part of the high growth rate in the north during decade I can be attributed to the low initial base; the higher base at the beginning of decade II translates into a lower rate of growth despite a large increase in actual physical output. Another important reason is that, by the late seventies, most of the early gains of the new technology had already been exploited in the north. In contrast, the new seed-fertilizer technology for paddy arrived on a wide scale in Uttar Pradesh and in the east later (mid to late seventies) than it did in Punjab and Haryana (early seventies), so that in these two regions its impact was felt largely in the second period. As we shall subsequently see, there are marked differences in the source of growth, in terms of area and yield

increases, between the northern states and the rest of the country.

The numerically high growth rates in the north and Uttar Pradesh, as compared to the east, can, in part, be explained by the procurement pricing policy, or, to be more specific, since procurement prices are more or less uniform all over the country, to the existence of a large number of government procurement centres in Punjab, Haryana, and Uttar Pradesh. The paucity of these centres in the east (and the central states for that matter), by depriving farmers of an assured price and outlet for their produce, probably contributed to slower production growth in these regions from what might have been. This is not to diminish the importance of the greater access to irrigation in the north and Uttar Pradesh. The point being made is that, quite apart from irrigation, paucity of procurement centres could also be responsible for lower rates of growth in some regions.

Growth in the south has been disappointing at less than 2 per cent per annum throughout with Tamil Nadu and Kerala primarily responsible for this poor growth. Only in Andhra Pradesh did the growth exceed 3 per cent per annum (3.4 per cent) between 1967-90.

TABLE 7. GROWTH IN PRODUCTION OF WHEAT BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 34.1 | 5.4 | 4.8 | 4.7 | No |
| Uttar Pradesh | 36.1 | 5.8 | 4.3 | 4.9 | No |
| East | 8.7 | 4.1 | 11.3 | 3.6 | Yes at 7% |
| Centre | 15.5 | 4.2 | 4.7 | 3.4 | No |
| West | 3.7 | 2.6 | 8.3 | -3.5* | Yes |
| South | 0.3 | -0.3* | 8.4 | -6.1 | Yes |
| Total above | 98.4 | | | | |
| All India | 100 | 4.9 | 5.4 | 4.0 | No |

Notes: * not significant at a 10 per cent level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Wheat*: Growth of wheat output has been higher than of rice output in most of the regions that produce sizeable quantities of both crops (north, Uttar Pradesh, east, centre). One reason for the higher rates is the earlier introduction of the HYV varieties in wheat (mid-sixties as compared to the seventies for rice). Another reason has been that wheat is largely grown under irrigated conditions (more than 75 per cent of area under wheat is irrigated) while rice is not (less than 45 per cent is irrigated under rice; figures for 1985-86), so that year to year variations in rice production are much more marked. Other probable explanations include a more supportive pricing and procurement policy for wheat, at least in the earlier years, better credit facilities for wheat farmers and a tilt of infrastructural investment towards states where wheat was the dominant crop.

Looking across regions, growth rates, by and large, are higher in the north and Uttar Pradesh as compared to the east and centre. This is related to the greater access to irrigation and development of procurement centres in the north and Uttar Pradesh. Between the north and Uttar Pradesh, growth is somewhat higher in Uttar Pradesh during decade II as compared to decade I whereas in the north there is virtually no change in pace. This is a somewhat muted replication of the pattern found for rice. The reasons too are similar - the relatively late adoption of new techniques in Uttar Pradesh and its consequent catching up to the high per hectare productivity levels of the north.

TABLE 8. TREND GROWTH IN PRODUCTION OF SUGARCANE BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 5.8 | -0.07* | 2.8** | 1.6* | No |
| Uttar Pradesh | 44.8 | 3.0 | 4.4 | 4.4 | No |
| East | 5.6 | 0.5* | 1.4 | 1.6** | No |
| Centre | 1.3 | 0.6* | 11.1 | -0.6* | Yes |
| West | 17.4 | 5.2 | 6.6 | 3.2 | Yes at 7% |
| South | 25.0 | 2.7 | 2.9 | 3.3 | No |
| Total above | 99.8 | | | | |
| All India | 100 | 2.8 | 4.1 | 3.4 | No |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Sugarcane*: The main producers are Uttar Pradesh, west and the south. Among them, production has grown the fastest during the entire post-green revolution period in the west (5.2 per cent per annum), although a significant slowdown has occurred between decades I and II (at a 7 per cent level of significance). A low initial base, higher procurement prices than anywhere else in the country, (and hence higher profits than other competing crops) along with assured cheap water from irrigation systems are the main reasons for this high growth rate.[9] In Uttar Pradesh and the south, output growth has been more modest (3 per cent per annum and 2.7 per cent per annum respectively) with no break in trend.

TABLE 9. GROWTH IN PRODUCTION OF GROUNDNUT BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 0.3 | -10.6 | -3.5 | -16.4 | Yes |
| Uttar Pradesh | 1.4 | -5.2 | 0.3* | -4.0* | No |
| East | 6.6 | 9.5 | 6.2 | 11.3 | Yes |
| Centre | 6.2 | -0.5* | 2.0* | 3.9** | No |
| West | 31.1 | 0.9 | 1.7* | -2.3* | No |
| South | 54.0 | 1.9 | 0.2* | 4.6 | Yes at 7% |
| Total above | 99.6 | | | | |
| All India | 100 | 1.4 | 1.1* | 2.5* | No |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Groundnut*: The overall production of groundnut grew at only 1.4 per cent per annum between 1967-90. A bright spot, though, is the upward break with trend in the south (a major producer) and the east (a minor producer). The increase in production is largely limited to Andhra Pradesh in the south and Orissa in the east and in both these states, as we shall later see, area increases under the crop are important explanators of growth. It is not clear why area under groundnut increased in these states, and not elsewhere. A more supportive price policy that promised greater profits in groundnut as compared to other competing crops, appropriate agro-climatic conditions, and measures taken to reduce the risk in groundnut cultivation may be probable rea-

sons.[10] But further empirical work is necessary for better understanding and possibly reversing the recent negative trend that has characterized output growth of groundnut in the west which is another substantial producer of this crop.

TABLE 10. GROWTH IN PRODUCTION OF JOWAR BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 0.2 | -2.8 | -5.1* | -0.9* | No |
| Uttar Pradesh | 4.3 | 0.7* | 1.5* | 4.5* | No |
| East | 0.1 | 2.4* | 0.4* | 2.3* | No |
| Centre | 18.7 | 0.5* | -2.7* | 2.5* | Yes |
| West | 50.1 | 3.3 | 4.7* | -0.4* | No |
| South | 26.3 | -0.2* | 0.6* | -1.5* | No |
| Total above | 99.8 | | | | |
| All India | 100 | 1.3 | 1.6* | -0.02 | No |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Jowar*: Production growth of jowar is marked by an insignificant trend in virtually every region and every period. The only exception is the west, in particular Maharashtra, where extensive use of HYVs (HYVs are used on 51 per cent of the land under jowar in Maharashtra compared to 31 per cent in the rest of the country; average of 1986-89) have been instrumental in yielding a statistically significant growth rate of over 3 per cent per annum during the entire post-green revolution period. In recent years, production also seems to have picked up in the centre although the growth rate here is still not statistically significant.

TABLE 11. GROWTH IN PRODUCTION OF COTTON BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 34.5 | 3.8 | 4.5 | 5.5 | No |
| Uttar Pradesh | 0.2 | -3.1 | -12.8 | -2.7* | Yes |
| East | 0.0 | -7.2 | -2.6 | 0.0 | No |
| Centre | 10.7 | 2.4 | 3.1 | 2.1* | No |
| West | 32.4 | 0.2* | -0.09 | -0.9* | No |
| South | 21.8 | 4.2 | 5.7 | 2.3 | No |
| Total above | 99.7 | | | | |
| All India | 100 | 2.2 | 2.1* | 1.6* | No |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Cotton*: Over the entire period, reasonable growth occurred in the north and the south but an insignificant trend was the norm throughout in the west. In the north, growth was higher in decade II as compared to decade I (although not statistically so) while the reverse pattern prevailed in the south. As we shall see later, the production growth in the north was in large part due to increases in area, whereas in the south, yield increases were the dominant source of growth.

TABLE 12. GROWTH IN PRODUCTION OF GRAM BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 9.1 | -6.6 | -2.2* | -7.0* | No |
| Uttar Pradesh | 25.0 | -1.6 | -4.0 | 0.6* | Yes |
| East | 4.7 | -1.6 | -4.8 | -0.4* | Yes |
| Centre | 50.1 | 1.5 | 4.1 | 0.2 | No |
| West | 8.6 | 4.6 | 4.6* | 4.4* | No |
| South | 2.4 | 0.2 | -2.6 | 2.4 | No |
| Total above | 99.9 | | | | |
| All India | 100 | -0.6* | -0.2* | 0.3* | No |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Gram*: Production of this most important of the pulses is largely concentrated in Uttar Pradesh and the central region. At the all-India level, growth is not significantly different from zero in any period. While the overall trend during the entire period is negative in Uttar Pradesh, there is evidence of a shift from the large negative trend during decade I (-4 per cent per annum) to a small positive trend during decade II. In the centre, on the other hand, trend growth in the second period is smaller than during the first one (although significant and positive in both periods).

*Rapeseed/Mustard*: Among oilseeds, output growth of rape/mustard is one of the striking success stories of Indian agriculture. Regional production is concentrated in the drier belt of the northern, Uttar Pradesh, eastern, and central regions. Within these, there has been a significant increase in growth in the north, east, and central regions. Viable HYVs, high support prices, and increasing rotation with wheat cultivation (which, as seen earlier, has been one of the fastest growing crops in Indian agriculture) are the primary reasons behind the spurt in production. Production in Uttar Pradesh, though, has stagnated and the reason for this is not immediately apparent.

TABLE 13. GROWTH IN PRODUCTION OF RAPE/MUSTARD BY REGION

(per cent per annum)

| Region | Per cent share in all-India production average 1987-90 | Post-Green Revolution 1967-90 | Decade I 1967-78 | Decade II 1978-90 | Significant change between Decade I and Decade II at a 5% level |
|---|---|---|---|---|---|
| North | 14.9 | 6.8 | 2.7* | 14.7 | Yes |
| Uttar Pradesh | 20.8 | -1.9 | -0.2* | -2.9* | No |
| East | 15.4 | 7.0 | 3.7 | 9.7 | Yes |
| Centre | 40.1 | 11.6 | 7.1 | 17.8 | Yes |
| West | 7.2 | 17.0 | 13.2 | 18.3 | No |
| South | 0.0 | - | - | - | - |
| Total above | 98.5 | | | | |
| All India | 100 | 4.3 | 1.7* | 8.1 | Yes |

Notes: * not significant at a 10% level; ** significant between 5% and 10% level; all others are significant at less than 5 per cent.
Source: Data from GOI, MOA.

*Regional Patterns*: A recapitulation of the crops where there was a significant shift in the rate of growth between decades I and II of the post-green revolution period presents the following picture (only those crops where the share of the particular region was more than 10 per cent of the all-India production between 1987-90 are included; this is to exclude noise):

| Region | Upward Shift | Downward Shift |
|---|---|---|
| North | Rape/Mustard | Rice |
| Uttar Pradesh | Gram | |
| East | Rice, Rape/Mustard | |
| Centre | Jowar, Rape/Mustard | |
| West | | Sugarcane |
| South | Groundnut | |

In nine cases (out of a possible twenty five under the criterion chosen for inclusion) there was a significant shift in trend; in seven cases the shift was in an upward direction while in the remaining two cases the shift was in a downward direction. Of the seven cases of upward shifts, as many as four are in the east and centre. This is a significant result in that it highlights the coming of age, in agricultural terms, of the two regions that have traditionally been marked as the stragglers of Indian agriculture. The mix of crops is diversified too including as it does rice, jowar, and rape/mustard. Other promising trends include the upward shifts of rape/mustard in the north, and of groundnut in the south. These are patterns that get suppressed at an aggregate level and their importance lies in the indications they provide of emerging trends in comparative advantage of different regions across crops. By the same token, the downward shift in the production of rice in the north and of sugarcane in the west is an indication of the engines that have served well in the past may now be running out of steam.

## SOURCES OF GROWTH

The focus of the discussion so far has been on the underlying growth trends in production. We may now ask where this growth has come from, or in other words, what are the sources of growth? The question can be approached in two ways. One is to estimate production functions and thereby delineate the contribution of individual inputs to the final output. The other way, and the one used here, is to decompose production growth into growth in area and growth in per hectare yields.

There are a number of decomposition methods available in the literature. Two are used here on different sets of data. In part A, rates of growth in the index numbers of area and yield for all crops, foodgrains and non-foodgrains are estimated for various periods at the all-India level. The area and yield growth rates are then the sources of the production growth estimated earlier in Table 4. In part B, a decomposition equation is estimated for all the main crops at the state level:

$$\Delta Q = A\Delta Y + Y\Delta A + \Delta A\Delta Y$$

where Q is output, A is area, Y is yield

Both methods have their uses. The method in part A uses more information (trend rates rather than point-to-point growth rates). The advantage in using the method in part B is that it separates out three effects: the pure yield effect (area fixed), the pure area effect (yield fixed) and the mixed effect due to simultaneous changes in area and yields and is, at the same time, simpler to work with than decomposing a time series into more than two additive or multiplicative terms[11]. The trend rates in part A are over the whole period 1949-89. The initial and terminal years in part B are the triennia 1970-73 and 1986-89. Each of these triennia contains a 'peak' year: 1970-71 and 1988-89, and a 'trough' year: 1972-73 and 1987-88.

### *A. Sources of Growth in Principal Crop Groups at the All-India level.*

Table 6 shows the all-India trend growth in production, area and yields for foodgrains, non-foodgrains and all crops. A few notable points emerge. First, between 1949-50 and 1988-89, area under all crops grew at a rate of 0.7 per cent per annum. But, there was a continuous slowdown: In the pre-green revolution period, area under cultivation grew at 1.6 per cent per annum; this decreased to 0.5 per cent per annum in the first decade following the green revolution and to 0.02 per cent per annum (not statistically different

from zero) in the second decade of the green revolution. This confirms the generally held notion that the extensive margin of cultivation was reached in Indian agriculture somewhere in the mid-1970s.

Second, the decrease in area is more pronounced in foodgrains; the area under foodgrains actually declined in absolute terms during Decade II implying some switch from foodgrains to non-foodgrains. Further analysis showed that the decrease in area under foodgrains during Decade II was mainly due to a decrease in area under coarse cereals (-0.2 per cent per annum) and pulses (-0.03 per cent per annum). Area under rice and wheat did not decrease. Within non-foodgrains, there was an increase in area under oilseeds (0.8 per cent per annum) and sugarcane (1.3 per cent per annum) but a decrease in area under fibres (-1.9 per cent per annum).

Third, increases in area were relatively more important for production growth in non-foodgrains in each period. Conversely, yield increases contributed more to foodgrain production growth. While these patterns show some general trends, they conceal much of what happened at a more disaggregated level.

TABLE 14. GROWTH RATES IN AREA, PRODUCTION, AND YIELDS AT THE ALL-INDIA LEVEL

(per cent per annum)

| Crop Group | | Entire period 1949-89 | Pre-Green Revolution 1949-65 | Post-Green Revolution 1967-89 | Significant change between pre and post Green Revolution | Post-Green Revolution Decade I 1967-78 | Post-Green Revolution Decade II 1978-89 | Significant change between Decade I & Decade II |
|---|---|---|---|---|---|---|---|---|
| All Crops | P | 2.5 | 3.1 | 2.5 | No | 2.3 | 2.8 | No |
| | A | 0.7 | 1.6 | 0.4 | Yes | 0.5 | 0.02* | No |
| | Y | 1.4 | 1.2 | 1.7 | No | 1.4 | 2.4 | No |
| Foodgrains | P | 2.4 | 2.8 | 2.5 | No | 2.2 | 2.7 | No |
| | A | 0.6 | 1.3 | 0.2 | Yes | 0.4 | -0.2* | Yes at 8% |
| | Y | 1.5 | 1.4 | 0.9 | No | 1.3 | 2.6 | No |
| Non-foodgrains | P | 2.6 | 3.7 | 2.6 | Yes | 2.6 | 3.0 | No |
| | A | 1.1 | 2.4 | 0.9 | Yes | 0.9 | 0.6 | No |
| | Y | 1.1 | 0.9 | 1.4 | Yes | 1.4 | 1.8 | No |

Notes: * not significant at 5% level; all others are significant at less than 5% level.
Source: Data from GOI, MOA.

*B. Sources of Growth in the Principal Crops at the State/Region Level.*

The uneven growth across crops and regions is, in part, reflected in the disparate sources of this growth. A decomposition of the intertemporal growth in output over the period 1970-73 to 1986-89 into increase in area under cultivation (keeping yield unchanged at the base level) increase in yields per hectare (keeping area unchanged) and the interaction between area and yields shows that crops that have performed better than average in terms of growth in output have done so because in their case area increases complemented yield improvements. In crops that have not performed as well, but do show some growth, increase in productivity has been the primary source of growth. In the extreme case where output has not shown any growth (or in some cases decreased in absolute terms), modest improvements in yields have not been able to make up for the large decreases in the area cultivated.

The results of the state level decomposition exercise are presented in Tables 16 through 28. The aggregate results for all of India are summarized below in Table 15. The crops considered are rice, wheat, sugarcane, jowar, maize, bajra, gram, tur, groundnut, rape/mustard, cotton, jute

and tobacco. The results are presented in percentage form to facilitate interpretation, that is, the percent share of each of the three components in incremental output is shown.

TABLE 15. SOURCES OF GROWTH AT THE ALL-INDIA LEVEL BY CROP

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) | | |
|---|---|---|---|---|---|
| | | | Area | Yield | Mix |
| Rice | 21,183 | 151 | 17 | 76 | 7 |
| Wheat | 23,170 | 193 | 26 | 60 | 14 |
| Sugarcane | 74,216 | 161 | 50 | 38 | 12 |
| Jowar | 3,035 | 140 | -14 | 121 | -7 |
| Maize | 890 | 114 | 3 | 97 | 0 |
| Bajra | -559 | 90 | -126 | 30 | -4 |
| Gram | -532 | 89 | -126 | 30 | -4 |
| Tur | 575 | 131 | 111 | -8 | -3 |
| Groundnut | 1,630 | 130 | 7 | 92 | 2 |
| Rape/Mustard | 1,752 | 201 | 29 | 56 | 16 |
| Cotton | 1,508* | 126 | -40 | 156 | -16 |
| Jute | 1,390* | 127 | -12 | 115 | -4 |
| Tobacco | 56 | 114 | -137 | 296 | -59 |

Notes: * in '000 bales
Source: Data from GOI, MOA.

*Rice*: At the all-India level, yield increases account for 76 per cent of growth in production, area increases account for 17 per cent and the interaction term accounts for the remaining 7 per cent. There are, however, marked differences between states. In Punjab and Haryana, both of which started from a low production base in the early seventies and where growth has been the highest, area increases are the dominant (accounting for 55 per cent of incremental production) source of growth. Increases in per hectare productivity are not the main source of growth despite a common conception to the contrary. The widespread adoption of the new technology did significantly raise absolute yield levels in these two states; as a result a large area substitution, primarily from coarse cereals such as jowar, maize, and bajra and oilseeds such as groundnut, to rice cultivation occurred and this was responsible for a large part of the eventual increment in output. Area increases are also important in explaining growth in Assam and Madhya Pradesh but the reasons there are quite different: absolute yield levels did not grow by much (less than 0.8 per cent per annum over the entire period), absolute growth in production was very modest and consequently area increases, despite not growing by much in absolute terms, nevertheless accounted for a large part of the incremental production in percentage terms.

In most other main rice producing states (Andhra Pradesh, Maharashtra, Bihar, Orissa, West Bengal, Uttar Pradesh) the aggregate pattern repeats itself with yield improvements being the primary source of growth. A word however should be said about Kerala and Tamil Nadu, both of which were prominent producers in the early seventies but whose combined share in all-India rice production has decreased rapidly from 16.2 per cent in 1970-73 to 10.7 per cent in 1986-89. In both these states there was an absolute decrease in area under rice cultivation. The reasons for this vary. Lack of new technological options is cited as the primary factor in Kerala [Kannan and Pushpangadan, 1990, Pp. 1991-2004]. In Tamil Nadu, administrative and financial problems with the irrigation system as well as scarcity of water may have discouraged rice cultivation (rice being

TABLE 16. SOURCES OF GROWTH IN RICE

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 3,493 | 176 | 18 | 72 | 10 |
| Assam | 492 | 124 | 63 | 32 | 5 |
| Bihar | 982 | 121 | 13 | 85 | 2 |
| Gujarat | 109 | 126 | 7 | 91 | 2 |
| Haryana | 865 | 278 | 55 | 23 | 22 |
| Karnataka | 273 | 114 | 23 | 74 | 2 |
| Kerala | -280 | 79 | -142 | 59 | -18 |
| Madhya Pradesh | 947 | 127 | 41 | 53 | 6 |
| Maharashtra | 780 | 162 | 19 | 72 | 9 |
| Orissa | 542 | 114 | -49 | 159 | -10 |
| Punjab | 4,614 | 640 | 56 | 11 | 33 |
| Rajasthan | -4 | 97 | -129 | 30 | -1 |
| Tamil Nadu | 118 | 102 | -1,323 | 2,000 | -577 |
| Uttar Pradesh | 4,286 | 220 | 14 | 74 | 12 |
| West Bengal | 3,311 | 154 | 18 | 75 | 7 |
| All India | 21,183 | 151 | 17 | 76 | 7 |
| North | 5,479 | 509 | 55 | 14 | 31 |
| East | 5,326 | 132 | 12 | 85 | 3 |
| Centre | 943 | 126 | 41 | 53 | 6 |
| West | 889 | 153 | 17 | 76 | 7 |
| South | 3,603 | 127 | -27 | 138 | -10 |

Note: North includes Haryana and Punjab, East includes Assam, Bihar, Orissa and West Bengal, Centre includes Madhya Pradesh and Rajasthan, West includes Gujarat and Maharashtra, South includes Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, Uttar Pradesh is a region in itself.

TABLE 17. SOURCES OF GROWTH IN WHEAT

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | -4 | 58 | -102 | 3 | -1 |
| Assam | 44 | 160 | 124 | -14 | -10 |
| Bihar | 939 | 141 | 39 | 52 | 8 |
| Gujarat | 47 | 106 | -408 | 669 | -161 |
| Haryana | 3,047 | 231 | 37 | 42 | 21 |
| Karnataka | 18 | 114 | -136 | 290 | -54 |
| Kerala | | | | | |
| Madhya Pradesh | 1,793 | 167 | 6 | 90 | 4 |
| Maharashtra | 336 | 184 | -11 | 122 | -11 |
| Orissa | 25 | 152 | 109 | -6 | -3 |
| Punjab | 5,329 | 199 | 35 | 48 | 17 |
| Rajasthan | 1,560 | 184 | 21 | 68 | 12 |
| Tamil Nadu | | | | | |
| Uttar Pradesh | 9,987 | 232 | 32 | 48 | 20 |
| West Bengal | -165 | 80 | -34 | -71 | 5 |
| All India | 23,170 | 193 | 26 | 60 | 14 |
| North | 8,376 | 209 | 36 | 46 | 18 |
| East | 843 | 126 | 55 | 40 | 6 |
| Centre | 3,353 | 174 | 11 | 82 | 7 |
| West | 383 | 132 | -46 | 171 | -25 |
| South | 14 | 110 | -207 | 384 | -77 |

Note: See Table 16.

a water intensive crop). Although yield increases, perforce, account for all the increment in output, in absolute terms the yield gain has been small, especially in Kerala. Indeed Kannan and Pushpangadan (1990) suggest that average yields have increased in Kerala not because of any absolute yield improvements but because marginal lands have gone out of cultivation.

*Wheat*: Yield increases have also been the primary source of growth in wheat at the all-India level but they have been complemented, to a greater extent than in rice, by increases in area. Increase in area alone accounts for 26 per cent of production growth of wheat at the all-India level although, among some of the major producers such as Haryana, Punjab, Uttar Pradesh, and Bihar the proportion is over a third. Within these four states the actual rate of growth of output in Bihar is the least. In Punjab, Haryana, and Uttar Pradesh, absolute increases in yields, fuelled by the new technology, have been substantial (over 2.5 per cent per annum compounded between 1970-73 and 1986-89 in all three states), so that output doubled over the two odd decades, whereas in Bihar, where HYVs and fertilizers were not much in evidence till very recently, yields have grown much more slowly (1.2 per cent per annum compounded over the entire period) as a result of which output increased by just 41 per cent over the entire period.

Whereas area increases complemented yield improvements to a significant extent in the north, Uttar Pradesh, and the east, the pattern is different for the central states. In the centre, most (82 per cent) of the growth was due to yield improvements only. In Madhya Pradesh, large increases in HYVs and fertilizers (over 10 per cent per annum increase in both the HYV area under wheat and in rabi fertilizer consumption over 1970-73 to 1985-88) led to increases in yields accounting for over 90 per cent of incremental output whereas in Rajasthan, the sixth and last major wheat producer, the same pattern, though somewhat muted, led to productivity increases accounting for 68 per cent of the increased production.

*Sugarcane*: Increases in area accounts for 50 per cent of the increase in the output of sugarcane at the all-India level. This is primarily because the large profitability in sugarcane *vis-a-vis* other crops encourages area shifts into cane production. The aggregate pattern is replicated in each of the three main sugarcane producing states of Maharashtra, Uttar Pradesh, and Tamil Nadu (together the three accounted for 69 per cent of total output of cane over 1984-89) with the area component being the largest in Maharashtra (66 per cent). In each of these three states, absolute increases in per hectare yields also occurred, although in per cent terms they did not account for more than a third of the growth in output.

In Karnataka (a share of 8.4 per cent in total cane output over 1984-89), yields stagnated and increases in area were the sole source of growth. In Andhra Pradesh yields deteriorated substantially, so that despite a large increase in area, production increased only marginally (6 per cent in all between 1970-73 to 1986-89).

*Coarse Cereals* (Jowar, Maize, and Bajra): The sources of growth for the three main coarse cereals namely jowar, maize, and bajra are considered separately. While there has been some increase in the production of jowar and maize, the output of bajra has fallen in absolute terms over the last two decades. At the all-India level, yield increases have been the only source of growth in all three crops; in fact area under jowar and bajra decreased while that under maize remained virtually unchanged.

Differences, as always, exist at the state/regional level. For jowar, the five main producers are Andhra Pradesh, Karnataka, and Tamil Nadu in the south, Madhya Pradesh in the centre and Maharashtra in the west (together accounting for nearly 90 per cent of production in the mid to late 1980s). In Maharashtra, which by itself accounts for 40 per cent of all India production, yield increases (5.6 per cent per annum compounded over the entire period) fuelled by extensive HYV use (51 per cent of land under jowar in Maharashtra used HYVs in 1986-89 compared to 31 per cent in the rest of the country) were substantial and accounted for most (82 per cent) of the growth. In Andhra Pradesh, Madhya Pradesh, and Tamil Nadu yields increased less spectacularly reflecting the slower

TABLE 18. SOURCES OF GROWTH IN SUGARCANE

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 601 | 106 | 312 | -178 | -34 |
| Assam | 693 | 155 | 46 | 43 | 11 |
| Bihar | -557 | 89 | -168 | 83 | -15 |
| Gujarat | 4,921 | 364 | 45 | 25 | 30 |
| Haryana | -353 | 94 | -34 | -68 | 1 |
| Karnataka | 8,388 | 198 | 104 | -2 | -2 |
| Kerala | 23 | 106 | 0 | 100 | 0 |
| Madhya Pradesh | 374 | 125 | -21 | 129 | -7 |
| Maharashtra | 12,131 | 195 | 66 | 21 | 13 |
| Orissa | 1,155 | 162 | 75 | 17 | 8 |
| Punjab | 1,151 | 125 | -40 | 155 | -15 |
| Rajasthan | -282 | 78 | -120 | 28 | -7 |
| Tamil Nadu | 11,319 | 206 | 51 | 31 | 17 |
| Uttar Pradesh | 35,469 | 166 | 51 | 36 | 12 |
| West Bengal | -922 | 49 | -120 | 53 | -33 |
| All India | 74,216 | 161 | 50 | 38 | 12 |
| North | 798 | 107 | -74 | 185 | -10 |
| East | 370 | 104 | -282 | 426 | -44 |
| Centre | 92 | 103 | -401 | 579 | -78 |
| West | 17,052 | 217 | 62 | 22 | 16 |
| South | 20,056 | 168 | 78 | 14 | 8 |

Note: See Table 16.

TABLE 19. SOURCES OF GROWTH IN JOWAR

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | -150 | 87 | -295 | 325 | -129 |
| Assam | | | | | |
| Bihar | 1 | 88 | -316 | 354 | -138 |
| Gujarat | -130 | 67 | -117 | 28 | -11 |
| Haryana | -21 | 61 | -63 | -49 | 12 |
| Karnataka | 74 | 104 | 127 | -26 | -1 |
| Kerala | | | | | |
| Madhya Pradesh | 262 | 118 | -31 | 139 | -8 |
| Maharashtra | 2,851 | 279 | 7 | 82 | 11 |
| Orissa | | | | | |
| Punjab | | | | | |
| Rajasthan | -46 | 88 | -16 | -86 | 2 |
| Tamil Nadu | 130 | 124 | -11 | 114 | -3 |
| Uttar Pradesh | 54 | 113 | -136 | 286 | -51 |
| West Bengal | | | | | |
| All India | 3,035 | 140 | -14 | 121 | -7 |
| North | -21 | 61 | -63 | -49 | 12 |
| East | 1 | 88 | -316 | 354 | -138 |
| Centre | 216 | 112 | -38 | 144 | -6 |
| West | 2,721 | 237 | 3 | 93 | 4 |
| South | 54 | 102 | -1,026 | 1,353 | -227 |

Note: See Table 16.

TABLE 20. SOURCES OF GROWTH IN MAIZE

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 194 | 163 | 17 | 75 | 8 |
| Assam | 4 | 170 | 78 | 14 | 8 |
| Bihar | 235 | 134 | -73 | 231 | -58 |
| Gujarat | -49 | 87 | 127 | -195 | -32 |
| Haryana | -84 | 36 | -94 | -15 | 9 |
| Kamataka | 275 | 188 | 95 | 3 | 2 |
| Kerala | | | | | |
| Madhya Pradesh | 388 | 167 | 63 | 26 | 11 |
| Maharashtra | 87 | 445 | 67 | 10 | 23 |
| Orissa | 105 | 272 | 69 | 14 | 17 |
| Punjab | -480 | 45 | -101 | 2 | -1 |
| Rajasthan | -58 | 93 | 199 | -261 | -38 |
| Tamil Nadu | 24 | 259 | 59 | 21 | 20 |
| Uttar Pradesh | -97 | 93 | -288 | 238 | -50 |
| West Bengal | 101 | 344 | 11 | 70 | 19 |
| All India | 890 | 114 | 3 | 97 | 0 |
| North | -564 | 44 | -100 | -1 | 1 |
| East | 445 | 156 | -20 | 135 | -15 |
| Centre | 330 | 124 | 110 | -8 | -2 |
| West | 38 | 109 | 405 | -221 | -84 |
| South | 493 | 177 | 40 | 46 | 14 |

Note: See Table 16.

TABLE 21. SOURCES OF GROWTH IN BAJRA

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | -47 | 80 | -208 | 187 | -79 |
| Assam | | | | | |
| Bihar | -1 | 85 | -149 | 64 | -14 |
| Gujarat | -368 | 72 | -117 | 26 | -8 |
| Haryana | -166 | 74 | -92 | -11 | 3 |
| Kamataka | 60 | 135 | 25 | 70 | 6 |
| Kerala | | | | | |
| Madhya Pradesh | 7 | 106 | -339 | 544 | -106 |
| Maharashtra | 348 | 185 | 32 | 54 | 14 |
| Orissa | | | | | |
| Punjab | -156 | 11 | -99 | -7 | 6 |
| Rajasthan | -243 | 85 | -39 | -64 | 4 |
| Tamil Nadu | -14 | 95 | -862 | 1,247 | -485 |
| Uttar Pradesh | 31 | 104 | -487 | 748 | -161 |
| West Bengal | | | | | |
| All India | -559 | 90 | -126 | 30 | -4 |
| North | -322 | 60 | -85 | -22 | 8 |
| East | -1 | 85 | -149 | 64 | -14 |
| Centre | -236 | 87 | -48 | -56 | 4 |
| West | -20 | 99 | -505 | 430 | -25 |
| South | -1 | 100 | -16,663 | 22,345 | -5,782 |

Note: See Table 16.

adoption of HYVs, while area under jowar cultivation fell, as a result of which yields were the only source of growth. In Karnataka, per hectare yields decreased between 1970-73 to 1986-89 and an increase in area was solely responsible for the paltry output growth (0.3 per cent per annum) that occurred.

In maize, of the main producers, a significant increase in output (over 2 per cent per annum) occurred only in Andhra Pradesh, Karnataka, and Madhya Pradesh. In the latter two states, area increases dominated whereas in Andhra Pradesh increased yields accounted for roughly three-fourths of the growth in output.

Excepting in Maharashtra, there was an absolute fall in area under bajra cultivation in all the other main bajra producing states of Gujarat, Rajasthan, and Uttar Pradesh (together these four states accounted for 74 per cent of bajra produced in the country between 1984-89). Output increased significantly (3.9 per cent per annum compounded) only in Maharashtra where area increases complemented yield gains. In Gujarat and Rajasthan, output fell (although this may be a reflection of the terminal triennium chosen, since two of the three years 1986-87 and 1987-88 were years of drought in Rajasthan and Gujarat) whereas in Uttar Pradesh output increased marginally as a result of increased yields.

*Pulses* (Gram, Tur): The two main pulses are gram and tur accounting for 39 per cent and 20 per cent respectively of total value of output of all pulses (triennium ending 1981-82). Between 1970-73 and 1986-89 gram production decreased by 11 per cent while tur production increased by 31 per cent. Yields in both crops stagnated; the effect on production was because of area changes.

The question is why the difference in pattern? Why did area under tur increase while that under gram decrease? The reason seems to lie in the different agro-climatic conditions necessary for the cultivation of the two crops. Gram is a rabi crop grown primarily in the northern and central states where it competes with wheat (and oilseeds such as rape/mustard) for acreage. The larger profits possible in wheat (because of technological and pricing support) adversely affect gram cultivation. Tur, on the other hand, is a hardy kharif crop, more drought resistant than its immediate competitor notably paddy, and this low risk factor seems to be the main reason why tur is extensively cultivated by farmers in the rainfed areas of Gujarat, Maharashtra, Uttar Pradesh, and Karnataka.

In Madhya Pradesh, which produces sizeable quantities of both pulses, the pattern is quite the opposite: In percentage terms, area increases in gram and yield increases in tur are the main sources of growth. In gram, this is probably because wheat cultivation in Madhya Pradesh is still largely under rainfed conditions and gram is still a viable alternative to uncertain wheat yields. For tur, the answer lies in the distinction between absolutes and percentages. Production stagnated over the two odd decades under review, yields increased somewhat (0.9 per cent per annum) while area decreased (0.7 per cent per annum); in percentage terms this shows up as yields accounting for all the growth.

*Oilseeds* (Groundnut, Rapeseed/Mustard Seed): Groundnut and rape/mustard seed are the two main oilseeds accounting for 44 per cent and 19 per cent respectively of total value of all oilseeds produced (triennium ending 1981-82) in the country. In the period under review, groundnut production grew much more modestly (1.2 per cent per annum) than rape/mustard (4.5 per cent per annum). The growth in groundnut output was solely because of yield improvements while area increases complemented improvements in the yields of rape/mustard.

The reason why area has increased under rape/mustard but not under groundnut has to do with at least three factors. First, the HYVs available are superior for rape/mustard providing higher profits and hence an incentive for more extensive cultivation. Second, rape/mustard (grown in the rabi season) is more tolerant to moisture stress and variations in weather and is also somewhat less susceptible to pests and diseases than groundnut (grown primarily in the kharif season) A third factor may be the increasing rotation of rape/mustard with wheat -- thus expansion of wheat leading to concomittant expansion of rape/mustard.

At the state level, area under groundnut has increased in Andhra Pradesh and Karnataka in the south and in Orissa in the east, especially in recent

TABLE 22. SOURCES OF GROWTH IN GRAM

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | -3 | 86 | -144 | 56 | -12 |
| Assam | 1 | 146 | 82 | 13 | 5 |
| Bihar | -20 | 87 | -242 | 206 | -63 |
| Gujarat | -5 | 86 | 131 | -195 | -36 |
| Haryana | -296 | 55 | -119 | 41 | -22 |
| Karnataka | 37 | 176 | 65 | 23 | 12 |
| Kerala | | | | | |
| Madhya Pradesh | 451 | 143 | 85 | 11 | 4 |
| Maharashtra | 164 | 281 | 35 | 40 | 25 |
| Orissa | 16 | 234 | 78 | 11 | 11 |
| Punjab | -217 | 22 | -96 | -16 | 12 |
| Rajasthan | -223 | 77 | -105 | 6 | -1 |
| Tamil Nadu | | | | | |
| Uttar Pradesh | -372 | 76 | -122 | 31 | -9 |
| West Bengal | -47 | 46 | -109 | 23 | -13 |
| All India | -532 | 89 | -126 | 30 | -4 |
| North | -514 | 45 | -107 | 17 | -10 |
| East | -51 | 80 | -167 | 99 | -32 |
| Centre | 228 | 111 | 70 | 28 | 2 |
| West | 159 | 224 | 47 | 34 | 19 |
| South | 33 | 147 | 57 | 34 | 9 |

Note: See Table 16.

TABLE 23. SOURCES OF GROWTH IN TUR

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 18 | 137 | 179 | -47 | -32 |
| Assam | 3 | 206 | 99 | 1 | 1 |
| Bihar | -20 | 81 | -218 | 203 | -84 |
| Gujarat | 130 | 425 | 86 | 4 | 10 |
| Haryana | 36 | 874 | 51 | 10 | 39 |
| Karnataka | 74 | 158 | 125 | -15 | -11 |
| Kerala | | | | | |
| Madhya Pradesh | 10 | 102 | -449 | 614 | -65 |
| Maharashtra | 250 | 199 | 50 | 34 | 17 |
| Orissa | 76 | 373 | 69 | 11 | 20 |
| Punjab | 23 | 2,433 | 47 | 4 | 48 |
| Rajasthan | -5 | 70 | -128 | 46 | -18 |
| Tamil Nadu | 60 | 264 | 33 | 43 | 24 |
| Uttar Pradesh | 111 | 121 | -37 | 149 | -12 |
| West Bengal | -9 | 45 | -121 | 63 | -42 |
| All India | 575 | 131 | 111 | -8 | -3 |
| North | 59 | 1,152 | 53 | 7 | 40 |
| East | 50 | 132 | 54 | 39 | 7 |
| Centre | 6 | 101 | -979 | 1,230 | -151 |
| West | 379 | 230 | 62 | 21 | 17 |
| South | 151 | 172 | 95 | 3 | 2 |

Note: See Table 16.

TABLE 24. SOURCES OF GROWTH IN GROUNDNUT

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 704 | 164 | 48 | 40 | 12 |
| Assam | | | | | |
| Bihar | 1 | 128 | 30 | 65 | 5 |
| Gujarat | 194 | 116 | -70 | 191 | -21 |
| Haryana | -3 | 62 | -115 | 26 | -12 |
| Karnataka | 289 | 148 | 66 | 26 | 8 |
| Kerala | -12 | 30 | -56 | -72 | 28 |
| Madhya Pradesh | -50 | 84 | -258 | 271 | -113 |
| Maharashtra | 259 | 161 | -4 | 106 | -3 |
| Orissa | 403 | 456 | 96 | 1 | 3 |
| Punjab | -140 | 17 | -98 | -11 | 9 |
| Rajasthan | 34 | 124 | -27 | 135 | -9 |
| Tamil Nadu | 54 | 105 | -87 | 196 | -8 |
| Uttar Pradesh | -128 | 45 | -113 | 36 | -23 |
| West Bengal | | | | | |
| All India | 1,630 | 130 | 7 | 92 | 2 |
| North | -143 | 19 | -98 | -10 | 8 |
| East | 401 | 442 | 94 | 1 | 4 |
| Centre | -16 | 96 | -845 | 1,061 | -316 |
| West | 453 | 127 | -30 | 142 | -12 |
| South | 1,035 | 137 | 53 | 39 | 8 |

Note: See Table 16.

TABLE 25. SOURCES OF GROWTH IN RAPESEED/MUSTARD

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 1 | 350 | 110 | -3 | -7 |
| Assam | 96 | 255 | 81 | 8 | 11 |
| Bihar | 17 | 140 | 1 | 99 | 0 |
| Gujarat | 232 | 1,458 | 32 | 13 | 55 |
| Haryana | 248 | 369 | 35 | 33 | 32 |
| Karnataka | | | | | |
| Kerala | | | | | |
| Madhya Pradesh | 226 | 371 | 32 | 37 | 32 |
| Maharashtra | | | | | |
| Orissa | 39 | 238 | 109 | -4 | -6 |
| Punjab | 80 | 198 | 23 | 62 | 14 |
| Rajasthan | 858 | 539 | 69 | 8 | 23 |
| Tamil Nadu | | | | | |
| Uttar Pradesh | -337 | 69 | -164 | 131 | -67 |
| West Bengal | 241 | 735 | 38 | 18 | 44 |
| All India | 1,752 | 201 | 29 | 56 | 16 |
| North | 329 | 289 | 33 | 41 | 26 |
| East | 393 | 330 | 58 | 18 | 24 |
| Centre | 1,085 | 489 | 55 | 14 | 31 |
| West | 232 | 1,458 | 32 | 13 | 55 |
| South | 1 | 350 | 110 | -3 | -7 |

Note: See Table 16.

years, reflecting a departure from the all-India picture. This may be due to increased financial incentives for groundnut cultivation in these states, although this needs to be empirically verified. In a similar departure from the trend elsewhere, area under rapeseed/mustard in Uttar Pradesh decreased leading to a decrease in output and this in perhaps a reflection of more profitable alternatives available during the rabi season.

Elsewhere, the main producing states -- Gujarat, Maharashtra, and Tamil Nadu for groundnut and Rajasthan, Gujarat, Haryana, Madhya Pradesh, Punjab, and West Bengal for rape/mustard reflect the aggregate pattern.

*Fibres* (Cotton, Jute): In the fibres group, yield increases at the all- India level are the sole reason behind the (modest) growth in output of both cotton and jute; in fact, area under cultivation decreased in both crops. At the state level though, the cultivation of cotton has expanded fairly dramatically in Punjab and Haryana with the area under cotton nearly doubling since the early 1970s, so that in these two states, area expansion is also an important contributor to growth. The state level pattern in jute production in all the three major producers - Assam, Bihar and West Bengal - reflects the dominant role of yield growth in explaining production growth.

*Tobacco:* Increased yields and decreased area explain the modest growth in tobacco. Andhra Pradesh, the largest producer, reflects this all-India pattern, although in Gujarat, the other important tobacco producer (together these two states account for about 70 per cent of total production), some increase in area complemented the increases in yields.

In summation, the results on the crop level sources of growth show that at the all-India level area increases are important contributors to growth only in five crops, namely, rice, wheat, sugarcane, rape/mustard, and tur. Of these rice and wheat have benefitted from new seed varieties, from a supportive price policy and from large subsidies on key modern inputs. Sugarcane too has benefitted to a large extent from a supportive price policy and from access to low cost water from irrigation systems. All of these incentives have encouraged farmers to opt for an increased cultivation of these three crops and increases in area under these crops are the outcome.

Many of the same factors responsible for increased cultivation of wheat and rice, namely, supportive prices and technological breakthrough in seed varieties are behind the increased area that has come under rape/mustard. The difference is that these incentives have come at a fairly later date (early 1980s) for rape/mustard. An important additional factor behind the growth in rape/mustard has been the greater tolerance of this crop to moisture-stress, pests and diseases as compared to some of the other oilseeds. The relatively lower risk, the lower water intensity of cultivation and its increasing rotation with wheat are also important contributory factors behind the large increase in area and production of rape/mustard.

The low risk factor is perhaps the only viable explanation of area under tur increasing. As mentioned earlier, tur is a hardy drought-resistant crop and many farmers in rainfed areas grow tur along with other crops such as paddy to impart a degree of stability to their portfolio of crops.

Apart from these five crops, area increases have not been a substantial source of growth in any of the other crops. Yield increases have dominated the mostly paltry production growth of these crops. This is, of course, not to suggest that yield increases have not been important in rice, wheat, sugarcane and rape/mustard. They have been important in these four crops also, and perhaps even more so than elsewhere because increased (absolute) yields encouraged farmers to actually go ahead and devote more area to these crops.

## FUTURE DIRECTIONS

What do these sources of growth, and the past trends in growth, portend for the future? One thing is clear: yield improvements will have to account for the main part of any growth of overall output in the future since little unused area is available for agricultural purposes. While area shifts are still possible within crops, there is little likelihood of any significant increase in 'new' cultivable area. Experiences with reclaiming wastelands for agriculture, on a sustainable basis, have not been very encouraging.

The question then is: where, in regional terms,

TABLE 26. SOURCES OF GROWTH IN COTTON

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | 437 | 447 | 20 | 47 | 33 |
| Assam | | | | | |
| Bihar | -9 | 5 | -92 | -62 | 54 |
| Gujarat | -895 | 52 | -81 | -32 | 12 |
| Haryana | 383 | 189 | 87 | 8 | 6 |
| Karnataka | 152 | 132 | -151 | 492 | -240 |
| Kerala | | | | | |
| Madhya Pradesh | -35 | 89 | -225 | 165 | -41 |
| Maharashtra | 378 | 144 | 3 | 95 | 1 |
| Orissa | | | | | |
| Punjab | 899 | 191 | 45 | 39 | 16 |
| Rajasthan | 185 | 158 | 44 | 44 | 11 |
| Tamil Nadu | 123 | 133 | -66 | 212 | -46 |
| Uttar Pradesh | -17 | 54 | -124 | 56 | -32 |
| West Bengal | | | | | |
| All India | 1,508 | 126 | -40 | 156 | -16 |
| North | 1,282 | 190 | 59 | 27 | 14 |
| East | 10 | 2 | -98 | -60 | 57 |
| Centre | 150 | 123 | -46 | 163 | -17 |
| West | -517 | 81 | -78 | -26 | 4 |
| South | 712 | 173 | -28 | 160 | -33 |

Note: See Table 16.

TABLE 27. SOURCES OF GROWTH IN JUTE IN IMPORTANT JUTE GROWING STATES

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Assam | -193 | 81 | -152 | 72 | -21 |
| Bihar | 349 | 154 | 5 | 93 | 2 |
| Orissa | -79 | 78 | -143 | 64 | 20 |
| West Bengal | 1,418 | 148 | 21 | 72 | 7 |
| All India | 1,390 | 127 | -12 | 115 | -4 |
| East | 1,495 | 130 | -4 | 105 | -1 |

Note: See Table 16.

TABLE 28. SOURCES OF GROWTH OF TOBACCO IN IMPORTANT TOBACCO GROWING STATES

| Crop | Production increase between 1970-73 and 1986-89 (000 tonnes) | Production Index in 1986-89 (base: 1970-73 = 100) | Sources of Growth (Percent Terms) Area | Yield | Mix |
|---|---|---|---|---|---|
| Andhra Pradesh | -24 | 86 | -293 | 326 | -133 |
| Bihar | 8 | 178 | 16 | 75 | 9 |
| Gujarat | 39 | 134 | 25 | 69 | 6 |
| Karnataka | 18 | 191 | 18 | 71 | 11 |
| Tamil Nadu | -10 | 52 | -83 | -29 | 11 |
| West Bengal | 6 | 170 | 24 | 65 | 11 |
| All India | 56 | 114 | -137 | 296 | -59 |
| East | 14 | 174 | 20 | 70 | 10 |
| West | 39 | 134 | 25 | 69 | 6 |
| South | -16 | 92 | -431 | 491 | -160 |

Note: See Table 16.

will the growth come from and what, in turn, does the answer imply for the direction that policy should take? With regard to the regional outlook, recent trends in production growth clearly indicate that policies to promote agricultural growth should increasingly focus on the problems and prospects of the eastern, Uttar Pradesh, and central regions of the country. These three regions, put together, account for nearly half of the total domestic product (47.1 per cent during 1984-87) that originates from Indian agriculture. If recent trends are anything to go by, these regions will increasingly enjoy a comparative advantage in the production of agricultural commodities.

There are indications that productivity may be plateauing in important crops in the north so that large incremental increases, at least in traditional crops, seem unlikely.[12] In this region there may be greater promise in non-traditional crops such as fruits and vegetables but here again much will depend on how the food processing industry comes up.

In much of the west and the south, scarce resources should be increasingly devoted to sectors other than agriculture. Scarce land and water resources in Tamil Nadu and Kerala will inhibit large increases in agricultural output in a large part of the southern region. The low shares of agriculture in the SDPs of Gujarat, Maharashtra and Tamil Nadu, and the rapid decrease in these shares in recent years, suggests that sectors other than agriculture enjoy a comparative advantage in these three states. It does not make much sense to try and deliberately induce a reversal of this natural course towards industrialization. Indeed one of the reasons agriculture has not shown any appreciable growth in these states may be because the resources available were put to better use in the industrial and services sectors. This is reflected in the rural-urban division of population in these states. According to the 1981 census the proportion of urban population to total population was the highest in Maharashtra (35 per cent) followed by Tamil Nadu (33 per cent) and then by Gujarat (31 per cent); in each of the other twelve main states this proportion was less than 30 per cent. This can be due to a combination of lack of opportunity in agriculture driving labor towards the cities (the push factor) or the greater opportunities in urban areas attracting labor (the pull factor); but whatever be the dominant reason the comparative advantage does appear to lie with the industrial and services sectors *vis-a-vis* agriculture in these states.

That really leaves the east, the centre, and Uttar Pradesh where a combination of factors such as a relatively high irrigation potential, good rainfall, and a large rural population would appear to tilt the comparative advantage in favour of agricultural growth. Indeed one of the main findings of this paper is that accelerated growth in the agricultural sector is already underway in parts of these regions; it is not something that has still to take off in the future. It may therefore not be inopportune to increasingly focus towards these regions rather than simultaneously trying to devise policies that would encourage growth everywhere. However, it needs to be recognized that a large part of agricultural production in these states is under rainfed conditions so that while irrigation development may be a laudable long run objective, much of the growth in the short to medium term will have to come through increasing the efficiency and stability of rainfed farming. This will have to be achieved by a combination of better technology that will have to encompass improved drought resistant/flood resistant varieties of HYV seeds, increased fertilizer application, a strengthened input delivery system, and committed extension services as well as the provision of better infrastructure which will have to include rural roads, better marketing facilities, government procurement centres, improved watershed management, and increased power supply to agriculture. Only then will the targeted acceleration in overall production growth being envisaged in the Eighth Plan and the Agricultural Policy Resolution, become a reality.

NOTES

1. All trend growth rates in this paper are exponential trend rates calculated using log linear regressions. Mathematically, the growth in Y is calculated as the least squares estimate of b in the equation log Y = constant + b*time. In percentage terms the growth rate is then taken to be (b*100).

2. The stagnation in production in the pre-Independence period is fairly well documented in the literature. For instance, between 1891 and 1946, the output of all crops grew at 0.4% per annum with foodgrains growing at 0.1% per annum [Rao

and Deshpande, 1986 Pp. A101-A111].

3. All Growth rates mentioned in this paragraph are computed using from the constant price (1980/81 prices) National Accounts series. Data from CSO, *National Accounts Statistics*.

4. Throughout this paper, a statistical break in trend is evaluated using the usual dummy variable technique. See, for instance, Sadasivan for a recent discussion of the methodology involved [Sadasivan, 1989, Pp. A167-A180].

5. For Malaysia, Philippines and Thailand there is evidence of a significant downward break with trend. These nations, because of their geographical distance from India and consequent variations in agro-climatic conditions, are probably less appropriate comparators for India.

6. Growth rates in agriculture can vary substantially depending on the choice of the initial and terminal years. For this reason care needs to be exercised in the choice of the end points, so that, as far as is possible, like is compared to like.

7. The virtual stagnation of agriculture in Kerala and Tamil Nadu, for over a decade now, is well documented. In Kerala, lack of the new technology has been blamed [Kannan and Pushpangadan, 1990 Pp. 1991-2004]. In Tamil Nadu financial and administrative problems with an irrigation network that is highly dependent on the monsoon rains have been held to be a primary reason behind the poor growth [Bhalla and Tyagi, 1989].

8. International comparisons are of course beset with complications too. No two countries have the same policies or the same technology and infrastrucuture .. factors which critically determine growth. For this reason, such comparisons are also to be treated with caution.

9. The state advised minimum prices announced for sugarcane in Maharashtra (the main cane producing state in the western region), averaged over the years 1979/80-1987/88, were 29.6% above the GOI recommended price. In no other state was the discrepancy between these two prices so great.

10. The cultivation of groundnut is very susceptible to external stimuli such as pests, diseases and variations in weather. This high risk factor is one of the main reasons why production has fallen so steeply in the north and also why it is so difficult to encourage farmers to take to cultivating this crop.

11. See Vidya Sagar (1980) for a further discussion of the issues and options involved in growth decomposition exercises.

12. Rice and wheat are the two main crops of the agricultural system of the north. The per hectare yield of rice, averaged over the two northern states, was 2.86 tons/hectare in 1978/79, 2.91 tons/hectare in 1983/84 and 2.68 tons/hectare in 1988/89. All three years are peak years of production. The figures for wheat yields, in the same years, were 2.57, 2.83 and 3.57 tons/hectare respectively. Trend growth rates, taking account of the intervening years, portray the same pattern. It therefore does seem that productivity, in at least rice, is plateauing although a caveat here is that there may be some shift to high valued but low yielding varieties of rice in these states. Firm data on these are not available so this cannot be empirically verified.

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ANNEX TABLE

ALL INDIA INDEX NUMBERS OF PRODUCTION WEIGHTS

| Crop | Production weights Triennium ending | |
|---|---|---|
| | 1969-70 | 1981-82 |
| Rice | 33.98 | 29.74 |
| Wheat | 12.16 | 14.45 |
| Jowar | 4.86 | 4.43 |
| Bajra | 2.83 | 1.87 |
| Maize | 3.06 | 2.41 |
| Ragi | 1.01 | 0.95 |
| Small Millets | 0.81 | 0.47 |
| Barley | 1.34 | 0.66 |
| Coarse Cereals | 13.91 | 10.79 |
| Total Cereals | 60.05 | 54.98 |
| Gram | 3.58 | 3.07 |
| Tur | 1.35 | 1.58 |
| Other Pulses | 3.14 | 3.29 |
| Total Pulses | 8.07 | 7.94 |
| Total Foodgrains | 68.12 | 62.92 |
| Groundnut | 4.82 | 5.60 |
| Sesamum | 0.62 | 0.65 |
| Rapeseed & Mustard | 1.73 | 2.41 |
| Lineseed | 0.43 | 0.45 |
| Castorseed | 0.11 | 0.19 |
| Safflower | 0.09 | 0.32 |
| Nigerseed | 0.10 | 0.13 |
| Sunflower | | 0.10 |
| Soyabean | | 0.25 |
| Nine Oilseeds | 7.90 | 10.10 |
| Coconut | 1.87 | 1.83 |
| Cotton (seed) | 1.19 | 0.71 |
| Total Oilseeds | 10.96 | 12.64 |
| Cotton (Lint) | 3.01 | 4.37 |
| Jute | 0.81 | 0.55 |
| Mesta | 0.15 | 0.14 |
| Jute & Mesta | 0.96 | 0.69 |
| Sannhemp | 0.06 | 0.03 |
| Total Fibres | 4.03 | 5.09 |
| Tea | 1.85 | 1.46 |
| Coffee | 0.24 | 0.44 |
| Rubber | 0.19 | 0.39 |
| Fruits & Vwgetables | 3.97 | 4.90 |
| Sugarcane | 7.01 | 8.11 |
| Tobacco | 1.14 | 1.12 |
| Guarseed | 0.18 | 0.34 |
| Misc. Crops | 8.33 | 9.57 |
| Non-foodgrains | 31.88 | 37.08 |
| All Crops | 100.00 | 100.00 |

Source: GOI, Ministry of Agriculture.

# ROLE OF IRRIGATION IN RAISING INTENSITY OF CROPPING

B.D. Dhawan

*The paper attempts a fresh empirical investigation into the impact of irrigation on intensity of cropping. The all-India changes in intensity of cropping and irrigation are reviewed and results of regression analysis based on time series data for the period 1950-87 are presented. Cross-sectional data for 14 States are analysed through regression method for seven points of time, namely, 1953-57, 1958-62, 1963-67, 1968-72, 1973-77, 1978-82 and 1983-87. The results show that the relationship between intensity of cropping and irrigation is stable. Finally, we present some statewise preliminary estimates of the impact of irrigation on intensity of cropping and summarise the main findings.*

## INTRODUCTION

The key to year-round cropping of our limited land resource is widely perceived as the development of irrigation. In the monsoonal climate of 2 to 4 months duration that we have in India, irrigation becomes practically a prior requirement for cropping the farm land during the dry period. This is especially true for crops which are on the field during the summer season. Thus the extent of rise in intensity of cropping following the development of irrigation facilities vitally hinges on the availability of irrigation water during the rabi/summer season *vis-a-vis* the kharif/monsoon season.

Neverthless, in view of the admittedly slow increase in the level of intensity of cropping, some doubts arise now and then about the beneficial role of irrigation in enhancing intensity of cropping in India. Earlier, these doubts were powerfully expressed - and propagated - by V.K.R.V. Rao in his Panse Memorial Lecture in 1974. Despite the later signal work by Dharm Narain in this area, both in the conceptual and the empirical realms, doubts lingered on. Dhawan pointed out *inter alia* (a) the naivete of expecting one-to-one correspondence between intensity of cropping and irrigation, and (b) the paramount need in empirical investigation for reckoning with 'quality of irrigation' via the seasonal orientation of irrigation facility instead of type of irrigation [Dhawan, 1985].

The case for a fresh empirical investigation into the impact of irrigation on intensity of cropping has arisen because of the following recent works. At one extreme, Rao, Ray, and Subbarao report some 'evidence of a mild *increase* in the impact of irrigation on cropping intensity' (emphasis added) [Rao *et al*, 1988, p. 69]. At the other end, Alagh urges need for further enquiry into the relationship between intensity of cropping and irrigation, because he discerns the elasticity of intensity of cropping with irrigation approaching zero in some selected states [Alagh, 1987]. Satya Sai, taking the cue from Alagh, examines the relationship for the most irrigated region of the nation, namely, Punjab-Haryana area, and reports that the impact of irrigation on intensity of cropping here during the post-HYV period has been lower than in the earlier pre-HYV period - but certainly not approaching zero [Satya Sai, 1990].

The basic essential framework for assessing the relationship between intensity of cropping and irrigation, namely, the use of multiple regression technique, has been well laid by Dharm Narain and Roy [1980]. The same approach is followed in the present investigation. As the empirical findings are contingent on the definitions of the relevant variables, it is imperative that some consensus is reached among the investigators on definitional as well as procedural matters. This is precisely but briefly what is attempted in the first Section I on methodology.

The all-India changes in intensity of cropping and irrigation are reviewed in Section II. In Section III, we present the results of our regression analysis based on the all India time series data for the period 1950-87. To test whether the relationship between intensity of cropping and irrigation has remained invariant over time, cross-sectional data for 14 States are analysed through regression method for seven points of time, namely, 1953-57, 1958-62, 1963-67, 1968-72, 1973-77, 1978-82 and 1983-87. These

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results, which lend support to the hypothesis of stable relationship between intensity of cropping and irrigation at the national level, are discussed in the Section IV. In the next Section V we present some statewise preliminary estimates of the impact of irrigation on intensity of cropping. Finally, in Section VI, we summarise the main findings of the investigation.

## I. METHODOLOGY

Though the measurement of irrigation's impact on intensity of cropping is an attempt to get at the area effect of irrigation development in the past (or in the future), the effect is not fully assessed to the extent irrigation has helped in the past in the expansion of net sown area itself. There is no denying that a part, albeit a small one, of the substantial increase in net cropped area over the years has been aided by irrigation. This part of the area effect of irrigation can be captured in regression analysis either by relating gross cropped area to total irrigated area, or by redefining intensity of cropping as per the FAO procedure, whereby gross cropped area is expressed as a percentage of cultivable instead of cultivated area. We, however, refrain from departing from the conventional procedure. The area effect of irrigation estimated in this manner is more relevant for planning purposes because of the perception that scope (as well as the need) for further increase in net sown area in India does not exist any more.

It is necessary that we comprehend the true import of a measure of intensity of cropping. Its meaning is aptly conveyed by 'multiple cropping', which has been used interchangeably in the Indian literature. This alternative term connotes the number of crops raised during an agricultural year from a given plot of land under plough. And to distinguish this from the phenomenon of mixed cropping in subsistence farming -- wherein two or more crops are sown together simultaneously -- a rider is added, that from the same plot of land the crops are raised sequentially, that is, one after the other, during a single agricultural year.

Indian researchers have tried to modify the conventional measure of intensity of cropping by bringing in the added dimension of crop duration. This modification has been with a view to getting nearer to the concept of intensity of land use per annum. For this purpose two routes have been adopted. In one, less frequented route, cropwise durations measured in months are averaged by using crop areas as weights, and later expressing this weighted crop duration as per cent of 12 months of a year. The other route, which has become more common, is to enhance the reported area of long duration crops by a factor of two if these are two seasonal (like cotton, chillies and tobacco) - and by a factor of three if these are annual crops like sugarcane - while computing intensity of cropping in the usual conventional manner. Without such modification, the usefulness of knowing simply the number of crops grown per year stems from the significance of demand for hired labour which is known to be substantial for both sowing and harvesting times. Evidently, the more the crops, the greater the income/welfare implications for the landless class dependent on hiring out their labour power.

In the measurement of the impact of irrigation on intensity of cropping two methodological points are of great pertinence. These are about (i) the way one defines both irrigation and intensity of cropping in one's empirical investigation and (ii) the choice of the regression model. Before taking up these points one by one, we would like to underscore another related aspect, namely, the role of the data base used in the measurement work. Evidently, the results are going to be affected thereby, sometimes in a known direction and more often in unknown direction. Let us concretise this aspect with specific instances.

We have two sources of data on the progress of irrigation in India. The plan documents constitute one source, the other being land utilisation statistics published in the documents of the departments of agriculture of the States and at the Centre. The first source gives irrigation progress in terms of irrigation capacity (called created irrigation potential) and actual utilisation, distinguished also by two irrigation categories, namely, major and minor irrigation works. These statistics are in gross terms, that is, these indicate how much crop-area is irrigable/irrigated in a given year.

The other source, on the other hand, gives statistics of only actual irrigated area in a year,

though with many more details. For one, we get information both in gross and net terms, that is to say, gross irrigated area and net irrigated area. For another, each of these is further distinguished: gross irrigated area is detailed by major crops and crop groups, whereas net irrigated area is categorised usually by four principal sources like canals, wells, tanks, and other sources of irrigation.

Researchers have primarily used the land utilisation statistics. As statistics of gross cropped area and net sown area (required for measuring intensity of cropping) are also available from this very source, data compatibility is maintained. Had they used irrigation statistics from the plan documents instead of departments of agriculture, they would have most likely ended up showing reduced impact of irrigation on intensity of cropping; because the magnitude of gross irrigated area reported in the plan documents tends to be higher than the one reported in the land utilisation statistics. This divergence is attributed to the sluggishness of the 'patwaris' and 'karnams' (who supply data on land utilisation to the department of agriculture) in recording fully the change in irrigation status of fields on the one hand, and to the overzealousness of irrigation engineers/administrators to report impressive progress in irrigation development to the planners on the other.

As for the reliability of the basic land utilisation statistics, two observations are necessary. First, the reliability varies between ryotwari states (with administrative machinery for maintaining land records) and permanent settlement states of Kerala, West Bengal, and Orissa (for the latter states, cadastral surveys are used for building up land utilisation data). Second, as the village 'patwari' got entrusted with extra duties over time, and as the supervision in data compilation declined with the passage of time, apprehension has grown that the quality of data is poorer now than before. These facts should make the researcher very circumspect in drawing conclusions from his empirical findings.

In what follows the estimational procedure used in this study is spelt out. To begin with, definitional questions regarding intensity of cropping and irrigation variables are taken up. Next, regression models used in the study are outlined. Finally, a few observations on possible biases in the estimates are made.

*Definitions*: In our investigation, no adjustment for crop duration is done to the usual measure of intensity of cropping, namely, the ratio of gross cropped to net cropped/sown area. As per convention, this ratio is expressed in per cent terms. This simplifies the task of interpreting the regression coefficient of irrigation variable, which too is conventionally put in per cent terms, that is, irrigated area expressed as a percentage of net sown area. But it must be recorded here that intensity of cropping, when mentioned in pure ratio or fractional form, is truly a straightforward indicator of the average number of crops obtained by farmers from a unit of land area in a single year. Thus in fractional form a magnitude of 1.27 for intensity of cropping for 1987-88 is more communicative than the corresponding value of 127 in percentage terms.

Dharm Narain and Roy deal with the problem of crop duration by dropping the area under sugarcane from both the measure of intensity of cropping and the irrigation ratio [Dharm Narain and Roy, 1980]. It is noteworthy that the irrigation impact so estimated did not differ from the one arising by the use of unmodified measure of intensity of cropping (as well as irrigation ratio). On this ticklish issue Dhawan observed that the adjustment for crop duration aspect, if it must be done by a researcher, ought to be done on both the variables [Dhawan, 1988]. Otherwise, regressing the intensity of cropping adjusted for crop duration on unadjusted irrigation ratio is bound to yield an upward biased estimate of irrigation's impact on cropping intensity, thereby creating an incorrect impression of more than the actual impact of irrigation. Even if no regression analysis is attempted, say, in an evaluation study on investment in a minor irrigation work, nor any attempt made to relate change in intensity of cropping to the corresponding change in the irrigation ratio, the user of such a report might get an exaggerated view of the beneficial role of irrigation in raising intensity of cropping. The scope for such an exaggeration is greater when investment in irrigation radically alters crop pattern in favour of long duration crops like

sugarcane and cotton.

The question of defining irrigation is essentially one of choosing between gross and net irrigated area statistics. There is no disputing that the extent of expansion in irrigation facilities is better reflected by the increase in gross rather than net irrigated area. While computing net irrigated area the farm land area benefiting from irrigation during at least one of the three crop seasons (kharif, rabi, and summer) in an agricultural year is getting measured. Gross irrigated area, on the other hand, is the sum of area under all crops grown under irrigated regime during all the three crop seasons. It thus reflects crop acreage in contrast to land acreage protected or benefited by irrigation development.

The difference between gross and net irrigated area is land area irrigated in more than one crop season in a year. With the development of tube-wells and reservoir-backed canal irrigation, lands within their commands are increasingly getting irrigated in two to three seasons of the year in contrast to practically one-seasonal irrigation provided earlier by diversion canals, tanks, and shallow wells. This has led to a faster rise in more than once irrigated land (sometimes called irrigated land that is double cropped) than net irrigated land area. As a result, the ratio of gross to net irrigated land, called intensity of irrigation, has risen over time. This ratio is also widely deemed as a measure of 'quality of irrigation', as also a measure of intensity of cropping on irrigated lands. That it is incorrect usage in the latter sense has been argued by Dhawan [1985]. Evidently, relating intensity of cropping to net irrigated area (expressed as per cent of net sown area) is bound to result in an overstated impact of irrigation on intensity of cropping.

Dhawan argued that the appropriate specification of irrigation variable in intensity of cropping analysis is not net but gross irrigated area (as per cent of net sown area), which is also the measure used in irrigation planning in India -- an irrigation project report seldom mentions irrigation development in net irrigated terms [Dhawan, 1985]. The conventional regression analysis has certainly improved by adding to it another irrigation variable, namely, intensity of irrigation, first attempted by Dharm Narain and Roy [1980]. This improvement is now widely believed to reflect the quality aspect of the basic irrigation variable viz. net irrigated area. This is true upto a point. In fact, Dharm Narain and Roy are clearly on record that quality of irrigation in terms of the seasonal character of irrigation is imperfectly captured through intensity of irrigation. An alternative route to quality aspect of irrigation has been to split total irrigated area variable into its component variables, namely, areas under tanks, canals, wells/tubewells, etc., all expressed as per cent of net sown area. This route was also explored by Dharm Narain and Roy [1980]. Dhawan had made two observations in regard to these attempts to get at the quality of irrigation in the regression analysis [Dhawan, 1988].

First, a *single* irrigation variable, defined as the ratio of gross irrigated area to net sown area, would equally well serve the purpose at hand, thus obviating the need for two separate ratio variables, namely, the ratio of net irrigated area to net sown area and the ratio of gross to net irrigated area. Readers would note that in the single suggested variable are subsumed the other two variables, as the first one is a product of the latter two. And statistically informed readers would know that the two variable procedure means loss of one 'degree of freedom' in estimation. Second, the quality of irrigation, in the context of intensity of cropping analysis, is better captured by the season-wise orientation of irrigation than by three main types of irrigation, namely, canals, wells, and tanks under which irrigation statistics are usually distinguished in the official documents. This is amply demonstrated in the present investigation.

*The Regression Model*: Both linear and non-linear specifications have been employed in the literature on intensity of cropping analysis carried out within the multiple regression framework. For a variety of considerations, double logarithmic format is not commended. Two of these may be mentioned here. First, 'a log-linear specification is not appropriate as it envisages the intensity of cropping to be zero when irrigation level too is zero - in rainfed farming conditions of India the intensity of cropping, when expressed in per cent terms, is anticipated to be a little over 100' [Satya Sai, 1990, p. 299]. Second, intensity of cropping,

though positively related with rainfall variable, does not change in constancy with rainfall. Yadav reports a parabolic (i.e. quadratic) relation between intensity of cropping and normal rainfall across Indian states [Yadav, 1990].

Multiple regression analysis can be carried out with cross sectional as well as time series data. The all-India results in the present study are derived both from a cross section of data on 14 states and from time series data for the country as a whole. The cross sectional results are obtained for different points of time, so as to test the hypothesis of a stable impact of irrigation on intensity of cropping.

Though the basic model for analysis is the same for both cross-sectional and time series data, in practice there are differences arising mainly because of data (and time resource) constraints on some needed variables. In what follows, we spell out the methods and procedures employed in this study. We begin with the cross-sectional model used for all-India analysis, which is of central concern in the present study. This is undertaken primarily to assess if the relationship between intensity of cropping and irrigation is weakening (or mildly improving) over time. In the cross-sectional analysis the following model is used in the present study.

$$CI = a + b.IRR + c.K + d.RAIN + e.RAIN^2 \quad \ldots (1)$$

where: CI = conventional measure of intensity of cropping i.e. ratio of gross to net sown area (per cent); IRR = irrigation ratio of gross irrigated to net sown area (per cent); K = K-factor indicating orientation of irrigation in a state towards the kharif season (fraction); RAIN = normal rainfall of a state (cm). a, b, c, d and e are parameters to be estimated.

The parameters a, b and d are expected to be positive, and the parameters c and e to be negative. While CI and IRR are obtained from the official statistics of gross cropped area, net sown area and gross irrigated area, statewise RAIN data shown in Table 1 are obtained from Yadav [1990]. These rainfall values for each state are the same as given in Rao *et al* except for the difference in respect of Punjab, for which Yadav gives 59 cm and Rao *et al* 70 cm [Rao *et al*, 1988, Table 5.6, p. 70]. Statewise values of the K-factor given in Table 1 are from Yadav [1990]. It may be noted that these are the averages of three years 1983-84 to 1985-86 [Dhawan, 1988, Table 4.5, p. 94].

In an alternative specification, an attempt has been made to replace both the irrigation variables, namely, IRR and K, by three types of irrigation. That is to say, we introduce net irrigated areas under canals, wells and tanks all expressed as per cent of net sown area. Year-wise cross sectional regressions showed remarkable stability over time. It was, therefore, decided to pool data for 5 continuous years. The 14 states included in the cross-sectional analysis are listed in Table 1, which also gives the normal rainfall and the K-factor values for each state.

TABLE 1. NORMAL RAINFALL AND K VALUES IN DIFFERENT STATES

| States | Normal Rainfall (cm) | K - Factor (1983-85) |
|---|---|---|
| Andhra Pradesh | 89 | 0.69 |
| Bihar | 129 | 0.47 |
| Gujarat | 74 | 0.46 |
| Haryana | 70 | 0.28 |
| Karnataka | 82 | 0.79 |
| Kerala | 275 | 0.50 |
| Madhya Pradesh | 123 | 0.38 |
| Maharashtra | 91 | 0.54 |
| Orissa | 157 | 0.87 |
| Punjab | 59 | 0.37 |
| Rajasthan | 49 | 0.08 |
| Tamil Nadu | 99 | 0.71 |
| Uttar Pradesh | 108 | 0.27 |
| West Bengal | 70 | 0.74 |

For all-India time series analysis, the following model could be operationalised:

$$CI = a + b.IRR + d.\ INDEXRAIN \quad \ldots (2)$$

Here, CI and IRR are defined in the same earlier manner, and INDEXRAIN is an index of weather conditions. As there is no index of rainfall at the national level (the Meteorological Department provides actual rainfall variations for each of the 35 meteorological divisions), we have two options before us. The first is to use a dummy variable for drought years like 1987-88, 1979-80, 1966-67, 1965-66 and 1957-58 in our time series analysis. This would surely take care of the perceptible dip in intensity of cropping in these years when the irrigation ratio tended to rise. The second option, which we have gone in for, is to

use fluctuations in the available index of agricultural output around the trend line as a proxy for rainfall conditions. To such fluctuations, measured in percentage terms, we have added 100 to get an index of rainfall for each year in our time series.

In the alternative specification, model (2) is modified, replacing the irrigation variable by its three principal components of canal-irrigated area, well-irrigated area and tank- irrigated area, all expressed as per cent of net sown area.

Both the models (1) and (2) suffer from the omission of relevant variables like tractorisation, other mechanisation, and labour availability. As these omitted variables are positively related with both intensity of cropping and irrigation, one may apprehend the presence of an upward bias in the estimated coefficient of irrigation variable. In the estimational work based on the model (1), note may be taken of two deficiencies: (i) the exclusion of weather conditions and (ii) the use of the same K-values for all the cross sections. *A priori* it is difficult to conjecture about the effect of such deficiencies on our estimates of impact of irrigation on intensity of cropping.

## II. REVIEW OF PROGRESS IN IRRIGATION AND ITS IMPACT ON INTENSITY OF CROPPING

*Salient Changes*: Intensity of cropping on a net sown area of the order of 140 million ha is presently around 130 per cent. That is to say, hardly 1.3 crops on the average are being raised on our land under plough. This is far away from the desired target of at least double, if not triple, cropping of our limited land resource. In point of fact, no state in the country has yet reached this landmark. The best achievement in this regard is from the state of Punjab, where a level of 176 per cent of intensity of cropping was recorded in 1987-88 when the all-India level stood around 127 per cent.

Over time, there has been a perceptible, albeit slow, rise in intensity of cropping at the national level (as well as in most states). The all-India average has risen from a level of 111 per cent in 1950-51 to 118 per cent in 1970-71, 123 per cent in 1980-81, and on to 127 per cent in 1987-88, the latest year taken in our analysis. This uptrend in intensity of cropping implies a rate of growth of about 0.35 per cent per annum. This growth has been very steady around the trend line. Though the intensity of cropping tended to dip in years of drought and spurt slightly in above-normal rainfall years, yet the coefficient of variation around the trend line was only about 6 per cent.

Gross irrigated area under crops, as per the land utilisation statistics, rose from about 22.6 million ha in 1950-51 to about 28.0 million ha in 1960-61, 38.2 million ha in 1970-71, 49.9 million ha in 1980-81 and 55.6 million ha in 1987-88. Its annual rate of growth comes to 2.72 per cent. In the same period, there occurred some increase in net sown area (it rose from 118.75 million ha in 1950-51 to 140.51 million ha in 1986-87). Hence, the irrigation ratio, defined as the ratio of gross irrigated area to net sown area, rose at a lower rate of about 2.32 per cent per annum.

More specifically, the irrigation ratio rose from a level of about 19 per cent in 1950-51 to about 41 per cent in 1987-88. Of course, the conventional measure of irrigation ratio, expressed as a ratio of net irrigated area to net sown area, shows a lower progress; it rose from about 17 to about 32 per cent in the same period. (A similar picture emerges on the basis of the third possible measure of the irrigation ratio, namely, ratio of gross irrigated to gross cropped area, which rose from a level 18 to 33 per cent in the above period). Thus, it is obvious that the impact of irrigation expansion on intensity of cropping is *ceteris paribus* bound to appear higher if conventional measure of irrigation ratio is used. In fact, Satya Sai reports an impact of about 0.95 percentage point rise in intensity of cropping corresponding to one percentage point increase in the conventional irrigation ratio during the period 1950-51 to 1982-83 [Satya Sai, 1990]. But the same impact reduces to about 0.61 percentage points corresponding to one point rise in the irrigation ratio as defined in the present study.

Since 1951, there have been several noteworthy changes in irrigation facilities. First, their regional dispersal became less uneven. This was mainly because of more even development of irrigation under the public aegis. Of course, this was offset to some extent by increase in inter-state disparity in irrigation expansion within the farmers' own ownership. Second, the composition of irrigation underwent noticeable changes.

More significantly, the expansion was fastest in ground water irrigation which registered a growth rate of nearly 4 per cent per annum. In contrast, canal irrigation increased by 1.9 per cent per annum but far more steadily. The third most important source of irrigation, namely, tanks, *diminished* at the annual rate of 0.7 per cent per annum during the period under study. The comparative data for the three sources of irrigation, which now account for over nine-tenths of total irrigation, are given in Table 2.

TABLE 2. ANNUAL GROWTH RATES, ALONGWITH FLUCTUATIONS, IN IRRIGATION SOURCES

| Sr. No. | Source | Growth rate | Fluctuations around the trend line i.e. coefficient of variation (%) |
|---|---|---|---|
| 1. | Wells (including tube-wells) | 4.0 | 10.0 |
| 2. | Canals | 1.9 | 2.1 |
| 3. | Tanks | (-) 0.7 | 10.8 |
| 4. | All Sources: | | |
| | (a) net irrigated area basis | 2.2 | 2.3 |
| | (b) gross irrigated area basis | 2.7 | 2.5 |

Differences in growth rates of different sources of irrigation favoured well irrigation whose relative share rose from 29 per cent in 1950-51 to 49 per cent in 1986-87. Within wells, the shift was from the traditional (animal/human operated) dug or open wells to tubewells and dugwells equipped with power pumps. Reported area under tubewell irrigation in 1986-87, namely, 12.2 million ha, considerably exceeded the corresponding area of 8.8 million ha under dugwell irrigation. Over time, diesel driven pumps have in turn been replaced by electric ones. Because of marginally lower rate of growth recorded by canal irrigated area *vis-a-vis* total net irrigated area, its share in total irrigation diminished from 40 per cent in 1950-51 to 38 per cent in 1986-87. Within canal irrigation, newer canal works were increasingly backed with storage reservoirs as compared to earlier works which simply diverted river flows.

Another noteworthy development in Indian irrigation has been the rise of conjunctiveness or jointness in irrigation. On the one hand, many canal and tank irrigators acquired access to private well irrigation. On the other hand, some tanks started getting water replenishments from new canals within whose commands these happened to be located. The benefit of such supplementation were offset to some extent by degradation of forest and soil cover in catchment areas of the tanks.

As a result of the aforesaid changes, the one-season character of Indian irrigation system was further attenuated. Consequently, area irrigated more than once during an agricultural year grew much faster (5.6 per cent per annum). Thus the ratio of gross to net irrigated area improved from 1.08 in 1950-51 to 1.29 in 1986-87.

### III. RESULTS OF ALL INDIA REGRESSION ANALYSIS (1950-51 TO 1987-88)

When intensity of cropping is regressed simultaneously both on irrigation and the proxy for rainfall variable, the regression coefficients of irrigation as well as rainfall turn out to be statistically significant. The coefficient of the irrigation ratio variable is around 0.65, with a small standard error of about 0.02. The estimated regression equation, given below, is a very good fit to the data, $R^2$ attaining a value of about 0.98.

$$CI = \underset{(2.19)}{91.21} + \underset{(0.0175)}{0.6476}\,IRR + \underset{(0.0217)}{0.0925}\,INDEX\,RAIN, \quad \ldots (3)$$

$$R^2 = 0.9758 \qquad n = 38$$

where: CI = all-India intensity of cropping (%); IRR = irrigation ratio (gross irrigated area as % of net sown area). INDEX RAIN = proxy for all-India rainfall index
(Figures in parentheses are standard errors).

Bearing in mind that the regression coefficient of irrigation variable is probably overestimated due to the omission of variables like tractorisation from the equation (3), it is found that the relationship between intensity of cropping and irrigation ratio is not of one-to-one correspondence as per the general perception in this regard. However, it turns out to be much better than that predicted by Dhawan earlier in 1988: the estimated regression coefficient of about 0.65 is higher than the predicted magnitude of 0.48 [Dhawan, 1988].

Our effort to estimate the irrigation impact by

type of irrigation does not prove rewarding. Below we give the estimated regression equation in this regard.

$$CI = \underset{(2.52)}{91.16} + \underset{(0.39)}{1.31}\,NCANAL + \underset{(0.20)}{1.12}\,NWELL + \underset{(0.68)}{3.36}\,NTANK + \underset{(0.02)}{0.07}\,INDEXRAIN \quad \ldots (4)$$

$$R^2 = 0.9797 \qquad n = 38$$

where, NCANAL, NWELL and NTANK stand for *net* irrigated areas under canals, wells, and tanks, respectively, each expressed as a percentage of net sown area.

The problem with equation (4) is that tank irrigation turns out with maximum effect on intensity of cropping, with its regression coefficient acquiring an incredible magnitude of 3.36. Since it is statistically significant, it cannot be dropped and the equation reestimated. The estimates appear to have been affected by two circumstances. First, there exists high multicollinearity on the one hand, and high individual correlation of two explanatory variables (canals and wells) with intensity of cropping on the other, as is evident from the following correlation matrix.

| | CI | NCANAL | NWELL | NTANK |
|---|---|---|---|---|
| CI | 1.00 | 0.97 | 0.97 | (-) 0.80 |
| NCANAL | | 1.00 | 0.98 | (-) 0.86 |
| NWELL | | | 1.00 | (-) 0.91 |
| NTANK | | | | 1.00 |

Second, statistics of irrigated area by type of irrigation are being compiled on the basis of net area, not gross irrigated area. This specification error in the explanatory variables might distort the regression estimates. In view of these two circumstances the results of equation (4) cannot be accepted at their face value[1].

## IV. RESULTS OF CROSS SECTIONAL ANALYSIS

Because of two reasons, we expect somewhat better results (in statistical sense) from our cross sectional than preceding temporal analysis. For one, the degree of multicollinearity among variables is expected to be lower. For another, specification of the model for cross sectional analysis is better, as we have included seasonal orientation of irrigation as an additional explanatory variable [vide model (1)].

*Cross Section of 1983-84 to 1987-88*: The following estimated equation for the cross section of 14 states for the 5-year period 1983-87 yields an irrigation impact value of about 0.46 for each unit change in irrigation ratio:

$$CI = \underset{(5.92)}{66.95} + \underset{(0.03)}{0.46}\,IRR + \underset{(0.1011)}{0.6618}\,RAIN - \underset{(0.0003)}{0.0015}\,RAIN^2 - \underset{(6.09)}{15.10}\,K \quad \ldots (5)$$

$$R^2 = 0.8283 \qquad n = 70$$

All the regression coefficients have the expected signs and are statistically significant. The coefficient of multiple determination is reasonably good. Needless to add, the regression coefficient of irrigation, though much less than the one obtained through time series analysis, is nearer the value of 0.48 predicted by Dhawan [1988].

When we estimate the model (1) by type of irrigation specification, the results are, once again, unsatisfactory. The estimated equation is as follows:

$$CI = \underset{(4.97)}{69.51} + \underset{(0.15)}{1.37}\,NCANAL + \underset{(0.11)}{0.38}\,NWELL - \underset{(0.29)}{1.42}\,NTANK + \underset{(0.0723)}{0.5149}\,RAIN - \underset{(.0002)}{0.0011}\,RAIN^2 \quad \ldots (6)$$

$$R^2 = 0.8834 \qquad n = 70$$

Though $R^2$ is very high and all the regression coefficients of this equation are statistically significant, the impact of tank irrigation on intensity of cropping turns out to be negative while the impact of canal irrigation *vis-a-vis* well irrigation is three times larger. Dropping tank irrigation, we still get the incredible result of canal irrigation development leading to improvement in intensity of cropping twice as much as from well irrigation development, as can be seen from the following equation:

$$CI = 71.76 + 1.18\ NCANAL + 0.57\ NWELL \quad (5.74)\ (0.17)\ (0.13)$$
$$+ 0.4069\ RAIN - 0.0007\ RAIN^2 \quad ...(7) \quad (0.08)\ (.0002)$$
$$R^2 = 0.8402 \quad n = 70$$

Some problem of multicollinearity, though of a lower degree than that in the case of time series data, is discernible, especially between canal and well irrigation, as shown in the following correlation matrix.

| | CI | NCANAL | NWELL | NTANK |
|---|---|---|---|---|
| CI | 1.00 | 0.78 | 0.66 | (-) 0.21 |
| NCANAL | | 1.00 | 0.81 | (-) 0.07 |
| NWELL | | | 1.00 | (-) 0.29 |
| NTANK | | | | 1.00 |

*Trend in Irrigation Impact*: The trend over the years can be judged by studying the changes in the coefficient of irrigation ratio obtained from each cross section for the 7 points of time. The complete regression equations are given in Table 3. One discerns signs of an upward drift in the impact of irrigation on intensity of cropping. More specifically, the regression coefficient of irrigation ratio moved as follows: 0.40 in 1953-57, 0.42 in 1958-62, 0.39 during 1963-67 and 1968-72, 0.42 during 1973-77, 0.43 during 1978-82, and 0.46 during 1983-87. However, the differences are statistically not significant. Therefore, the evidence is in favour of the hypothesis that the impact of irrigation on intensity of cropping remains more or less the same over time, somewhere between 0.39 and 0.46.

TABLE 3. ALL-INDIA CROSS-SECTIONAL REGRESSION FOR DIFFERENT PERIODS ON INTENSITY OF CROPPING

| Sr. No. | Periods of cross sectional analysis | n | Constant | Regression coefficients with standard errors | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | IRR | RAIN | $RAIN^2$ | K | $R^2$ |
| 1. | 1983-87 | 70 | 66.95 | 0.4555 | 0.6618 | (-)0.0015 | (-)15.10 | 0.8277 |
| | | | (5.91) | (0.0283) | (0.1011) | (0.0003) | (6.09) | |
| 2. | 1978-82 | 70 | 83.06 | 0.4318 | 0.4424 | (-)0.0009 | (-)18.80 | 0.8506 |
| | | | (4.51) | (0.0239) | (0.0768) | (0.0002) | (4.58) | |
| 3. | 1973-77 | 70 | 83.12 | 0.4152 | 0.4608 | (-)0.0009 | (-)21.48 | 0.8710 |
| | | | (3.81) | (0.0233) | (0.0652) | (0.0002) | (3.89) | |
| 4. | 1968-72 | 70 | 83.52 | 0.3885 | 0.4611 | (-)0.0010 | (-)21.42 | 0.8546 |
| | | | (3.55) | (0.0243) | (0.0608) | (0.0002) | (3.58) | |
| 5. | 1963-67 | 70 | 87.08 | 0.3911 | 0.4139 | (-)0.0010 | (-)21.10 | 0.7933 |
| | | | (3.42) | (0.0314) | (0.0601) | (0.0002) | (3.49) | |
| 6. | 1958-62 | 64 | 89.96 | 0.4219 | 0.4648 | (-)0.0012 | (-)33.01 | 0.7886 |
| | | | (3.48) | (0.0401) | (0.0516) | (0.0002) | (3.56) | |
| 7. | 1953-57 | 60 | 92.46 | 0.4074 | 0.3731 | (-)0.0009 | (-)27.48 | 0.8023 |
| | | | (3.10) | (0.0370) | (.0535) | (0.0002) | (3.07) | |

## V. STATEWISE EFFECT OF IRRIGATION EXPANSION ON INTENSITY OF CROPPING

So far, we have discussed the impact of irrigation development on intensity of cropping at the all-India level. In this section, we shall present the time series results for a number of states, namely, Uttar Pradesh, Rajasthan, Punjab, Haryana, Maharashtra, Tamil Nadu, Gujarat, Madhya Pradesh, Karnataka, and Andhra Pradesh. We begin with the state of Uttar Pradesh, the state with the largest irrigated acreage.

*Uttar Pradesh:*

Net sown area of this state, now about 17 million ha, has risen very steadily at the rate of about 0.13 per cent per annum during the 38 years period 1950-88. During the same period, gross cropped area rose faster at the annual rate of about 0.60 per cent, with the result that intensity of cropping improved from about 123 to about 143 per cent

(it touched the level of 146 per cent in 1986-87, a non-drought year). This improvement bears a very close relation with the expansion in gross irrigated area, which rose from about 5 million ha in 1950-51 to nearly 14 million ha in 1987-88. While the conventional irrigation ratio stood at about 59 per cent in 1987-88, the ratio of gross irrigated area to net sown area was 81 per cent. The rate of expansion in gross irrigated area works out to about 3 per cent per annum, which is somewhat above the corresponding national rate of expansion (2.7 per cent) and is along a rather steady path (CV around trend line = 7.8 per cent). Well irrigation has expanded faster than total irrigation, as revealed by the following statistics:

| | Growth rate | CV around trend line |
|---|---|---|
| 1. Net canal area | 1.89 | 6.5 |
| 2. Net well area | 3.42 | 9.7 |
| 3. Net tank area | 1.50 NS | 47.3 |
| 4. Net (total) irrigated area | 2.46 | 6.8 |

NS = not significant ; CV = coefficient of variation (%)

The temporal movements in tank-irrigated area, as shown above, require a cautionary explanation. The high fluctuations and the positive rate of growth in tank irrigation (though statistically insignificant) have arisen because of extremely low values for the three initial years, 1950-53 (50 to 60 thousand ha as compared to between 370 and 490 thousand ha for the subsequent period 1953-66). Since the corresponding magnitudes under 'other sources' of irrigation are unduly high for these three years, it appears to be a simple case of error of classification. Actually, between 1953-54 and 1987-88 net tank area shrank substantially from about 0.5 million ha to about 0.1 million ha. Thus the true change in the composition of state irrigation is revealed by the following relative shares:

| | Average per cent share in total irrigation | |
|---|---|---|
| | 1953-55 | 1985-87 |
| 1. Wells (including tube-wells) | 49 | 64 |
| 2. Canals | 36 | 32 |
| 3. Tanks | 9 | 1 |
| 4. Other sources | 6 | 3 |
| Total | 100 | 100 |

The improved share of well irrigation in the state irrigation is owing to explosive development of tubewell irrigation, much more in the private than in the public sector. In point of fact, dugwell irrigation has declined in absolute terms all over U.P., including East U.P. According to Prasad and Sharma [1991], area under tubewell irrigation even in East U.P. shot up from 0.08 million ha in 1950-51 to 2.10 million ha in 1984-85, while the area under open wells fell from 1.20 million ha to 0.15 million ha in the same period. In 1984-85, this region of the state of U.P. had nearly 600 thousand shallow tubewells in the private sector, and 9 thousand deep tubewells in the public sector; the number of dugwells was about 280 thousand.

Irrespective of the measure of irrigation development, intensity of cropping and irrigation ratio are found to be strongly correlated (r = 0.93) despite large fluctuations in weather conditions during the period under study. Of course, during years of severe drought the intensity of cropping tended to dip a bit below the preceding year's level, or the trend value predicted by irrigation level, as shown by the following statistics:

| Drought year | Intensity of cropping | |
|---|---|---|
| | actual | trend value |
| 1965-66 | 127.05 | 127.93 |
| 1966-67 | 127.48 | 129.44 |
| 1972-73 | 133.33 | 133.36 |
| 1979-80 | 139.14 | 140.82 |
| 1987-88 | 142.56 | 148.59 |

Leaving out 1950-53, the regression analysis is carried out for the 35-years period 1953-88. Rainfall variable in this analysis consists of deviations from normal rainfall for the two meteorological divisions of East and West U.P. Normal rainfall for East U.P. division is 1014 mm which is higher than the normal rainfall of West U.P. division, namely 940 mm. These deviations, measured in percentage terms, are found quite collinear. Because of this collinearity both rainfall variables turn out to be statistically insignificant, as shown by the equation below:

$$CI = \underset{(1.50)}{110.28} + \underset{(0.03)}{0.46}\,IRR + \underset{(0.019)}{0.007}\,EAST\,RAIN + \underset{(0.029)}{0.046}\,WEST\,RAIN \quad \ldots (8)$$

$$R^2 = 0.9166 \qquad n = 35$$

For reflecting weather conditions during the period under study we have aggregated the rainfall for the two divisions. Both rainfall and irrigation are positively correlated with intensity of cropping, as revealed by the following equation:

$$CI = \underset{(1.98)}{105.44} + \underset{(0.02)}{0.45}\,IRR + \underset{(0.007)}{0.003}\,RAIN \quad \ldots (9)$$

$R^2 = 0.9454 \quad n = 35$

where: CI = intensity of cropping (%); IRR = irrigation ratio (%); RAIN = sum of rainfall for two meteorological divisions; (Figures in parenthesis are standard errors)

It is found that one percentage point rise in irrigation ratio in U.P. gives rise to 0.45 percentage point rise in intensity of cropping. However, this impact value of irrigation is well below the magnitude of 0.73 predicted earlier by Dhawan [1988].

Regressing intensity of cropping on three types of irrigation and rainfall, we obtain two questionable results. One, the impact of tank irrigation on intensity of cropping is not only negative and statistically significant but also very substantial. Second, the impact by canals turns out to be much higher than that by wells. The multiple regression equation is as follows:

$$CI = \underset{(4.83)}{117.83} + \underset{(0.27)}{0.79}\,NCANAL + \underset{(0.12)}{0.28}\,NWELL - \underset{(1.20)}{3.94}\,NTANK + \underset{(0.0006)}{0.0023}\,RAIN \quad \ldots (10)$$

$R^2 = 0.9679 \quad n = 35$

where NCANAL, NWELL and NTANK are net area under canals, wells (including tubewells) and tanks, respectively, all measured as per cent of net sown area. Figures in parenthesis are standard errors.

The odd results might be due to multicollinearity, though all independent variables have statistically significant coefficients. The correlation matrix is as follows:

| | IC | NCANAL | NTANK | NWELL |
|---|---|---|---|---|
| IC | 1.00 | 0.96 | (-) 0.95 | 0.96 |
| NCANAL | | 1.00 | (-) 0.91 | 0.96 |
| NTANK | | | 1.00 | (-) 0.96 |
| NWELL | | | | 1.00 |

*Rajasthan:*

The intensity of cropping on 15 million ha of net sown area in this arid state is low. It has risen from a level of 105 per cent in 1950-51 to 116 per cent in 1987-88, the annual rate of rise being 0.27 per cent. Of course, the net sown area itself rose substantially over time, the annual rate of growth being at the rate of one per cent per annum. The irrigation coverage remains modest despite expansion in gross irrigated area at the rate of 3.4 per cent per annum. The gross irrigated area was about 4 million ha in 1987-88, when the irrigation ratio was 35 per cent. Canal irrigation expanded at the rate of 4.6 per cent per annum, and well irrigation at the rate of 3.1 per cent. Tank irrigation, however, did not expand. It exhibits large year-to-year fluctuations (CV = 40 per cent). Even canal and well irrigation do undergo considerable year-to-year fluctuations: for canal irrigation CV is 13.6 per cent and for well irrigation 8.9 per cent. The relative composition of different sources of irrigation, given below, shows the predominant position of well irrigation, which is the least unstable source of irrigation, at present as well as in the early fifties.

| Net area under: | 1952-53 (000 ha) | 1987-88 (000 ha) |
|---|---|---|
| 1. canals | 237 | 1,079 |
| 2. tanks | 144 | 75 |
| 3. wells | 847 | 2,118 |
| 4. other sources | 45 | 44 |
| Total | 1,274 | 3,327 |

Leaving out data for 1950-52 (because of stickiness), the estimated regression equation for the period 1952-88 is as follows:

$$CI = \underset{(1.84)}{92.89} + \underset{(0.05)}{0.60}\,IRR + \underset{(0.003)}{0.009}\,RAINEAST + \underset{(0.003)}{0.002}\,RAINWEST \quad \ldots (11)$$

$R^2 = 0.8219 \quad n = 36$

where RAINEAST and RAINWEST stand for per cent deviation from normal rainfall of East (N = 698 mm) and West (N = 335 mm) Rajasthan. Figures in parenthesis are standard errors.

Each percentage point rise in irrigation ratio leads to about 0.60 percentage point rise in intensity of cropping which is well below the magnitude of 0.92 for this state predicted in Dhawan [1988]. The statistical insignificance of the coefficient of rainfall variable for West Rajasthan is unexpected for this arid state and is due to collinearity between the two rainfall variables. This becomes clear when we run the following regression equation in which rainfall (of West Rajasthan) emerges as significant variable.

$$CI = \underset{(1.43)}{97.29} + \underset{(0.06)}{0.55}\ IRR + \underset{(0.0027)}{0.0099}\ RAINWEST \quad \ldots (12)$$

$R^2 = 0.7623$

When we combine the two rainfall variables into a single one, by giving a weight of 0.6 to rainfall for East Rajasthan and 0.4 to rainfall for West Rajasthan, we obtain the following regression equation:

$$CI = \underset{(1.66)}{93.56} + \underset{(0.05)}{0.59}\ IRR + \underset{(0.002)}{0.011}\ RAIN \quad \ldots (13)$$

$R^2 = 0.8178 \quad n = 36$

$R^2$ of this equation is only slightly lower than that of equation (11).

When irrigation is distinguished into canal, well, and tank irrigation, we have, once again, a negative coefficient for tank irrigation though statistically it is insignificant (Eq. 8). Hence in Eq. 9, we have dropped the NTANK variable. That well irrigation has greater impact on intensity of cropping than canal irrigation is evident in both the equations.

$$CI = \underset{(2.54)}{94.50} + \underset{(0.34)}{0.47}\ NCANAL + \underset{(0.23)}{0.84}\ NWELL - \underset{(0.91)}{1.38}\ NTANK + \underset{(0.0031)}{0.0098}\ RAINEAST + \underset{(0.0039)}{0.0033}\ RAINWEST \quad \ldots (14)$$

$R^2 = 0.8028$

$$CI = \underset{(2.23)}{92.53} + \underset{(0.34)}{0.56}\ NCANAL + \underset{(0.23)}{0.91}\ NWELL + \underset{(0.0030)}{0.0092}\ RAINEAST + \underset{(0.0039)}{0.0019}\ RAINWEST \quad \ldots (15)$$

$R^2 = 0.7876$

The statistical insignificance of the coefficient of canal irrigation in equations (14) and (15) is due to high correlation between canals and wells ($r = 0.85$). If we use single, weighted rainfall variable, as in equation (13), the equations (14) and (15) acquire the following form:

$$CI = \underset{(2.25)}{95.18} + \underset{(0.33)}{0.49}\ NCANAL + \underset{(0.22)}{0.81}\ NWELL - \underset{(0.89)}{1.44}\ NTANK + \underset{(0.003)}{0.014}\ RAIN \quad \ldots (16)$$

$R^2 = 0.8005$

$$CI = \underset{(1.97)}{93.30} + \underset{(0.33)}{0.59}\ NCANAL + \underset{(0.23)}{0.86}\ NWELL + \underset{(0.002)}{0.012}\ RAIN \quad \ldots (17)$$

$R^2 = 0.7836$

*Punjab:*

The highest intensity of cropping is found in Punjab which also has the highest development of irrigation in India. Even in the drought year of 1987-88, cropping intensity was about 176 per cent on a net sown area of the order of 4 million ha, which has risen at the annual rate of 0.27 per cent between 1967-68 and 1987-88. (Time period covered is comparatively smaller as this state was formed in 1966). Cropping intensity improved from 136.3 to 176.2 per cent in this period, the rate of growth being 1.4 per cent per annum. At the same time, expansion in irrigation occurred at an impressive pace, with gross irrigated area increasing at the annual rate of 3.1 per cent to reach 6.72 million ha in 1987-88. As a result, net irrigated area as per cent of net sown area reached the high level of 91 per cent and gross irrigated area as per cent of net sown area was over 161 per cent. Bulk of the expansion was in well irrigation (3 per cent per annum as compared to 0.5 per cent in the case of canal irrigation), in which private tubewells played a pre-eminent role. This resulted in a major change in the irrigation composition of the state as shown below:

| Net area under: | 1967-68 (million ha) | 1987-88 (million ha) |
|---|---|---|
| 1. canals | 1.29 | 1.41 |
| 2. wells | 1.03 | 2.31 |
| 3. other sources | 0.01 | 0.05 |
| Total | 2.33 | 3.77 |

Intensity of cropping is strongly correlated with irrigation ratio, as can be seen from the following equation:

$$CI = \underset{(3.42)}{78.1} + \underset{(0.02)}{0.58\ IRR} + \underset{(0.003)}{0.003\ RAIN} \quad \ldots (18)$$

$R^2 = 0.9738 \quad n = 21$

RAIN is in mm; other variables are defined as before.

Each percentage point rise in irrigation ratio raises intensity of cropping by about 0.58 percentage point which is slightly less than 0.63 predicted by Dhawan [1988]. If we distinguish canals and well irrigation, the coefficient of canal irrigation turns out to be negative (Eq. 19). This is inexplicable. In any case, it cannot be ascribed to multicollinearity, because 'r' between NWELL and NCANAL is only 0.44. When canal variable is dropped, the coefficients of other variables, namely, NWELL and RAIN remain unchanged (Eq. 20). This dominance of well irrigation over canal irrigation is due to the preponderance of private tubewells in the state.

$$CI = \underset{(34.05)}{78.35} + \underset{(0.17)}{1.63\ NWELL} - \underset{(1.05)}{0.001\ NCANAL} + \underset{(0.08)}{0.006\ RAIN} \quad \ldots (19)$$

$R^2 = 0.8754$

$$CI = \underset{(7.69)}{78.32} + \underset{(0.15)}{1.63\ NWELL} + \underset{(0.07)}{0.006\ RAIN} \quad \ldots (20)$$

$R^2 = 0.8754$

*Haryana*:

As in Punjab, intensity of cropping is fairly high in this state. But here it is quite variable over time. Though it rose between 1967 and 1987 at an annual rate of 0.62 per cent per annum, it was accompanied by a coefficient of variation (CV) of fluctuations around trend line of 4.3 per cent, well above the corresponding CV of 1.1 per cent for Punjab. This suggests high susceptibility to weather variations. In 1987-88, a drought year, the index of cropping intensity was 145.1.

Between 1967 and 1987, irrigation expanded at an impressive rate of 4 per cent per annum, from a level of 1.8 million ha to 3.9 million ha (this is in gross irrigated terms). As a result, gross irrigated area as per cent of net sown area rose from 51 to 120 per cent (net irrigated as per cent net sown rising from 32 to 80). The composition of irrigation in the state changed in favour of well irrigation, area under which grew at 6.3 per cent per annum as compared to 1.7 per cent annual increase in canal irrigation. Bulk of the well irrigation is now from private tubewells, though some state tubewells provide direct as well as 'augmentation' irrigation (through augmentation of canal supplies).

| Net area under: | 1967-68 (million ha) | 1987-88 (million ha) |
|---|---|---|
| 1. canals | 0.889 | 1.220 |
| 2. wells | 0.226 | 1.355 |
| 3. other sources | 0.016 | 0.005 |
| Total | 1.132 | 2.579 |

Intensity of cropping is positively correlated with irrigation ratio and rainfall. The relationship is quadratic in rainfall which shows high fluctuations. Rainfall was 56 per cent below the state normal (714 mm) in 1968-69, 37 per cent below normal in 1974, 49 per cent below normal in 1979-80 and 47 per cent below normal in 1987-88. Likewise, it was above normal by 30 per cent in 1971-72, 32 per cent in 1975-76, and 48 per cent in 1983-84. In fact, the coefficient of variation of rainfall is 31 per cent (the highest value of rainfall was three times the lowest value). The regression equation is:

$$CI = \underset{(12.07)}{83.05} + \underset{(0.06)}{0.32\ IRR} + \underset{(0.0336)}{0.1008\ RAIN} - \underset{(0.00002)}{0.0001\ RAIN^2} \quad \ldots (21)$$

$R^2 = 0.7147 \quad n = 21$

RAIN is measured in mm; figures within parenthesis are standard errors.

Each percentage point increase in irrigation ratio enhances intensity of cropping by 0.32 percentage points, much below the predicted value of 0.72. Because of high collinearity between well irrigation and canal irrigation (r = 0.95), our attempt to assess the comparative impact of these two sources of irrigation is not very rewarding, as can be seen from the estimated equation given below. Therefore, relationship between irrigation and intensity of cropping for

this state (and also for Punjab) need further investigation with the help of cross sectional data on districts.

$$CI = 74.71 + 0.53\,NCANAL + 0.51\,NWELL + 0.1196\,RAIN - 0.0001\,RAIN^2, \quad \ldots (22)$$
(36.60) (1.37) (0.54) (0.00003)

$R^2 = 0.6174$

*Maharashtra*:

This state also has a large net sown area of about 18 million ha which has remained practically unchanged since 1960 when the state was formed. Irrigation coverage in the state continues to remain very low in spite of the fact that the rate of expansion in gross irrigated area between 1959-60 and 1987-88 has been quite impressive, namely, 3.3 per cent per annum. No wonder, then, the intensity of cropping is still very low, rising from 105.4 in 1959-60 to 114.5 in 1987-88 at the annual rate of 0.33 per cent. The different sources of irrigation have expanded at varying rates: 1.7 per cent per annum for tank irrigation, 2.5 per cent for canal irrigation, 2.6 per cent for well irrigation, and 4.9 per cent for 'other sources'. Well irrigation accounts for nearly six-tenths of the total irrigation, followed by canal irrigation, tank irrigation, and 'other sources', as shown below for 1987-88.

| | million ha |
|---|---|
| 1. Net canal area | 0.410 |
| 2. Net well area | 1.063 |
| 3. Net tank area | 0.281 |
| 4. Net area under other sources | 0.127 |
| Total | 1.881 |

Irrigation and intensity of cropping are well correlated during the period 1961-87 (r = 0.97). The estimated regression equation is as follows:

$$CI = 96.99 + 1.03\,IRR - 0.004\,RAIN\,MM + 0.030\,RAIN\,MW - 0.023\,RAIN\,VB, \quad \ldots (23)$$
(1.62) (0.14) (0.020) (0.023) (0.027)

$R^2 = 0.7966$ n = 27

where CI = intensity of cropping (%), IRR = modified irrigation ratio (%), RAINMM = departure from normal rainfall (713 mm) for Madhya Maharashtra Division (%), RAINMW = departure from normal rainfall (840 mm) for Marathawada region (%), RAINVB = departure from normal rainfall (1126 mm) for Vidarbha region (%).

The regression coefficient of IRR is 1.03 which is much more than 0.46 predicted by Dhawan [1988]. Because of the serious problem of multicollinearity among various types of irrigation sources, any attempt to work out separate irrigation effects for canals, tanks and wells fails, as can be seen from the equation (24). Replacing the three rainfall variables by one single variable as a simple mean of the three regions rainfall data does not bring out the significant role of rainfall - it only gives positive coefficient in the case of equation (23) as well as equation (24).

$$CI = 89.45 + 8.02\,NCANAL + 7.35\,NTANK - 1.24\,NWELL + 0.007\,RAINMM + 0.035\,RAINMW - 0.040\,RAINVB, \quad \ldots (24)$$
(3.21) (5.01) (5.52) (1.31) (0.022) (0.024) (0.028)

$R^2 = 0.8073$ n = 27

The matrix of correlation is an follows:

| | CI | NCANAL | NTANK | NWELL |
|---|---|---|---|---|
| CI | 1.00 | 0.87 | 0.87 | 0.82 |
| NCANAL | | 1.00 | 0.95 | 0.97 |
| NTANK | | | 1.00 | 0.92 |
| NWELL | | | | 1.00 |

*Tamil Nadu*:

There has been hardly any improvement in intensity of cropping on about 6 million ha of net sown area in this state; it was 114.8 per cent in 1950-51 and 116.4 per cent in 1987-88. This is not surprising because expansion in irrigation as such occurred at a slow and unsteady rate of 0.65 per cent per annum. As a result of this slow progress, the irrigation ratio rose from 36 per cent in 1950-51 to 51 per cent in 1987-88. However, the composition of irrigation sources changed significantly over time. Tank irrigation declined at the rate of 0.43 per cent annually, and well irrigation rose at the annual rate of 2.7 per cent

per annum, whereas canal irrigation remained almost unchanged. The relative shares of different sources of irrigation changed as follows:

| % share of: | 1950-51 | 1987-88 |
|---|---|---|
| 1. Net canal area | 43 | 30 |
| 2. Net tank area | 30 | 25 |
| 3. Net well area | 24 | 44 |
| 4. Other sources | 3 | 1 |
| All sources | 100 | 100 |

The decline in the area under tank irrigation would be still greater if we left out three initial years, 1950-51 to 1952-53 when tank area was reported to be low. In the analysis that follows, these three years are left out.

The multiple regression equation is as follows:

$$CI = \underset{(3.38)}{98.77} + \underset{(0.07)}{0.32}\,IRR + \underset{(0.0018)}{0.0039}\,RAIN \quad \ldots (25)$$

$R^2 = 0.5704$ $n = 35$

RAIN is measured in mm; other variables are as before.

Both rainfall and irrigation are significantly related to intensity of cropping, the regression coefficients for irrigation being 0.32 which is a little above 0.29 the value predicted by Dhawan [1988]. Surprisingly, if we substitute IRR (ratio of gross irrigated to net sown area) by the ratio net irrigated to net sown area, the regression coefficient turns out to be smaller, the irrigation impact value, based on conventional irrigation ratio, is lower, namely, 0.25; and $R^2 = 0.4019$. If we distinguish sources of irrigation, we get the puzzling result that tank irrigation has the maximal impact on intensity of cropping and well irrigation has the minimal impact. This can be seen from the following equation:

$$CI = \underset{(5.08)}{93.70} + \underset{(0.25)}{0.46}\,NCANAL + \underset{(0.25)}{1.04}\,NTANK + \underset{(0.12)}{0.39}\,NWELL + \underset{(0.022)}{0.021}\,RAINDEP, \quad \ldots (26)$$

$R^2 = 0.6238$ $n = 35$

RAINDEP is per cent departure from a normal value of 1018 mm.

For once, underlying the above results is not multicollinearity, as can be seen from the following matrix of correlation:

| | CI | NCANAL | NTANK | NWELL |
|---|---|---|---|---|
| CI | 1.00 | 0.30 | 0.44 | 0.09 |
| NCANAL | | 1.00 | (-)0.11 | 0.27 |
| NTANK | | | 1.00 | (-)0.75 |
| NWELL | | | | 1.00 |

*Gujarat*:

Intensity of cropping on a net sown area of about 10 million ha remains low, though some perceptible rise is noticeable between 1959-60 and 1987-88, a period marked by too many droughts. It was about 110 per cent in 1987-88 as compared to about 106 per cent in 1959-60. In the same period, gross irrigated area rose from 0.7 million ha to about 2.4 million ha, which is at an annual growth rate of nearly 5 per cent, and the irrigation ratio rose from 7 to 25 per cent of net sown area. Well irrigation, mainly from open wells and dug-cum-bore wells, predominates. Barring 'other sources', all types of irrigation expanded during the period under reference, the expansion being fastest in canal irrigation (6.6 per cent per annum), followed by wells (4.7 per cent) and tank irrigation (2.2 per cent) - the expansion in tank irrigation was beset with ample fluctuations around the trend lind (CV = 22 per cent). The composition of irrigation sources changed over time as follows:

| Net area under: | 1959-60 (000 ha) | 1987-88 (000 ha) |
|---|---|---|
| 1. canals | 66 (11) | 359 (18) |
| 2. tanks | 21 (3) | 25 (1) |
| 3. wells | 514 (83) | 1,653 (81) |
| 4. other sources | 20 (3) | 2 (neg) |
| Total | 620 (100) | 2,039 (100) |

Figures in brackets are per cent shares.

The fit of the regression equation is far from good, though the positive impact of irrigation does emerge, as can be seen from the following equation:

$$CI = \underset{(1.27)}{104.43} + \underset{(0.07)}{0.17}\,IRR - \underset{(0.018)}{0.007}\,RAINGUJ + \underset{(0.016)}{0.022}\,RAINSAURSH \quad \ldots (27)$$

$R^2 = 0.3175$ $n = 29$

where RAINGUJ = deviation from normal rainfall (846 mm) for Gujarat region (%); RAINSAURSH = deviation from normal rainfall (609 mm) for Saurashtra and Kutch regions. Figures in parenthesis are standard errors.

The regression coefficient of irrigation is 0.17 which is much less than the value of 0.54 predicted by Dhawan [1988]. It slightly improves to 0.20 when the two rainfall variables are averaged into one. But $R^2$, already small, becomes smaller still.

$$CI = \underset{(1.84)}{102.14} + \underset{(0.06)}{0.20}\ IRR + \underset{(0.0018)}{0.0024}\ RAIN, \quad \ldots (28)$$

$R^2 = 0.2890$

If we distinguish sources of irrigation, the results are distorted, mainly because of high collinearity (r = 0.98) between wells and canals:

$$CI = \underset{(2.43)}{100.86} - \underset{(1.62)}{4.21}\ NCANAL - \underset{(6.59)}{4.77}\ NTANK + \underset{(0.46)}{1.60}\ NWELL + \underset{(0.017)}{0.011}\ RAINGUJ + \underset{(0.014)}{0.019}\ RAINSAURSH, \quad \ldots (29)$$

$R^2 = 0.5515$ n = 29

Even when we use average rainfall variable, the main problem remains, though the coefficient of rainfall becomes significant:

$$CI = \underset{(2.41)}{97.14} + \underset{(0.0015)}{0.0043}\ RAIN - \underset{(1.49)}{4.45}\ NCANAL - \underset{(6.09)}{3.07}\ NTANK + \underset{(0.42)}{1.67}\ NWELL, \quad \ldots (30)$$

$R^2 = 0.5483$

The correlation matrix is as follows:

| | CI | NCANAL | NTANK | NWELL | RAIN |
|---|---|---|---|---|---|
| CI | 1.00 | 0.45 | 0.27 | 0.53 | 0.12 |
| NCANAL | | 1.00 | 0.71 | 0.98 | (-) 0.15 |
| NTANK | | | 1.00 | 0.67 | 0.05 |
| NWELL | | | | 1.00 | (-) 0.22 |
| RAIN | | | | | 1.00 |

*Madhya Pradesh:*

Because of low irrigation development, the intensity of cropping on state's huge net sown area of about 19 million ha is rather low, namely, 118 per cent. It is one state where net sown area has risen steadily over time, rising from about 14.5 million ha in 1952 at the annual rate of 0.8 per cent. But the expansion in gross cropped area occurred at a rate of about 1 per cent per annum, leading to a rise in intensity of cropping from 111.1 per cent in 1952 to 117.5 per cent in 1987-88. This was mainly because of expansion in irrigation at the rate of 4.6 per cent per annum, whereby the irrigation ratio improved from about 6 to 18 per cent in the 36-years period under reference. Over time, while tank irrigation shows large year-to-year fluctuations (CV = 20 per cent) without any definite uptrend, both well and canal irrigation expanded, the former at about 5.4 per cent annually and the latter at 4.3 per cent per annum; other sources, which are minor of importance, increased from 35 thousand ha in 1952-53 to about 335 thousand ha in 1987-88. The composition of irrigation sources in 1987-88 was as follows:

| | net area | |
|---|---|---|
| | (000 ha) | % share |
| canals | 1,368 | 41 |
| wells | 1,476 | 44 |
| tanks | 152 | 5 |
| other sources | 335 | 10 |
| Total | 3,331 | 100 |

Regressing intensity of cropping on irrigation ratio and rainfall, we obtain the following equation:

$$CI = \underset{(1.59)}{100.05} + \underset{(0.06)}{0.55}\ IRR + \underset{(0.002)}{0.002}\ RAINEAST + \underset{(0.002)}{0.005}\ RAINWEST, \quad \ldots (31)$$

$R^2 = 0.7792$ n = 36

where IRR is irrigation ratio (%), RAINEAST is deviation from normal rainfall (1328 mm) of East M.P. Division (%), and RAINWEST is deviation from normal rainfall (1038 mm) of West M.P. Division (%).

The irrigation impact, as also the rainfall impact, on intensity of cropping is positive. The statistical insignificance of rainfall coefficient of EAST MP is due to collinearity with WEST MP rainfall. Averaging the two rainfalls of the two divisions, we obtain the following equation:

$$CI = \underset{(1.57)}{100.01} + \underset{(0.06)}{0.55}\ IRR + \underset{(0.0012)}{0.0068}\ RAIN, \quad \ldots (32)$$

$R^2 = 0.7761$

The regression coefficient of IRR is 0.55 which is somewhat higher than 0.42 predicted by Dhawan [1988].

Distinguishing types of irrigation is not quite rewarding, mainly because of high multicollinearity between canal and well irrigation (r=0.99). The estimated regressions are:

$$CI = \underset{(2.50)}{102.77} + \underset{(1.04)}{0.45}\ NCANAL + \underset{(0.89)}{0.81}\ NWELL - \underset{(1.34)}{1.61}\ NTANK + \underset{0.002)}{0.002}\ RAINEAST + \underset{(0.002)}{0.004}\ RAINWEST, \quad ... (33)$$

$R^2 = 0.8045$

$$CI = \underset{(2.48)}{102.86} + \underset{(1.01)}{0.27}\ NCANAL + \underset{(0.85)}{0.96}\ NWELL + \underset{(1.33)}{1.59}\ NTANK + \underset{(0.0013)}{0.0061}\ RAIN, \quad ... (34)$$

$R^2 = 0.8011$

*Karnataka:*

Because of low rainfall and low level of irrigation development, the intensity of cropping on the state's net sown area of about 11 million ha is low. It was 103 per cent in 1950-51, and rose to 114 per cent in 1987-88. During this period, the gross irrigated area increased from 0.6 to 2.3 million ha, the annual rate of increase being about 3.5 per cent. As a result, the irrigation ratio rose from about 7 per cent in 1952-53 to over 15 per cent in 1987-88. While tank irrigation tended to decline, both canal and well irrigation increased at about 5 per cent and 4.7 per cent per annum respectively between 1952-53 and 1987-88. The composition of irrigation in 1952-53 and 1987-88 is shown below:

| Net area under: | 1952-53 (000 ha) | 1987-88 (000 ha) |
|---|---|---|
| 1. canals | 140 (23) | 765 (41) |
| 2. tanks | 282 (46) | 258 (14) |
| 3. wells | 137 (22) | 576 (31) |
| 4. other sources | 52 (7) | 254 (14) |
| Total | 610 (100) | 1,853 (100) |

In the absence of rainfall statistics for the years 1952-53 to 1956-57, the regression results pertain to the period 1957-58 to 1987-88. The main estimated equation is as follows:

$$CI = \underset{(2.49)}{97.10} + \underset{(0.10)}{0.71}\ IRR - \underset{(0.002)}{0.002}\ RAINNORTH + \underset{(0.001)}{0.001}\ RAINSOUTH, \quad ... (35)$$

$R^2 = 0.7848 \qquad n = 31$

where RAINNORTH and RAINSOUTH are per cent departures from normal rainfall of North Karnataka plains (878 mm) and South Karnataka plains (801 mm), respectively. Figures in parenthesis are standard errors.

The regression coefficient of IRR (0.71) is much above 0.21, the value predicted by Dhawan [1988]. Because of multicollinearity, especially between canal and well irrigation (r = 0.95), the regression attempt to assess the impact of different sources of irrigation proves futile:

$$CI = \underset{(4.66)}{100.31} + \underset{(0.56)}{1.80}\ NCANAL - \underset{(1.06)}{0.99}\ NTANK - \underset{(0.67)}{0.36}\ NWELL + \underset{(0.002)}{0.001}\ RAINNORTH + \underset{(0.001)}{0.002}\ RAINSOUTH \quad ... (36)$$

$R^2 = 0.7911$

The regression coefficient of tank irrigation is statistically not significant. Hence, if we drop it and retain either canal or well irrigation we get the following results:

$$CI = \underset{(2.52)}{96.93} + \underset{(0.24)}{1.77}\ NCANAL - \underset{(0.002)}{0.0001}\ RAINNORTH + \underset{(0.001)}{0.002}\ RAINSOUTH \quad ... (37)$$

$R^2 = 0.7825$

$$CI = \underset{(2.73)}{101.68} + \underset{(0.37)}{1.92}\ NWELL - \underset{(0.002)}{0.001}\ RAINNORTH + \underset{(0.001)}{0.0005}\ RAINSOUTH \quad ... (38)$$

$R^2 = 0.6696$

It will be seen that the regression coefficients of both canal and well irrigation are very high but probably these are overestimated

*Andhra Pradesh*:

Intensity of cropping on a net sown area of about 10 million ha was 109.15 per cent in 1952-53 and 116.59 per cent in 1987-88. This rise may be linked to the expansion in irrigation in the period 1952-87. The gross irrigated area increased at the annual rate of 1.58 per cent from 2.49 million ha in 1952-53 to 4.30 million ha, thereby enhancing the irrigation ratio from 22 to 41 per cent. While canal and well irrigation expanded at 1.31 and 4.05 per cent per annum, respectively, tank irrigation tended to decline. As a result, the composition of irrigation changed as follows:

| Net area under: | 1952-53 (million ha) | 1987-88 (million ha) |
|---|---|---|
| 1. canals | 1.204 (52) | 1.593 (47) |
| 2. tanks | 0.742 (32) | 0.663 (20) |
| 3. wells | 0.283 (12) | 0.991 (29) |
| 4. other sources | 0.063 (4) | 0.122 (4) |
| Total | 2.292 (100) | 3.369 (100) |

As rainfall data for three regions of Andhra Pradesh are available for the period 1957-87, the regression analysis is presented for this period. The estimated regression equation is as follows:

$$CI = \underset{(3.77)}{103.42} + \underset{(0.09)}{0.43}\,IRR - \underset{(0.003)}{0.003}\,RAINCOAST - \underset{(0.002)}{0.004}\,RAINTELENG + \underset{(0.0032)}{0.0004}\,RAINRAYALSEEMA, \quad \ldots (39)$$

$R^2 = 0.5692 \quad n = 31$

where RAINCOAST = deviation from normal rainfall (977 mm) of Coastal Andhra Region (%), RAINTELENG = deviation from normal rainfall (994 mm) of Telengana Region (%), and RAINRAYALSEEMA = deviation from normal rainfall (740 mm) for Rayalaseema Region (%).

The regression coefficients of rainfall variables are small and statistically not significant. The coefficient of IRR is 0.43 which is somewhat above 0.31, the value predicted by Dhawan [1988]. Attempt to assess impact of different sorceress of irrigation fails, mainly because of high correlation between canals and wells (r = 0.93) as can be seen from the following equation.

$$CI = \underset{(5.36)}{114.12} + \underset{(0.40)}{0.36}\,NCANAL - \underset{(0.33)}{0.51}\,NTANK + \underset{(0.52)}{0.18}\,NWELL - \underset{(0.003)}{0.003}\,RAINCOAST - \underset{(0.003)}{0.0001}\,RAINTELENG + \underset{(0.003)}{0.002}\,RAINRAYALSEEMA \quad \ldots (40)$$

$R^2 = 0.5825 \quad n = 31$

*Other States*:

Similar analysis of data for four states of Bihar, Orissa, West Bengal, and Kerala was rather unrewarding, presumably because of infirmities in the basic data. Our findings on these four states, whatever little worth these have, are briefly reported below.

*Orissa*:

Gross irrigated area of the state of Orissa has expanded between 1950-51 and 1987-88 at the annual rate of about 2.2 per cent, doubling from a level of about one million ha in 1950-51 to about 2 million ha by 1987-88. Though the fit of the semi-logarithmic trend is quite good ($R^2$=0.83), there is stickiness in the data, that is, the same figure for gross irrigated area appears for two or more successive years. For instance, it is 1.128 million ha for the entire sub-period 1955-60, 1.142 million ha for 1960-67, and 2.006 million ha for 1982-85. The same is true of other data. For example, net sown area remains 5.542 million ha during the sub-period 1954-60, and 6.130 ha during 1980-83.

While intensity of cropping and irrigation ratio are highly correlated (r = 0.8; and 0.6 if ratio of net irrigated area to net sown area is used), the estimated regression equation, given below for the period 1950-51 to 1985-86, gives questionable magnitudes for the intercept term and for the regression coefficient;

$$CI = \underset{(6.20)}{77.00} + \underset{(0.27)}{2.08}\,IRR, \quad \ldots (41)$$

$R^2 = 0.63 \quad n = 36$

The regression coefficient of IRR (2.08) is altogether too high compared to 0.13 predicted by Dhawan [1988]. As the regression coefficient is overestimated, the intercept term is correspondingly under-estimated (due to tilt in the regression line), falling below 100 that is the irreducible minimum level of intensity of cropping under wholly unirrigated conditions. While, the intercept term is restored to a credible level of 103.69 in the following multiple regression equation, the regression coefficient of canal irrigation remains still very high (1.84) and the coefficient of well irrigation though high (1.94) is statistically not significant:

$$CI = \underset{(8.55)}{103.69} + \underset{(0.67)}{1.84}\ NCANAL + \underset{(1.40)}{1.94}\ NWELL + \underset{(0.91)}{0.45}\ NTANK \quad \ldots (42)$$

$R^2 = 0.62 \qquad n = 36$

*West Bengal*:

The results of the simple regression for the period 1950-51 to 1985-86 are similar; intercept term is again well below 100, and the regression coefficient of irrigation ratio is above two. This is clear from the following equation:

$$CI = \underset{(8.69)}{66.59} + \underset{(0.31)}{2.18}\ IRR, \quad \ldots (43)$$

$R^2 = 0.59 \quad n = 36$

The regression coefficient of IRR is very high (2.18) compared to 0.26 predicted by Dhawan [1988]. Infirmities of data, especially its stickiness over time, are possibly responsible.[2] Though the intensity of cropping in the state has risen from 113 per cent in 1950-51 to nearly 157 per cent in 1987-88 (rising at the annual rate of almost one per cent per annum), the rise is jumpy at times precisely when irrigation ratio happens to be sticky. It is particularly stationary throughout the sixties and the seventies; in 1982-83 there is a jump, which is more marked in well irrigation (from 0.017 million ha, between 1964-65 and 1981-82, to 0.712 million ha right upto 1987-88). That is why we have made no attempt to assess the impact of different sources of irrigation.

*Bihar*:

From the statistical viewpoint, regression results for this state are poor. To begin with, the net sown area has tended to drift downwards during the period under study, though the decline is statistically not significant. On the other hand, gross cropped area has shown some upward trend though again not statistically significant. As a result of these two contrary tendencies, we find some rise in the level of intensity of cropping from 122 per cent in 1950-51 to 138 per cent in 1987-88 with large year-to-year fluctuations; e.g. 135 per cent in 1981-82, 116 per cent in 1982-83 and 135 per cent in 1983-84. In comparison, irrigation expanded at a much higher pace. The gross irrigated area rose at the annual rate of 2.54 per cent - increasing from 2.2 million ha in 1950-51 to 4.1 million ha in 1987-88. At the same time, the irrigation coverage, as measured by gross irrigated area as per cent of net sown area, improved from 25 to over 54 per cent. Whereas well irrigation expanded at the rate of nearly 5.95 per cent per annum, canal irrigation increased at 2.07 per cent per annum. But tank irrigation shrank substantially at the rate of 4 per cent per annum. There is no stickiness or jumps in data. Yet the results are of doubtful value.

Regressing intensity of cropping on irrigation ratio, one gets a low fit - the fitness is somewhat better if the conventional measure of irrigation ratio is used, as shown below:

$$CI = \underset{(2.81)}{125.90} + \underset{(0.08)}{0.15}\ IRR, \quad \ldots (44)$$

$R^2 = 0.09$

$$CI = \underset{(3.82)}{120.40} + \underset{(0.14)}{0.38}\ IRR\ (conventional), \quad \ldots (45)$$

$R^2 = 0.19 \qquad n = 36$

In equation (44), regression coefficient of IRR is 0.15 and is much below 0.53 as predicted by Dhawan [1988]. Distinguishing sources of irrigation does not help; $R^2$ still remains low (0.27)

and largest regression coefficient is for tank irrigation (2.53, an incredible value), as per the following equation:

$$CI = \underset{(6.27)}{116.20} + \underset{(0.74)}{0.34}\,NCANAL + \underset{(0.44)}{0.75}\,NWELL + \underset{(0.93)}{2.53}\,NTANK, \quad \ldots (46)$$

$R^2 = 0.27 \qquad n = 36$

Bringing in the rainfall variable does not improve the regression materially. For the period 1951-52 to 1987-88 (1950-51 excluded), the regression results are as follows:

$$CI = \underset{(4.43)}{117.53} + \underset{(0.07)}{0.10}\,IRR + \underset{(0.004)}{0.001}\,RAINPLATEAU + \underset{(0.004)}{0.008}\,RAINPLAINS, \quad \ldots (47)$$

$R^2 = 0.28 \qquad n = 37$

$$CI = \underset{(5.49)}{105.32} + \underset{(5.57)}{0.39}\,NCANAL + \underset{(0.36)}{0.77}\,NWELL + \underset{(0.82)}{3.43}\,NTANK + \underset{(0.003)}{0.004}\,RAINNORTH + \underset{(0.004)}{0.003}\,RAINSOUTH \quad \ldots (48)$$

$R^2 = 0.5409 \qquad n = 37$

*Kerala*:

Regression results for this state are of little worth, mainly because of one major infirmity in the irrigation data. This infirmity arises because of sharp downward revision in irrigated area statistics from 1975-76 onwards, as revealed by the following data.

| | 1974-75 (000 ha) | 1975-76 (000 ha) | 1987-88 (000 ha) |
|---|---|---|---|
| 1. gross irrigated area | 652 | 327 | 393 |
| 2. net canal irrigated area | 238 | 86 | 107 |
| 3. net area under tanks | 76 | 58 | 45 |
| 4. net area under wells | 6 | 0 | 6 |
| 5. net area under other sources | 145 | 31 | 142 |
| 6. net area under all sources | 465 | 228 | 439 |

It is noteworthy that the downward revision was so drastic that the pre-1975-76 level of irrigated area was not regained even by 1987-88. With such a massive kink in data, it is no wonder that no relation emerges between irrigation and intensity of cropping; the latter does show an upward rise. The simple regression equation, based on data for 1952-53 to 1985-86, is as follows:

$$CI = \underset{(5.98)}{134.73} - \underset{(0.25)}{0.29}\,IRR, \quad \ldots (49)$$

$R^2 = 0.04 \qquad n = 34$

## VI. SUMMARY AND CONCLUSIONS

Defining irrigation variable as a ratio of gross irrigated area to net sown area and without making any modification in the conventional measure of intensity of cropping, our multiple regression analysis reveals definite evidence of the close relationship between irrigation development and the rise in intensity of cropping at all-India level. The regression analysis across 14 states for the pooled data for the period 1983-84 to 1987-88 throws up a value of the impact of irrigation on intensity of cropping, namely, 0.46, that is very near the predicted value of 0.48. But the time series analysis for the period 1950-51 to 1987-88 reveals a higher impact value of irrigation, namely, 0.65 percentage points. It is believed that these estimates of the irrigation impact, based on time series data, are inherently biased upwards because of the omission of variables like tractorisation from the regression model. The all-India estimate based on cross-sectional analysis is most probably nearer the true value.

Pooled cross sectional analysis for different periods over 35 years time span of 1953-54 to 1987-88 does not sustain the thesis of decline in the all-India impact of irrigation on intensity of cropping over time. In fact, weak signs of improvement in this impact are discernible. Another noteworthy finding is that there is no definite pattern in the impact by type of irrigation. In fact, quite often results in this regard lack meaningfulness and credibility. It is more meaningful to analyse intensity of cropping by bringing in seasonal orientation of irrigation (via K-factor) than through types of irrigation.

Perhaps the salient finding of the statewise analysis is the large variation in the level of irrigation impact on intensity of cropping across the Indian states. For each percentage point rise in the irrigation ratio - defined as the ratio of gross irrigated area to net sown area but expressed in

per cent terms - the resultant increase in intensity of cropping (again expressed as ratio of gross cropped area to net sown area in percentage terms) can be as high as 1.03 percentage points (Maharashtra) and as low as 0.17 percentage points (Gujarat). The statewise levels of the impact (excluding the last four states) are recapitulated below by the level of impact.

| Range of Impact | States |
|---|---|
| 1. Low (below 0.45 points) | 1. Gujarat (0.17) |
| | 2. Haryana (0.32) |
| | 3. Tamil Nadu (0.32) |
| | 4. Andhra Pradesh (0.43) |
| 2. Average (0.46 - 0.66 points) | 1. U.P. (0.46) |
| | 2. Rajasthan (0.59) |
| | 3. M.P. (0.55) |
| | 4. Punjab (0.58) |
| 3. High (above 0.66 points) | 1. Karnataka (0.71) |
| | 2. Maharashtra (1.03) |

The impact has turned out to be low (i.e., below the all-India level which is in the range 0.46 - 0.66) in Gujarat, Haryana, and Tamil Nadu, all three belonging to three different regions of the country. In four states of U.P., Punjab, Rajasthan and M.P. (wheat belt?) the impact is of an average level. Only Maharashtra and Karnataka, both in the Deccan plateau, show above all-India impact of irrigation.

Another noteworthy finding is that there is no definite pattern in the impact by source of irrigation. In fact, quite often results in this regard lack meaningfulness and credibility, a point that emerged also at the all-India level. As suggested there, it is more meaningful to analyse intensity of cropping by bringing in seasonal orientation of irrigation (via K-factor) than through sources of irrigation.

A matter deserving attention of the scholars is to pay due heed to the basic weaknesses of our data base. Methodologies should be improved, especially to cope with such weaknesses. Finally, the statewise results need cross checking with similar results based on cross sectional research work. This may throw some light on why the estimates of the irrigation impact deviate, for some states, from the magnitudes predicted in Dhawan [1988].

NOTES

1. In view of the high correlation between NCANAL and NWELL and also their high and equal correlation with CI, we could have combined NCANAL and NWELL and reworked the regression without dropping NTANK.

2. This is one singular state where the irrigation impact, assessed through the use of ratio of net irrigated to net sown area is somewhat lower (2.05) than one resulting from the use of ratio of gross irrigated to net sown area (2.18).

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ABBREVIATIONS

| | |
|---|---|
| 1. NSA | Net Sown Area |
| 2. GSA | Gross Sown Area |
| 3. CROP INT | Intensity of Cropping |
| 4. GCA | Gross Cropped Area |
| 5. NIA | Net Irrigated Area |
| 6. GIA | Gross Irrigated Area |
| 7. IRR | Irrigation Ratio GIA/NSA.100 |
| 8. TC | Total (govt.+private) Canal Irrigated Area |
| 9. TA | Tank Irrigated Area |
| 10. W | Well irrigated area |
| 11. OS | Irrigated area under other sources |
| 12. TS | Total irrigated area from all sources (i.e. NIA) |
| 14. ASMO | Area Sown more than once |
| 15. IRA | GIA/NSA.100 |
| 16. IRB | NIA/NSA.100 |
| 17. IRG | TC/NIA.100 |
| 18. IRH | TA/NIA.100 |
| 19. IRI | W/NIA.100 |

Area in million ha.

A1. ALL INDIA LAND UTILISATION STATISTICS

| AGRI YEAR | N.S.A. | G.S.A. | CROP INT | NIA | GIA | IRR |
|---|---|---|---|---|---|---|
| 50-51 | 118.75 | 131.89 | 111.0652 | 20.85 | 22.56 | 18.99789 |
| 51-52 | 119.40 | 133.23 | 111.5829 | 21.05 | 23.18 | 19.41373 |
| 52-53 | 123.44 | 137.68 | 111.5359 | 21.12 | 23.30 | 18.87556 |
| 53-54 | 126.81 | 142.48 | 112.3570 | 21.87 | 24.36 | 19.20984 |
| 54-55 | 127.85 | 144.09 | 112.7023 | 22.09 | 24.95 | 19.51505 |
| 55-56 | 129.16 | 147.31 | 114.0523 | 22.76 | 25.64 | 19.85134 |
| 56-57 | 130.85 | 149.49 | 114.2453 | 22.53 | 25.71 | 19.64845 |
| 57-58 | 129.08 | 145.83 | 112.9764 | 23.16 | 26.63 | 20.63061 |
| 58-59 | 131.83 | 151.63 | 115.0193 | 23.40 | 26.95 | 20.44299 |
| 59-60 | 132.94 | 152.82 | 114.9541 | 24.04 | 27.45 | 20.64841 |
| 60-61 | 133.20 | 152.77 | 114.6921 | 24.66 | 27.98 | 21.00600 |
| 61-62 | 135.40 | 156.21 | 115.3692 | 24.88 | 28.46 | 21.01920 |
| 62-63 | 136.34 | 156.76 | 114.9772 | 25.66 | 29.45 | 21.60041 |
| 63-64 | 136.48 | 156.96 | 115.0058 | 25.89 | 29.71 | 21.76875 |
| 64-65 | 138.12 | 159.23 | 115.2838 | 26.60 | 30.70 | 22.22704 |
| 65-66 | 136.20 | 155.28 | 114.0088 | 26.34 | 30.90 | 22.68722 |
| 66-67 | 137.23 | 157.35 | 114.6615 | 26.91 | 32.68 | 23.81403 |
| 67-68 | 139.88 | 163.74 | 117.0574 | 27.19 | 33.21 | 23.74177 |
| 68-69 | 137.31 | 159.53 | 116.1823 | 29.01 | 35.48 | 25.83934 |
| 69-70 | 138.77 | 162.26 | 116.9272 | 30.20 | 36.97 | 26.64120 |
| 70-71 | 140.78 | 165.79 | 117.7653 | 31.10 | 38.19 | 27.12743 |
| 71-72 | 140.04 | 165.19 | 117.9591 | 31.55 | 38.43 | 27.44215 |
| 72-73 | 137.57 | 162.15 | 117.8672 | 31.83 | 39.06 | 28.39281 |
| 73-74 | 143.06 | 169.87 | 118.7403 | 32.55 | 40.28 | 28.15601 |
| 74-75 | 137.74 | 164.19 | 119.2028 | 33.71 | 41.74 | 30.30347 |
| 75-76 | 141.57 | 171.30 | 121.0002 | 34.59 | 43.38 | 30.64208 |
| 76-77 | 139.46 | 167.34 | 119.9913 | 35.15 | 43.55 | 31.22759 |
| 77-78 | 141.91 | 172.26 | 121.3867 | 36.55 | 46.03 | 32.43605 |
| 78-79 | 142.98 | 174.80 | 122.2548 | 38.06 | 48.31 | 33.78794 |
| 79-80 | 138.93 | 169.58 | 122.0614 | 38.52 | 49.21 | 35.42071 |
| 80-81 | 140.29 | 173.09 | 123.3801 | 38.81 | 49.87 | 35.54779 |
| 81-82 | 142.00 | 177.05 | 124.6830 | 39.92 | 51.55 | 36.30281 |
| 82-83 | 140.79 | 173.39 | 123.1550 | 40.72 | 52.12 | 37.01967 |
| 83-84 | 142.74 | 180.36 | 126.3556 | 41.96 | 53.94 | 37.78898 |
| 84-85 | 140.90 | 176.42 | 125.2093 | 41.72 | 54.67 | 38.80056 |
| 85-86 | 140.92 | 178.83 | 126.9017 | 42.00 | 54.65 | 38.78086 |
| 86-87 | 140.15 | 176.92 | 126.2361 | 43.10 | 55.64 | 39.70032 |

A2. ALL INDIA STATISTICS OF IRRIGATION

| AGRI YEAR | X1 | X2 | X3 | X4 | X5 | X6 | X7 |
|---|---|---|---|---|---|---|---|
| 50-51 | 7.16 | 1.14 | 8.30 | 3.61 | 5.98 | 2.97 | 20.85 |
| 51-52 | 7.49 | 1.19 | 8.68 | 3.49 | 6.52 | 2.36 | 21.05 |
| 52-53 | 7.51 | 1.35 | 8.86 | 3.30 | 6.52 | 2.44 | 21.12 |
| 53-54 | 7.55 | 1.31 | 8.86 | 4.23 | 6.69 | 2.10 | 21.87 |
| 54-55 | 7.83 | 1.24 | 9.07 | 4.03 | 6.83 | 2.27 | 22.19 |
| 55-56 | 8.03 | 1.36 | 9.39 | 4.42 | 6.74 | 2.21 | 22.76 |
| 56-57 | 7.92 | 1.36 | 9.27 | 4.49 | 6.57 | 2.20 | 22.53 |
| 57-58 | 8.30 | 1.35 | 9.65 | 4.54 | 6.82 | 2.15 | 23.16 |
| 58-59 | 8.39 | 1.28 | 9.67 | 4.76 | 6.69 | 2.29 | 23.40 |
| 59-60 | 8.75 | 1.31 | 10.06 | 4.65 | 7.08 | 2.21 | 24.00 |
| 60-61 | 9.10 | 1.23 | 10.32 | 4.57 | 7.30 | 2.44 | 24.62 |
| 61-62 | 9.34 | 1.16 | 10.50 | 4.61 | 7.09 | 2.42 | 24.63 |
| 62-63 | 9.69 | 1.15 | 10.83 | 4.78 | 6.75 | 2.40 | 24.76 |
| 63-64 | 9.86 | 1.16 | 11.02 | 4.60 | 6.76 | 2.48 | 24.86 |
| 64-65 | 10.08 | 1.14 | 11.22 | 4.78 | 6.99 | 2.52 | 25.51 |
| 65-66 | 9.86 | 1.10 | 10.96 | 4.26 | 8.65 | 2.48 | 26.34 |
| 66-67 | 10.22 | 1.03 | 11.25 | 4.42 | 9.20 | 2.04 | 26.91 |
| 67-68 | 10.30 | 0.95 | 11.24 | 4.49 | 9.11 | 2.35 | 27.19 |
| 68-69 | 10.99 | 0.91 | 11.89 | 3.93 | 10.80 | 2.39 | 29.01 |
| 69-70 | 11.72 | 0.88 | 12.61 | 4.06 | 11.18 | 2.36 | 30.20 |
| 70-71 | 11.97 | 0.89 | 12.86 | 4.11 | 11.89 | 2,27 | 31.12 |
| 71-72 | 12.25 | 0.87 | 13,12 | 3.73 | 12.28 | 2.42 | 31.55 |
| 72-73 | 12.13 | 0.86 | 13.00 | 3.62 | 12.96 | 2.26 | 31.83 |
| 73-74 | 12.20 | 0.87 | 13.07 | 3.90 | 13.28 | 2.30 | 32.54 |
| 74-75 | 12.66 | 0.86 | 13.53 | 3.55 | 14.21 | 2.42 | 33.71 |
| 75-76 | 12.90 | 0.90 | 13.80 | 4.00 | 14.40 | 2.40 | 34.60 |
| 76-77 | 13.00 | 0.80 | 13.80 | 3.90 | 15.10 | 2.30 | 35.10 |
| 77-78 | 13.70 | 0.80 | 14.50 | 3.90 | 15.60 | 2.50 | 36.50 |
| 78-79 | 14.30 | 0.80 | 15.10 | 3.90 | 16.50 | 2.60 | 38.10 |
| 79-80 | 13.90 | 0.80 | 14.70 | 3.50 | 17.80 | 2.40 | 38.40 |
| 80-81 | 14.50 | 0.80 | 15.30 | 3.20 | 17.70 | 2.60 | 38.80 |
| 81-82 | 14.70 | 0.80 | 15.50 | 3.50 | 18.10 | 2.60 | 39.70 |
| 82-83 | 14.80 | 0.50 | 15.30 | 3.10 | 19.10 | 2.40 | 39.90 |
| 83-84 | 15.70 | 0.50 | 16.20 | 3.80 | 19.50 | 2.40 | 41.90 |
| 84-85 | 15.40 | 0.50 | 15.90 | 3.30 | 19.90 | 2.60 | 41.70 |
| 85-86 | 15.40 | 0.50 | 15.90 | 3.10 | 20.60 | 2.60 | 42.20 |
| 86-87 | 15.80 | 0.50 | 16.30 | 3.00 | 21.00 | 2.70 | 43.00 |

X1 = Net area under government canals (million ha)
X2 = Net area under private canals (million ha)
X3 = Net area under all canals (million ha)
X4 = Net area under tanks (million ha)
X5 = Net area under wells (million ha)
X6 = Net area under other sources (million ha)
X7 = Net area under all sources (million ha)

S1. WEST BENGAL

| | NSA | GCA | NIA | GIA | CANAL | TANK | WELL | OS | TS=NIA | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 4.6920 | 5.2940 | .9780 | .9770 | .2760 | .4170 | .0120 | .2730 | .9780 | .6020 | 112.8303 | 20.8227 | 20.8440 | 5.8824 | 8.8875 | .2558 |
| 1951 | 4.6920 | 5.2940 | .9780 | .9970 | .2760 | .4170 | .0120 | .2730 | .9780 | .6020 | 112.8303 | 21.2489 | 20.8440 | 5.8824 | 8.8875 | .2558 |
| 1952 | 5.1950 | 6.0000 | 1.1270 | 1.1620 | .4660 | .4140 | .0160 | .2300 | 1.1270 | .8050 | 115.4957 | 22.3677 | 21.6939 | 8.9702 | 7.9692 | .3080 |
| 1953 | 5.2420 | 6.1090 | 1.1180 | 1.1640 | .4830 | .3980 | .0160 | .2210 | 1.1180 | .8670 | 116.5395 | 22.2050 | 21.3277 | 9.2140 | 7.5925 | .3052 |
| 1954 | 5.0620 | 5.8620 | 1.0650 | 1.0940 | .5100 | .3550 | .0150 | .1860 | 1.0650 | .8000 | 115.8040 | 21.6120 | 21.0391 | 10.0751 | 7.0130 | .2963 |
| 1955 | 5.2580 | 6.1270 | 1.1880 | 1.2180 | .5970 | .3810 | .0150 | .1950 | 1.1880 | .8690 | 116.5272 | 23.1647 | 22.5941 | 11.3541 | 7.2461 | .2853 |
| 1956 | 5.1400 | 5.9910 | 1.2040 | 1.2310 | .6060 | .3850 | .0160 | .1960 | 1.2040 | .8510 | 116.5564 | 23.9494 | 23.4241 | 11.7899 | 7.4903 | .3113 |
| 1957 | 5.1440 | 5.9060 | 1.2740 | 1.2900 | .6990 | .3740 | .0150 | .1860 | 1.2740 | .7620 | 114.8134 | 25.0778 | 24.7667 | 13.5886 | 7.2706 | .2916 |
| 1958 | 5.1720 | 6.0220 | 1.3360 | 1.3520 | .7690 | .3640 | .0160 | .1870 | 1.3360 | .8500 | 116.4346 | 26.1408 | 25.8314 | 14.8685 | 7.0379 | .3094 |
| 1959 | 5.2830 | 6.1740 | 1.3370 | 1.3520 | .7690 | .3640 | .0160 | .1870 | 1.3370 | .8910 | 116.8654 | 25.5915 | 25.3076 | 14.5561 | 6.8900 | .3029 |
| 1960 | 5.4360 | 6.3540 | 1.4010 | 1.4230 | .8580 | .3400 | .0160 | .1870 | 1.4010 | .9180 | 116.8874 | 26.1773 | 25.7726 | 15.7837 | 6.2546 | .2943 |
| 1961 | 5.4830 | 6.4640 | 1.4340 | 1.4560 | .8980 | .3340 | .0160 | .1870 | 1.4330 | .9810 | 117.8917 | 26.5548 | 26.1536 | 16.3779 | 6.0916 | .2918 |
| 1962 | 5.4430 | 6.3900 | 1.4300 | 1.4530 | .9010 | .3290 | .0160 | .1840 | 1.4300 | .9470 | 117.3985 | 26.6948 | 26.2723 | 16.5534 | 6.0445 | .2940 |
| 1963 | 5.5020 | 6.5100 | 1.4450 | 1.4680 | .9150 | .3300 | .0160 | .1840 | 1.4450 | 1.0080 | 118.3206 | 26.6812 | 26.2632 | 16.6303 | 5.9978 | .2908 |
| 1964 | 5.5680 | 6.6530 | 1.4780 | 1.4990 | .9410 | .3340 | .0170 | .1870 | 1.4780 | 1.0850 | 119.4864 | 26.9217 | 26.5445 | 16.9001 | 5.9986 | .3053 |
| 1965 | 5.5690 | 6.6530 | 1.4780 | 1.4990 | .9410 | .3340 | .0170 | .1870 | 1.4780 | 1.0840 | 119.4649 | 26.9169 | 26.5398 | 16.8971 | 5.9975 | .3053 |
| 1966 | 5.5010 | 6.6700 | 1.4730 | 1.4990 | .9410 | .3340 | .0170 | .1870 | 1.4780 | 1.1690 | 121.2507 | 27.2496 | 26.7769 | 17.1060 | 6.0716 | .3090 |
| 1967 | 5.5420 | 6.6860 | 1.4390 | 1.5410 | .9410 | .3340 | .0170 | .1870 | 1.4780 | 1.1440 | 120.6424 | 27.8058 | 25.9654 | 16.9794 | 6.0267 | .3067 |
| 1968 | 5.4010 | 6.7160 | 1.4840 | 1.5410 | .9410 | .3340 | .0160 | .1870 | 1.4780 | 1.3150 | 124.3473 | 28.5318 | 27.4764 | 17.4227 | 6.1840 | .2962 |
| 1969 | 5.6180 | 7.1080 | 1.4890 | 1.5410 | .9410 | .3340 | .0160 | .1870 | 1.4780 | 1.4900 | 126.5219 | 27.4297 | 26.5041 | 16.7497 | 5.9452 | .2848 |
| 1970 | 5.4630 | 7.1700 | 1.4840 | 1.5410 | .9600 | .3030 | .0170 | .2090 | 1.4890 | 1.7070 | 131.2466 | 28.2079 | 27.1646 | 17.5728 | 5.5464 | .3112 |
| 1971 | 5.7120 | 7.2710 | 1.4840 | 1.5410 | .9600 | .3030 | .0170 | .2100 | 1.4890 | 1.5590 | 127.2934 | 26.9783 | 25.9804 | 16.8067 | 5.3046 | .2976 |
| 1972 | 5.8780 | 7.0920 | 1.4890 | 1.5410 | .9600 | .3030 | .0170 | .2100 | 1.4890 | 1.2140 | 120.6533 | 26.2164 | 25.3317 | 16.3321 | 5.1548 | .2892 |
| 1973 | 5.1850 | 7.4620 | 1.4890 | 1.5410 | .9600 | .3030 | .0170 | .2100 | 1.4890 | 2.2770 | 143.9151 | 29.7203 | 28.7175 | 18.5149 | 5.8438 | .3279 |
| 1974 | 5.5920 | 7.7550 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 2.1630 | 138.6803 | 27.5572 | 26.6273 | 17.1674 | 5.4006 | .3040 |
| 1975 | 5.6190 | 7.9580 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 2.3390 | 141.6266 | 27.4248 | 26.4994 | 17.0849 | 5.3746 | .3025 |
| 1976 | 5.5590 | 7.6320 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 2.0730 | 137.2909 | 27.7208 | 26.7854 | 17.2693 | 5.4326 | .3058 |
| 1977 | 5.6020 | 7.8780 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 2.2760 | 140.6283 | 27.5080 | 26.5798 | 17.1367 | 5.3909 | .3035 |
| 1978 | 5.5760 | 7.3870 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 1.8110 | 132.4785 | 27.6363 | 26.7037 | 17.2166 | 5.4161 | .3049 |
| 1979 | 5.4400 | 7.4070 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 1.9670 | 136.1581 | 28.3272 | 27.3713 | 17.6471 | 5.5515 | .3125 |
| 1980 | 5.5650 | 7.6190 | 1.4890 | 1.5410 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 2.0540 | 136.9093 | 27.6909 | 26.7565 | 17.2507 | 5.4268 | .3055 |
| 1981 | 5.5650 | 7.3980 | 1.4890 | 1.7350 | .9600 | .3020 | .0170 | .2090 | 1.4890 | 1.8330 | 132.9380 | 31.1770 | 26.7565 | 17.2507 | 5.4268 | .3055 |
| 1982 | 5.3410 | 7.0040 | 1.8340 | 1.8340 | .6800 | .2610 | .6180 | .2750 | 1.8340 | 1.4390 | 125.8580 | 32.9560 | 32.9560 | 12.2192 | 4.6900 | 11.1051 |
| 1983 | 5.3410 | 7.8420 | 1.9800 | 1.9800 | .7240 | .2780 | .7170 | .2610 | 1.9800 | 2.5010 | 146.8264 | 37.0717 | 37.0717 | 13.5555 | 5.2050 | 13.4245 |
| 1984 | 5.3410 | 7.5840 | 1.9800 | 1.9800 | .7240 | .2780 | .7170 | .2610 | 1.9800 | 2.2430 | 141.9959 | 37.0717 | 37.0717 | 13.5555 | 5.2050 | 13.4245 |
| 1985 | 5.3410 | 7.9870 | 1.9110 | 1.9110 | .7170 | .2630 | .7120 | .2190 | 1.9110 | 2.6460 | 149.5413 | 35.7798 | 35.7798 | 13.4245 | 4.9242 | 13.3308 |
| 1986 | 5.3410 | 8.2110 | 1.9110 | 1.9110 | .7170 | .2630 | .7120 | .2190 | 1.9110 | 2.8700 | 153.7353 | 35.7798 | 35.7798 | 13.4245 | 4.9242 | 13.3308 |
| 1987 | 5.3410 | 8.3790 | 1.9110 | 1.9110 | .7170 | .2630 | .7120 | .2190 | 1.9110 | 3.0380 | 156.8807 | 35.7798 | 35.7798 | 13.4245 | 4.9242 | 13.3308 |

S2. UTTAR PRADESH

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 16.0400 | 19.7200 | 4.7800 | 5.1600 | 1.8340 | .0060 | 2.1560 | .7880 | 4.7840 | 3.6800 | 122.9426 | 32.1696 | 29.8005 | 11.4339 | .0374 | 13.4414 |
| 1951 | 16.2400 | 19.6900 | 5.1000 | 5.5900 | 1.9960 | .0060 | 2.5260 | .5760 | 5.1040 | 3.4500 | 121.2438 | 34.4212 | 31.4039 | 12.2906 | .0369 | 15.5542 |
| 1952 | 16.3100 | 19.7300 | 4.9000 | 5.3900 | 1.8610 | .0050 | 2.4040 | .6330 | 4.9030 | 3.4200 | 120.9687 | 33.0472 | 30.0429 | 11.4102 | .0307 | 14.7394 |
| 1953 | 16.3800 | 20.2500 | 5.0300 | 5.4700 | 1.8160 | .4660 | 2.4310 | .3220 | 5.0350 | 3.8700 | 123.6264 | 33.3944 | 30.7082 | 11.0867 | 2.8449 | 14.8413 |
| 1954 | 16.6300 | 20.5600 | 5.9300 | 5.4400 | 1.8000 | .4110 | 2.4380 | .2830 | 4.9330 | 3.9300 | 123.6320 | 32.7120 | 29.6452 | 10.8238 | 2.4714 | 14.6603 |
| 1955 | 16.6700 | 20.7700 | 4.8900 | 5.3000 | 1.7240 | .4900 | 2.3740 | .3060 | 4.8940 | 4.1000 | 124.5951 | 31.7936 | 29.3341 | 10.3419 | 2.9394 | 14.2412 |
| 1956 | 16.7300 | 21.1000 | 4.5600 | 4.9900 | 1.7120 | .4160 | 2.1650 | .2760 | 4.5680 | 4.3700 | 126.1207 | 29.8267 | 27.2564 | 10.2331 | 2.4866 | 12.9408 |
| 1957 | 16.6500 | 20.8100 | 4.8800 | 5.3300 | 1.8730 | .3760 | 2.3710 | .2600 | 4.8810 | 4.1600 | 124.9850 | 32.0120 | 29.3093 | 11.2492 | 2.2583 | 14.2402 |
| 1958 | 16.9400 | 21.4800 | 5.0900 | 5.6300 | 1.8440 | .4340 | 2.3010 | .2750 | 4.8550 | 4.5400 | 126.8005 | 33.2349 | 30.0472 | 10.8855 | 2.5620 | 13.5832 |
| 1959 | 16.9900 | 21.4800 | 5.0100 | 5.4600 | 2.0020 | .4140 | 2.3910 | .2870 | 5.0940 | 4.4900 | 126.4273 | 32.1366 | 29.4879 | 11.7834 | 2.4367 | 14.0730 |
| 1960 | 17.0900 | 21.8900 | 4.8000 | 5.2400 | 2.0010 | .4190 | 2.8670 | .2680 | 5.0740 | 4.8000 | 128.0866 | 30.6612 | 28.0866 | 11.7086 | 2.4517 | 16.7759 |
| 1961 | 17.2900 | 22.1500 | 4.8600 | 5.3000 | 1.9040 | .3940 | 2.3160 | .2450 | 4.8590 | 4.8600 | 128.1087 | 30.6536 | 28.1087 | 11.0121 | 2.2788 | 13.3950 |
| 1962 | 17.2700 | 21.9600 | 5.2800 | 5.8500 | 2.1080 | .4390 | 2.4600 | .2750 | 5.2820 | 4.6900 | 127.1569 | 33.8738 | 30.5732 | 12.2061 | 2.5420 | 14.2444 |
| 1963 | 17.2800 | 22.0500 | 5.3700 | 5.9700 | 2.1760 | .4410 | 2.4840 | .2770 | 5.3780 | 4.7700 | 127.6042 | 34.5486 | 31.0764 | 12.5926 | 2.5521 | 14.3750 |
| 1964 | 17.3300 | 22.2200 | 5.4900 | 6.0600 | 2.2330 | .4090 | 2.5740 | .2740 | 5.4900 | 4.8900 | 128.2170 | 34.9683 | 31.6792 | 12.8852 | 2.3601 | 14.8529 |
| 1965 | 17.3400 | 22.0300 | 5.8700 | 6.6200 | 2.3000 | .3910 | 2.9060 | .2790 | 5.8750 | 4.6900 | 127.0473 | 38.1776 | 33.8524 | 13.2641 | 2.2549 | 16.7589 |
| 1966 | 17.3200 | 22.0800 | 6.2600 | 7.1600 | 2.3850 | .3420 | 3.2680 | .2610 | 6.2550 | 4.7600 | 127.4827 | 41.3395 | 36.1432 | 13.7702 | 1.9746 | 18.8684 |
| 1967 | 17.4700 | 22.7100 | 5.6600 | 6.3500 | 2.0690 | .3230 | 3.0220 | .2430 | 5.6570 | 5.2400 | 129.9943 | 36.3480 | 32.3984 | 11.8432 | 1.8489 | 17.2982 |
| 1968 | 17.4100 | 22.3100 | 6.5600 | 7.5600 | 2.3530 | .3570 | 3.6210 | .2310 | 6.5620 | 4.9000 | 128.1447 | 43.4233 | 37.6795 | 13.5152 | 2.0505 | 20.7984 |
| 1969 | 17.3600 | 22.9700 | 6.8500 | 7.9500 | 2.4230 | .3600 | 3.7920 | .2440 | 6.8190 | 5.6100 | 132.3157 | 45.7949 | 39.4585 | 13.9574 | 2.0737 | 21.8433 |
| 1970 | 17.3000 | 23.2100 | 7.2200 | 8.3600 | 2.4980 | .3710 | 4.0340 | .2870 | 7.1900 | 5.9100 | 134.1618 | 48.3237 | 41.7341 | 14.4393 | 2.1445 | 23.3179 |
| 1971 | 17.3200 | 23.0200 | 6.9900 | 8.0900 | 2.4980 | .3350 | 3.8660 | .2900 | 6.9890 | 5.7000 | 132.9099 | 46.7090 | 40.3580 | 14.4226 | 1.9342 | 22.3210 |
| 1972 | 17.1900 | 22.9200 | 7.2900 | 8.5100 | 2.4550 | .3240 | 4.2160 | .2940 | 7.2880 | 5.7300 | 133.3333 | 49.5055 | 42.4084 | 14.2816 | 1.8848 | 24.5259 |
| 1973 | 17.1700 | 23.0000 | 7.2400 | 8.4900 | 2.4660 | .3220 | 4.2090 | .2440 | 7.2410 | 5.8300 | 133.9546 | 49.4467 | 42.1666 | 14.3623 | 1.8754 | 24.5137 |
| 1974 | 17.1600 | 22.7900 | 7.7900 | 9.1900 | 2.6240 | .3450 | 4.4930 | .3310 | 7.7930 | 5.6300 | 132.8089 | 53.5548 | 45.3963 | 15.2914 | 2.0105 | 26.1830 |
| 1975 | 17.2000 | 23.1000 | 7.9300 | 9.2300 | 2.7430 | .3390 | 4.5030 | .3490 | 7.9330 | 4.9000 | 128.4884 | 53.6628 | 46.1047 | 15.9477 | 1.9709 | 26.1802 |
| 1976 | 17.3800 | 23.1500 | 8.2600 | 9.7400 | 2.3470 | .2940 | 4.7930 | .3250 | 8.2600 | 5.7700 | 133.1991 | 56.0414 | 47.5259 | 13.5040 | 1.6916 | 27.5777 |
| 1977 | 17.4200 | 23.3500 | 8.4900 | 10.0000 | 2.9620 | .2760 | 4.9430 | .3120 | 8.4930 | 5.9300 | 134.0413 | 57.4053 | 48.7371 | 17.0034 | 1.5844 | 28.3754 |
| 1978 | 17.4800 | 24.3000 | 8.8900 | 10.5700 | 3.1170 | .2320 | 5.2220 | .3210 | 8.8920 | 6.8200 | 139.0160 | 60.4691 | 50.8581 | 17.8318 | 1.3272 | 29.8741 |
| 1979 | 16.9900 | 23.6400 | 8.9100 | 11.0500 | 2.8040 | .1360 | 5.6760 | .2960 | 8.9120 | 6.6500 | 139.1407 | 65.0383 | 52.4426 | 16.5038 | .8005 | 33.4079 |
| 1980 | 17.2200 | 24.5700 | 9.4500 | 11.3700 | 3.1780 | .1660 | 5.7990 | .3090 | 9.4530 | 7.3500 | 142.6829 | 66.0279 | 54.8780 | 18.4553 | .9640 | 33.6760 |
| 1981 | 17.2900 | 24.7700 | 9.5400 | 11.6200 | 3.2030 | .1860 | 5.8810 | .2710 | 9.5410 | 7.4800 | 143.2620 | 67.2065 | 55.1764 | 18.5252 | 1.0758 | 34.0139 |
| 1982 | 17.2200 | 24.7100 | 9.8800 | 12.1200 | 3.3270 | .1670 | 6.0710 | .3190 | 9.8840 | 7.4900 | 143.4959 | 70.3833 | 57.3751 | 19.3206 | .9698 | 35.2555 |
| 1983 | 17.2700 | 25.0700 | 9.8800 | 12.1500 | 3.3300 | .1520 | 6.0810 | .3160 | 9.8790 | 7.8000 | 145.1650 | 70.3532 | 57.2090 | 19.2820 | .8801 | 35.2113 |
| 1984 | 17.2500 | 25.1200 | 9.8800 | 12.1500 | 3.3300 | .1520 | 6.0810 | .3160 | 9.8790 | 7.8700 | 145.6232 | 70.4348 | 57.2754 | 19.3043 | .8812 | 35.2522 |
| 1985 | 17.2500 | 24.9800 | 9.8800 | 12.1500 | 3.3300 | .1520 | 6.0810 | .3160 | 9.8790 | 7.7300 | 144.8116 | 70.4348 | 57.2754 | 19.3043 | .8812 | 35.2522 |
| 1986 | 17.2320 | 25.1980 | 9.8540 | 13.4110 | 3.1380 | .1270 | 6.3180 | .2710 | 9.8540 | 7.9660 | 146.2279 | 77.8261 | 57.1843 | 18.2103 | .7370 | 36.6643 |
| 1987 | 17.1350 | 24.4280 | 10.0430 | 13.9200 | 3.0290 | .1010 | 6.5910 | .3220 | 10.0430 | 7.2930 | 142.5620 | 81.2372 | 58.6110 | 17.6773 | .5894 | 38.4651 |

S3. RAJASTHAN

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 9.4490 | 9.9170 | 1.1360 | 1.2480 | .2650 | .0350 | .6530 | .0170 | .9710 | .4680 | 104.9529 | 13.2077 | 12.0224 | 2.8045 | .3704 | 6.9108 |
| 1951 | 9.4490 | 9.9170 | 1.1360 | 1.2480 | .2650 | .0350 | .6530 | .0170 | .9710 | .4680 | 104.9529 | 13.2077 | 12.0224 | 2.8045 | .3704 | 6.9108 |
| 1952 | 10.2810 | 10.8180 | 1.2740 | 1.5292 | .2370 | .1440 | .8470 | .0450 | 1.2740 | .5370 | 105.2232 | 14.8740 | 12.3918 | 2.3052 | 1.4006 | 8.2385 |
| 1953 | 10.7390 | 11.2930 | 1.1480 | 1.3730 | .2380 | .1090 | .7880 | .0140 | 1.1480 | .5540 | 105.1588 | 12.7852 | 10.6900 | 2.2162 | 1.0150 | 7.3377 |
| 1954 | 10.9620 | 11.8340 | 1.2230 | 1.4900 | .2490 | .1440 | .8180 | .0130 | 1.2230 | .8720 | 107.9548 | 13.5924 | 11.1567 | 2.2715 | 1.3136 | 7.4621 |
| 1955 | 11.3540 | 12.4350 | 1.3340 | 1.5750 | .2810 | .1760 | .8620 | .0160 | 1.3340 | 1.0810 | 109.5209 | 13.8718 | 11.7492 | 2.4749 | 1.5501 | 7.5920 |
| 1956 | 12.2810 | 13.5520 | 1.3960 | 1.6730 | .2760 | .1870 | .8950 | .0380 | 1.3960 | 1.2710 | 110.3493 | 13.6227 | 11.3672 | 2.2474 | 1.5227 | 7.2877 |
| 1957 | 11.9630 | 12.7940 | 1.4280 | 1.7080 | .3110 | .2200 | .8900 | .0080 | 1.4290 | .8310 | 106.9464 | 14.2774 | 11.9368 | 2.5997 | 1.8390 | 7.4396 |
| 1958 | 12.4420 | 13.5680 | 1.4280 | 1.6270 | .3270 | .3100 | .7780 | .0140 | 1.4290 | 1.1260 | 109.0500 | 13.0767 | 11.4773 | 2.6282 | 2.4916 | 6.2530 |
| 1959 | 13.0620 | 14.2990 | 1.6560 | 1.6560 | .4160 | .2520 | .9740 | .0130 | 1.6560 | 1.2370 | 109.4702 | 12.6780 | 12.6780 | 3.1848 | 1.9293 | 7.4567 |
| 1960 | 13.1120 | 14.0130 | 1.7510 | 1.7510 | .5350 | .1660 | 1.0140 | .0370 | 1.7520 | .9010 | 106.8716 | 13.3542 | 13.3542 | 4.0802 | 1.2660 | 7.7334 |
| 1961 | 13.7420 | 15.0450 | 1.8230 | 1.8230 | .5810 | .2150 | .9770 | .0500 | 1.8230 | 1.3030 | 109.4819 | 13.2659 | 13.2659 | 4.2279 | 1.5645 | 7.1096 |
| 1962 | 13.8210 | 14.8330 | 1.8590 | 1.8590 | .6430 | .1210 | 1.0660 | .0290 | 1.8590 | 1.0120 | 107.3222 | 13.4505 | 13.4505 | 4.6523 | .8755 | 7.7129 |
| 1963 | 13.4970 | 14.4640 | 1.8630 | 1.8630 | .6100 | .1200 | 1.1100 | .0230 | 1.8630 | .9670 | 107.1646 | 13.8031 | 13.8031 | 4.5195 | .8891 | 8.2240 |
| 1964 | 14.4520 | 15.5010 | 2.0800 | 2.0800 | .6140 | .2950 | 1.1270 | .0430 | 2.0800 | 1.0490 | 107.2585 | 14.3925 | 14.3925 | 4.2485 | 2.0412 | 7.7982 |
| 1965 | 14.1310 | 14.9710 | 1.7520 | 2.0680 | .4870 | .2030 | 1.0230 | .0400 | 1.7530 | .8400 | 105.9444 | 14.6345 | 12.3983 | 3.4463 | 1.4366 | 7.2394 |
| 1966 | 14.5970 | 15.4470 | 2.1210 | 2.1210 | .5530 | .1860 | 1.0330 | .0220 | 1.7950 | .8500 | 105.8231 | 14.5304 | 14.5304 | 3.7884 | 1.2742 | 7.0768 |
| 1967 | 15.0960 | 16.6560 | 1.8650 | 2.1410 | .6070 | .2520 | .9950 | .0090 | 1.8650 | 1.5600 | 110.3339 | 14.1826 | 12.3543 | 4.0209 | 1.6693 | 6.5911 |
| 1968 | 13.3140 | 14.2560 | 2.1190 | 2.5450 | .7010 | .2190 | 1.1880 | .0110 | 2.1190 | .9420 | 107.0753 | 19.1152 | 15.9156 | 5.2651 | 1.6449 | 8.9229 |
| 1969 | 13.0950 | 14.2660 | 2.0590 | 2.4190 | .7530 | .1980 | 1.0870 | .0210 | 2.0590 | 1.1710 | 108.9423 | 18.4727 | 15.7236 | 5.7503 | 1.5120 | 8.3009 |
| 1970 | 15.1790 | 16.7290 | 2.1320 | 2.4530 | .7560 | .2700 | 1.0830 | .0230 | 2.1320 | 1.5500 | 110.2115 | 16.1605 | 14.0457 | 4.9806 | 1.7788 | 7.1349 |
| 1971 | 15.2630 | 16.7730 | 2.1730 | 2.4400 | .8110 | .1790 | 1.1500 | .0320 | 2.1730 | 1.5100 | 109.8932 | 15.9864 | 14.2370 | 5.3135 | 1.1728 | 7.5346 |
| 1972 | 14.8590 | 16.0970 | 2.2700 | 2.6820 | .8190 | .1060 | 1.3130 | .0310 | 2.2700 | 1.2380 | 108.3317 | 18.0497 | 15.2769 | 5.5118 | .7134 | 8.8364 |
| 1973 | 15.9670 | 17.8860 | 2.3780 | 2.6790 | .8440 | .2330 | 1.2620 | .0380 | 2.3780 | 1.9190 | 112.0185 | 16.7784 | 14.8932 | 2.2859 | 1.4593 | 7.9038 |
| 1974 | 13.9590 | 15.7110 | 2.6470 | 3.1430 | .8810 | .1610 | 1.5730 | .0310 | 2.6470 | 1.7520 | 112.5510 | 22.5159 | 18.9627 | 6.3113 | 1.1534 | 11.2687 |
| 1975 | 15.1050 | 17.1640 | 2.5470 | 2.9340 | .8870 | .2530 | 1.3770 | .0310 | 2.5470 | 2.0590 | 113.6312 | 19.4240 | 16.8620 | 5.8722 | 1.6749 | 9.1162 |
| 1976 | 15.0600 | 16.8990 | 2.6080 | 2.9760 | .8670 | .2830 | 1.4890 | .0170 | 2.6080 | 1.8390 | 112.2112 | 19.7610 | 17.3174 | 5.7570 | 1.8792 | 9.8871 |
| 1977 | 15.1680 | 16.9240 | 2.7650 | 3.1670 | .9140 | .2310 | 1.5500 | .0700 | 2.7640 | 1.7560 | 111.5770 | 20.8795 | 18.2292 | 6.0258 | 1.5229 | 10.2189 |
| 1978 | 15.4710 | 17.4960 | 2.8950 | 3.4510 | .9500 | .1920 | 1.7300 | .0230 | 2.8970 | 2.0250 | 113.0890 | 22.3063 | 18.7124 | 6.1405 | 1.2410 | 11.1822 |
| 1979 | 14.2070 | 16.3710 | 3.3080 | 4.0840 | .9820 | .2150 | 2.0900 | .0230 | 3.3080 | 2.1640 | 115.2319 | 28.7464 | 23.2843 | 6.9121 | 1.5133 | 14.7111 |
| 1980 | 15.2680 | 17.3500 | 2.9830 | 3.7490 | .9410 | .1120 | 1.8740 | .0560 | 2.9830 | 2.0820 | 113.6364 | 24.5546 | 19.5376 | 6.1632 | .7336 | 12.2740 |
| 1981 | 15.5780 | 18.5970 | 2.9030 | 3.7220 | .9460 | .0850 | 1.8270 | .0450 | 2.9030 | 3.0190 | 119.3799 | 23.8927 | 18.6353 | 6.0727 | .5456 | 11.7281 |
| 1982 | 15.6600 | 18.3950 | 3.2180 | 4.0880 | 1.0250 | .1430 | 1.9970 | .0530 | 3.2180 | 2.7350 | 117.4649 | 26.1047 | 20.5492 | 6.5453 | .9132 | 12.7522 |
| 1983 | 16.2340 | 18.8770 | 3.2760 | 4.0140 | 1.1190 | .2140 | 1.9060 | .0370 | 3.2760 | 2.6430 | 116.2806 | 24.7259 | 20.1799 | 6.8929 | 1.3182 | 11.7408 |
| 1984 | 15.2150 | 17.2860 | 3.2040 | 3.8300 | 1.0580 | .1240 | 1.9860 | .0360 | 3.2040 | 2.0710 | 113.6116 | 25.1725 | 21.0582 | 6.9537 | .8150 | 13.0529 |
| 1985 | 15.5640 | 18.1370 | 3.1090 | 3.8630 | 1.1540 | .0840 | 1.8510 | .0200 | 3.1090 | 2.5730 | 116.5317 | 24.8201 | 19.9756 | 7.4145 | .5397 | 11.8928 |
| 1986 | 15.4290 | 17.6400 | 3.4210 | 4.3510 | 1.2050 | .1240 | 2.0540 | .0380 | 3.4210 | 2.2110 | 114.3302 | 28.2001 | 22.1725 | 7.8100 | .8037 | 13.3126 |
| 1987 | 11.5140 | 13.3080 | 3.3270 | 3.9950 | 1.0790 | .0750 | 2.1180 | .0440 | 3.3270 | 1.7940 | 115.5810 | 34.6969 | 28.8953 | 9.3712 | .6514 | 18.3950 |

S4. ANDHRA PRADESH

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 9.6310 | 9.7460 | 1.8230 | 2.0870 | 1.0950 | .4880 | .2000 | .0400 | 1.8230 | .1150 | 101.1941 | 21.6696 | 18.9285 | 11.3695 | 5.0670 | 2.0766 |
| 1951 | 10.5050 | 10.6310 | 1.8350 | 2.1010 | 1.1170 | .5070 | .1570 | .0540 | 1.8350 | .1260 | 101.1994 | 20.0000 | 17.4679 | 10.6330 | 4.8263 | 1.4945 |
| 1952 | 10.1750 | 11.1060 | 2.2920 | 2.4930 | 1.2036 | .7420 | .2830 | .0630 | 2.2920 | .9310 | 109.1499 | 24.5012 | 22.5258 | 11.8290 | 7.2924 | 2.7813 |
| 1953 | 10.9070 | 11.9250 | 2.6520 | 2.9832 | 1.2160 | 1.0620 | .2780 | .0970 | 2.6524 | 1.0180 | 109.3335 | 27.3512 | 24.3147 | 11.1488 | 9.7369 | 2.5488 |
| 1954 | 10.9370 | 11.9100 | 2.6090 | 3.0070 | 1.2310 | .9960 | .2990 | .0830 | 2.6090 | .9730 | 108.8964 | 27.4938 | 23.8548 | 11.2554 | 9.1067 | 2.7338 |
| 1955 | 11.1560 | 12.1570 | 2.7150 | 3.1630 | 1.2770 | 1.0560 | .2810 | .1020 | 2.7150 | 1.0010 | 108.9728 | 28.3525 | 24.3367 | 11.4468 | 9.4658 | 2.5188 |
| 1956 | 11.2420 | 12.3000 | 2.8270 | 3.3480 | 1.2600 | 1.1660 | .3170 | .0840 | 2.8270 | 1.0580 | 109.4111 | 29.7812 | 25.1468 | 11.2080 | 10.3718 | 2.8198 |
| 1957 | 10.8880 | 11.8630 | 2.7040 | 3.3370 | 1.2230 | 1.0980 | .2980 | .0860 | 2.7040 | .9750 | 108.9548 | 30.6484 | 24.8347 | 11.2325 | 10.0845 | 2.7370 |
| 1958 | 10.9210 | 11.9490 | 2.8180 | 3.4560 | 1.2080 | 1.1780 | .2910 | .1060 | 2.8180 | 1.0280 | 109.4131 | 31.6455 | 25.8035 | 11.0613 | 10.7866 | 2.6646 |
| 1959 | 10.7630 | 11.8080 | 2.9150 | 3.4880 | 1.3160 | 1.1380 | .3240 | .0980 | 2.8750 | 1.0450 | 109.7092 | 32.4073 | 27.0835 | 12.2271 | 10.5733 | 3.0103 |
| 1960 | 10.7840 | 11.8160 | 2.9090 | 3.4720 | 1.3310 | 1.5100 | .3270 | .0980 | 2.9090 | 1.0320 | 109.5697 | 32.1958 | 26.9751 | 12.3424 | 14.0022 | 3.0323 |
| 1961 | 11.2900 | 12.7120 | 3.0290 | 3.7390 | 1.2650 | 1.2580 | .4040 | .1040 | 3.0290 | 1.4220 | 112.5952 | 33.1178 | 26.8291 | 11.2046 | 11.1426 | 3.5784 |
| 1962 | 11.6440 | 12.8420 | 3.1820 | 3.7840 | 1.2840 | 1.3300 | .4340 | .1340 | 3.1820 | 1.1980 | 110.2886 | 32.4974 | 27.3274 | 11.0271 | 11.4222 | 3.7272 |
| 1963 | 11.4060 | 12.7520 | 3.0970 | 3.6640 | 1.3120 | 1.2260 | ..3960 | .1620 | 3.0970 | 1.3460 | 111.8008 | 32.1234 | 27.1524 | 11.5027 | 10.7487 | 3.4719 |
| 1964 | 11.4840 | 12.7560 | 3.1580 | 3.8500 | 1.2750 | 1.3410 | .4050 | .1370 | 3.1580 | 1.2720 | 111.0763 | 33.5249 | 27.4991 | 11.1024 | 11.6771 | 3.5266 |
| 1965 | 10.9940 | 12.0910 | 2.9770 | 3.5330 | 1.2260 | 1.1890 | .4550 | .1080 | 2.9770 | 1.0970 | 109.9782 | 32.1357 | 27.0784 | 11.1515 | 10.8150 | 4.1386 |
| 1966 | 11.3430 | 12.6760 | 3.0700 | 3.8250 | 1.2480 | 1.2580 | .4620 | .1020 | 3.0700 | 1.3330 | 111.7517 | 33.7212 | 27.0652 | 11.0024 | 11.0905 | 4.0730 |
| 1967 | 11.3680 | 12.7940 | 3.0890 | 3.9720 | 1.3060 | 1.2200 | .4570 | .1050 | 3.0890 | 1.4260 | 112.5440 | 34.9402 | 27.1728 | 11.4884 | 10.7319 | 4.0201 |
| 1968 | 10.7190 | 12.4570 | 2.7170 | 3.6150 | 1.3950 | .7730 | .4670 | .0820 | 2.7170 | 1.7380 | 116.2142 | 33.7252 | 25.3475 | 13.0143 | 7.2115 | 4.3567 |
| 1969 | 11.5100 | 13.1450 | 3.1890 | 4.1530 | 1.4880 | 1.0710 | .5020 | .1280 | 3.1890 | 1.6350 | 114.2050 | 36.0817 | 27.7063 | 12.9279 | 9.3050 | 4.3614 |
| 1970 | 11.7350 | 13.3470 | 3.3130 | 4.2220 | 1.5790 | 1.1120 | .5090 | .1130 | 3.3130 | 1.6120 | 113.7367 | 35.9778 | 28.2318 | 13.4555 | 9.4759 | 4.3375 |
| 1971 | 11.2690 | 12.6520 | 2.9980 | 3.7870 | 1.5210 | .8130 | .5700 | .0960 | 2.9980 | 1.3830 | 112.2726 | 33.6055 | 26.6040 | 13.4972 | 7.2145 | 5.0581 |
| 1972 | 11.0780 | 12.3140 | 2.9550 | 3.5730 | 1.4240 | .8070 | .6270 | .0960 | 2.9550 | 1.2360 | 111.1572 | 32.2531 | 26.6745 | 12.8543 | 7.2847 | 5.6599 |
| 1973 | 11.6360 | 13.2380 | 3.2810 | 4.1540 | 1.4920 | 1.0280 | .6450 | .1170 | 3.2810 | 1.6020 | 113.7676 | 35.6996 | 28.1970 | 12.8223 | 8.8347 | 5.5431 |
| 1974 | 11.4920 | 13.2830 | 3.3460 | 4.4230 | 1.5900 | .9500 | .6940 | .1120 | 3.3460 | 1.7910 | 115.5848 | 38.4876 | 29.1159 | 13.8357 | 8.2666 | 6.0390 |
| 1975 | 11.1720 | 12.9580 | 3.4370 | 4.5280 | 1.6260 | 1.1000 | .5840 | .1260 | 3.4270 | 1.7860 | 115.9864 | 40.5299 | 30.7644 | 14.5542 | 9.8460 | 5.2274 |
| 1976 | 10.6020 | 11.8630 | 3.4340 | 4.1560 | 1.6040 | 1.0890 | .6240 | .1170 | 3.4340 | 1.2610 | 111.8940 | 39.2002 | 32.3901 | 15.1292 | 10.2716 | 5.8857 |
| 1977 | 10.9180 | 12.5360 | 3.3590 | 4.3780 | 1.6430 | .9120 | .6960 | .1090 | 3.3590 | 1.6180 | 114.8196 | 40.0989 | 30.7657 | 15.0485 | 8.3532 | 6.3748 |
| 1978 | 11.3490 | 13.1210 | 3.6550 | 4.6980 | 1.6740 | 1.1400 | .7250 | .1160 | 3.6550 | 1.7720 | 115.6137 | 41.3957 | 32.2055 | 14.7502 | 10.0449 | 6.3882 |
| 1979 | 10.5320 | 12.2810 | 3.2250 | 4.2370 | 1.6470 | .7490 | .7400 | .0900 | 3.2250 | 1.7490 | 116.6065 | 40.2298 | 30.6210 | 15.6381 | 7.1117 | 7.0262 |
| 1980 | 10.7380 | 12.2820 | 3.4630 | 4.3420 | 1.6930 | .9000 | .7760 | .0930 | 3.4630 | 1.5440 | 114.3788 | 40.4358 | 32.2500 | 15.7664 | 8.3814 | 7.2267 |
| 1981 | 11.3240 | 13.0470 | 3.6920 | 4.6780 | 1.7560 | 1.0450 | .7860 | .1050 | 3.6920 | 1.7230 | 115.2155 | 41.3105 | 32.6033 | 15.5069 | 9.2282 | 6.9410 |
| 1982 | 11.0340 | 12.7690 | 3.5270 | 4.5180 | 1.7430 | .8520 | .8390 | .0930 | 3.5270 | 1.7350 | 115.7241 | 40.9462 | 31.9648 | 15.7966 | 7.7216 | 7.6038 |
| 1983 | 11.4360 | 12.3930 | 3.8780 | 5.0580 | 1.8390 | 1.0870 | .8380 | .1140 | 3.8780 | .9570 | 108.3683 | 44.2288 | 33.9105 | 16.0808 | 9.5051 | 7.3277 |
| 1984 | 10.4860 | 12.2120 | 3.5220 | 4.4700 | 1.7940 | .7740 | .8370 | .1170 | 3.5220 | 1.7260 | 116.4600 | 42.6283 | 33.5876 | 17.1085 | 7.3813 | 7.9821 |
| 1985 | 10.4270 | 12.1000 | 3.5380 | 4.3370 | 1.7830 | .7860 | .8560 | .1130 | 3.5380 | 1.6730 | 116.0449 | 41.5939 | 33.9311 | 17.0998 | 7.5381 | 8.2095 |
| 1986 | 10.0470 | 11.6930 | 3.5500 | 4.3600 | 1.7800 | .7770 | .7930 | .1100 | 3.5500 | 1.6460 | 116.3830 | 43.3960 | 35.3339 | 17.7167 | 7.7337 | 7.8929 |
| 1987 | 10.4250 | 12.1550 | 3.3690 | 4.2980 | 1.5930 | .6630 | .9910 | .1220 | 3.3690 | 1.7300 | 116.5947 | 41.2278 | 32.3165 | 15.2806 | 6.3597 | 9.5060 |

S5. TAMIL NADU

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 5.9520 | 6.8320 | 1.7650 | 2.1680 | .7580 | .5380 | .4200 | .0490 | 1.7650 | .8800 | 114.7849 | 36.4247 | 29.6539 | 12.7352 | 9.0390 | 7.0565 |
| 1951 | 6.2200 | 7.3250 | 1.9110 | 2.3620 | .7650 | .6280 | .4930 | .0240 | 1.9110 | 1.1050 | 117.7653 | 37.9743 | 30.7235 | 12.2990 | 10.0965 | 7.9260 |
| 1952 | 5.2800 | 6.0960 | 1.8190 | 2.3020 | .7160 | .6300 | .4220 | .0520 | 1.8190 | .8160 | 115.4545 | 43.5985 | 34.4508 | 13.5606 | 11.9318 | 7.9924 |
| 1953 | 5.6520 | 6.7570 | 2.1570 | 2.7420 | .7520 | .8230 | .5200 | .0620 | 2.1570 | 1.1050 | 119.5506 | 48.5138 | 38.1635 | 13.3050 | 14.5612 | 9.2003 |
| 1954 | 5.7490 | 6.8450 | 2.1440 | 2.9340 | .7710 | .8690 | .4500 | .0550 | 2.1440 | 1.0960 | 119.0642 | 51.0350 | 37.2934 | 13.4110 | 15.1157 | 7.8274 |
| 1955 | 5.6690 | 6.7870 | 2.1220 | 2.9240 | .7820 | .8000 | .4990 | .0420 | 2.1220 | 1.1180 | 119.7213 | 51.5788 | 37.4316 | 13.7943 | 14.1118 | 8.8023 |
| 1956 | 5.7660 | 6.8580 | 2.2070 | 2.8910 | .7970 | .8780 | .4940 | .0360 | 2.2070 | 1.0920 | 118.9386 | 50.1387 | 38.2761 | 13.8224 | 15.2272 | 8.5675 |
| 1957 | 5.6070 | 6.6780 | 2.2050 | 2.9580 | .8110 | .8380 | .5180 | .0390 | 2.2050 | 1.0710 | 119.1011 | 52.7555 | 39.3258 | 14.4641 | 14.9456 | 9.2385 |
| 1958 | 5.7300 | 6.8390 | 2.2340 | 2.9250 | .8300 | .8300 | .5380 | .0360 | 2.2340 | 1.1090 | 119.3543 | 51.0471 | 38.9878 | 14.4852 | 14.4852 | 9.3892 |
| 1959 | 5.8300 | 6.9610 | 2.2520 | 2.9440 | .8330 | .8230 | .5580 | .0380 | 2.2520 | 1.1310 | 119.3997 | 50.4974 | 38.6278 | 14.2882 | 14.1166 | 9.5712 |
| 1960 | 5.9960 | 7.3200 | 2.4620 | 3.2350 | .8820 | .9370 | .5980 | .0460 | 2.4620 | 1.3240 | 122.0814 | 53.9526 | 41.0607 | 14.7098 | 15.6271 | 9.9733 |
| 1961 | 6.0170 | 7.2700 | 2.5030 | 3.2070 | .9250 | .9400 | .5940 | .0440 | 2.5030 | 1.2530 | 120.8243 | 53.2990 | 41.5988 | 15.3731 | 15.6224 | 9.8720 |
| 1962 | 6.0960 | 7.2890 | 2.5080 | 3.2950 | .9030 | .9460 | .6150 | .0440 | 2.5070 | 1.1930 | 119.5702 | 54.0518 | 41.1417 | 14.8130 | 15.5184 | 10.0886 |
| 1963 | 6.0550 | 7.1920 | 2.4340 | 3.2680 | .8740 | .9150 | .6040 | .0410 | 2.4340 | 1.1370 | 118.7779 | 53.9719 | 40.1982 | 14.4344 | 15.1115 | 9.9752 |
| 1964 | 6.0300 | 7.1760 | 2.4250 | 3.2630 | .8920 | .8920 | .5980 | .0410 | 2.4250 | 1.1460 | 119.0050 | 54.1128 | 40.2156 | 14.7927 | 14.7927 | 9.9171 |
| 1965 | 5.9340 | 7.0650 | 2.3970 | 3.1780 | .7990 | .9030 | .6590 | .0380 | 2.3990 | 1.1310 | 119.0597 | 53.5558 | 40.3943 | 13.4648 | 15.2174 | 11.1055 |
| 1966 | 6.0850 | 7.3050 | 2.5110 | 3.3720 | .8600 | .9660 | .6400 | .0460 | 2.5110 | 1.2200 | 120.0493 | 55.4150 | 41.2654 | 14.1331 | 15.8751 | 10.5177 |
| 1967 | 6.0830 | 7.3090 | 2.6290 | 3.4760 | .8930 | .9900 | .6980 | .0480 | 2.6290 | 1.2260 | 120.1545 | 57.1429 | 43.2188 | 14.6803 | 16.2749 | 11.4746 |
| 1968 | 5.8410 | 6.9140 | 2.4170 | 3.0920 | .8920 | .7500 | .7440 | .0310 | 2.4170 | 1.0730 | 118.3701 | 52.9361 | 41.3799 | 15.2714 | 12.8403 | 12.7375 |
| 1969 | 6.0690 | 7.1610 | 2.5070 | 3.2720 | .9060 | .8790 | .6910 | .0310 | 2.5070 | 1.0920 | 117.9931 | 53.9133 | 41.3083 | 14.9283 | 14.4834 | 11.3857 |
| 1970 | 6.1690 | 7.3840 | 2.5920 | 3.4100 | .8840 | .8980 | .7740 | .0360 | 2.5290 | 1.2150 | 119.6953 | 55.2764 | 42.0165 | 14.3297 | 14.5567 | 12.5466 |
| 1971 | 6.3480 | 7.6420 | 2.7100 | 3.5290 | .9310 | .9230 | .8200 | .0350 | 2.7100 | 1.2940 | 120.3844 | 55.5923 | 42.6906 | 14.6660 | 14.5400 | 12.9175 |
| 1972 | 6.3320 | 7.6990 | 2.8150 | 3.6730 | .9420 | .9500 | .8930 | .0320 | 2.8150 | 1.3670 | 121.5888 | 58.0069 | 44.4567 | 14.8768 | 15.0032 | 14.1030 |
| 1973 | 6.1750 | 7.6490 | 2.8160 | 3.6740 | .9270 | .9300 | .9270 | .0320 | 2.8160 | 1.4740 | 123.8704 | 59.4980 | 45.6032 | 15.0121 | 15.0607 | 15.0121 |
| 1974 | 5.6540 | 6.6400 | 2.4380 | 3.0330 | .8870 | .5940 | .9250 | .0330 | 2.4380 | .9860 | 117.4390 | 53.6434 | 43.1199 | 15.6880 | 10.5058 | 16.3601 |
| 1975 | 5.9800 | 7.2350 | 2.5650 | 3.3760 | .9100 | .7500 | .8700 | .0350 | 2.5650 | 1.2550 | 120.9866 | 56.4548 | 42.8930 | 15.2174 | 12.5418 | 14.5485 |
| 1976 | 6.0070 | 7.1470 | 2.3300 | 3.0010 | .6770 | .8000 | .8250 | .0280 | 2.3300 | 1.1400 | 118.9779 | 49.9584 | 38.7881 | 11.2702 | 13.3178 | 13.7340 |
| 1977 | 6.2950 | 7.7680 | 2.8360 | 3.7230 | .9260 | .9100 | 1.0660 | .0420 | 2.8360 | 1.4730 | 123.3995 | 59.1422 | 45.0516 | 14.7101 | 14.4559 | 16.9341 |
| 1978 | 6.2510 | 7.6840 | 2.8730 | 3.8180 | .9200 | .8420 | 1.0690 | .0430 | 2.8730 | 1.4330 | 122.9243 | 61.0782 | 45.9606 | 14.7176 | 13.4698 | 17.1013 |
| 1979 | 6.2320 | 7.7170 | 2.9840 | 3.9820 | .9320 | .8960 | 1.1170 | .0380 | 2.9840 | 1.4850 | 123.8286 | 63.8960 | 47.8819 | 14.9551 | 14.3774 | 17.9236 |
| 1980 | 5.3600 | 6.4700 | 2.5700 | 3.2940 | .8890 | .5900 | 1.0670 | .0240 | 2.5710 | 1.1100 | 120.7090 | 61.4552 | 47.9478 | 16.5858 | 11.0075 | 19.9067 |
| 1981 | 5.7400 | 6.9090 | 2.7090 | 3.4250 | .9010 | .7390 | 1.0440 | .0250 | 2.7090 | 1.1690 | 120.3659 | 59.6690 | 47.1951 | 15.6969 | 12.8746 | 18.1882 |
| 1982 | 5.2590 | 6.0300 | 2.2550 | 2.7320 | .7640 | .5170 | .9590 | .0150 | 2.2550 | .7710 | 114.6606 | 51.9490 | 42.8789 | 14.5275 | 9.8308 | 18.2354 |
| 1983 | 5.8460 | 6.9450 | 2.6180 | 3.2490 | .8650 | .8070 | .9260 | .0200 | 2.6180 | 1.0990 | 118.7992 | 55.5765 | 44.7828 | 14.7964 | 13.8043 | 15.8399 |
| 1984 | 5.7880 | 7.0880 | 2.6400 | 3.5070 | .8970 | .7150 | 1.0070 | .0210 | 2.6400 | 1.3000 | 122.4603 | 60.5909 | 45.6116 | 15.4976 | 12.3531 | 17.3981 |
| 1985 | 5.6990 | 6.8180 | 2.5010 | 3.2400 | .7740 | .6720 | 1.0300 | .0250 | 2.5010 | 1.1190 | 119.6350 | 56.8521 | 43.8849 | 13.5813 | 11.7915 | 18.0733 |
| 1986 | 5.5440 | 6.5080 | 2.3560 | 2.8440 | .8190 | .5100 | 1.0100 | .0170 | 2.3560 | .9640 | 117.3882 | 51.2987 | 42.4964 | 14.7727 | 9.1991 | 18.2179 |
| 1987 | 5.7780 | 6.7280 | 2.4380 | 2.9450 | .7210 | .6100 | 1.0920 | .0150 | 2.4380 | .9500 | 116.4417 | 50.9692 | 42.1945 | 12.4784 | 10.5573 | 18.8993 |

S6. KARNATAKA

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | 9.4590 | 9.7140 | .6100 | .6370 | .1400 | .2820 | .1370 | .0520 | .6100 | .2550 | 102.6958 | 6.7343 | 6.4489 | 1.4801 | 2.9813 | 1.4484 |
| 1953 | 9.7510 | 10.1060 | .6530 | .6960 | .1500 | .3080 | .1380 | .0600 | .6530 | .3550 | 103.6407 | 7.1377 | 6.6967 | 1.5383 | 3.1587 | 1.4152 |
| 1954 | 9.8100 | 10.1440 | .6960 | .7300 | .1590 | .3190 | .1420 | .0760 | .6960 | .3340 | 103.4047 | 7.4414 | 7.0948 | 1.6208 | 3.2518 | 1.4475 |
| 1955 | 9.8460 | 10.1870 | .7120 | .7280 | .1530 | .3280 | .1250 | .1060 | .7120 | .3410 | 103.4633 | 7.3939 | 7.2314 | 1.5539 | 3.3313 | 1.2696 |
| 1956 | 10.2800 | 10.2800 | .7320 | .7530 | .1630 | .3240 | .1280 | .1170 | .7320 | .0000 | 100.0000 | 7.3249 | 7.1206 | 1.5856 | 3.1518 | 1.2451 |
| 1957 | 10.0330 | 10.3740 | .7500 | .7790 | .1720 | .3320 | .1260 | .1200 | .7500 | .3410 | 103.3988 | 7.7644 | 7.4753 | 1.7143 | 3.3091 | 1.2559 |
| 1958 | 10.0570 | 10.4120 | .7690 | .8560 | .1890 | .3440 | .1220 | .1150 | .7690 | .3550 | 103.5299 | 8.5115 | 7.6464 | 1.8793 | 3.4205 | 1.2131 |
| 1959 | 10.0990 | 10.4730 | .7960 | .8980 | .2100 | .3450 | .1210 | .1210 | .7960 | .3740 | 103.7033 | 8.8920 | 7.8820 | 2.0794 | 3.4162 | 1.1981 |
| 1960 | 10.2280 | 10.5880 | .8580 | .9760 | .2360 | .3440 | .1330 | .1460 | .8580 | .3600 | 103.5197 | 9.5424 | 8.3887 | 2.3074 | 3.3633 | 1.3004 |
| 1961 | 10.2640 | 10.6420 | .9200 | 1.0190 | .2640 | .3600 | .1500 | .1470 | .9190 | .3780 | 103.6828 | 9.9279 | 8.9634 | 2.5721 | 3.5074 | 1.4614 |
| 1962 | 10.3960 | 10.7610 | .9410 | .9940 | .2690 | .3700 | .1560 | .1460 | .9410 | .3650 | 103.5110 | 9.5614 | 9.0516 | 2.5875 | 3.5591 | 1.5006 |
| 1963 | 10.4800 | 10.8520 | .9600 | 1.0070 | .2800 | .3770 | .1760 | .1280 | .9600 | .3720 | 103.5496 | 9.6088 | 9.1603 | 2.6718 | 3.5973 | 1.6794 |
| 1964 | 10.4030 | 10.7930 | 1.0310 | 1.0800 | .3540 | .3710 | .1730 | .1330 | 1.0310 | .3900 | 103.7489 | 10.3816 | 9.9106 | 3.4029 | 3.5663 | 1.6630 |
| 1965 | 10.0420 | 10.4300 | .9750 | 1.0380 | .3610 | .3240 | .1630 | .1280 | .9750 | .3880 | 103.8638 | 10.3366 | 9.7092 | 3.5949 | 3.2264 | 1.6232 |
| 1966 | 10.0140 | 10.9670 | 1.0220 | 1.1870 | .3760 | .3200 | .1780 | .1480 | 1.0220 | .9530 | 109.5167 | 11.8534 | 10.2057 | 3.7547 | 3.1955 | 1.7775 |
| 1967 | 9.9860 | 10.9170 | 1.0820 | 1.2210 | .4240 | .3390 | .1870 | .1320 | 1.0820 | .9310 | 109.3231 | 12.2271 | 10.8352 | 4.2459 | 3.3948 | 1.8726 |
| 1968 | 10.0490 | 10.5350 | 1.2340 | 1.3760 | .4480 | .3500 | .3170 | .1180 | 1.2340 | .4860 | 104.8363 | 13.6929 | 12.2798 | 4.4582 | 3.4829 | 3.1545 |
| 1969 | 10.1970 | 10.7930 | 1.1440 | 1.3050 | .3980 | .3730 | .2600 | .1130 | 1.1440 | .5960 | 105.8449 | 12.7979 | 11.2190 | 3.9031 | 3.6579 | 2.5498 |
| 1970 | 10.2480 | 10.8870 | 1.1370 | 1.3550 | .4210 | .3650 | .2590 | .0920 | 1.1370 | .6390 | 106.2354 | 13.2221 | 11.0948 | 4.1081 | 3.5617 | 2.5273 |
| 1971 | 10.3310 | 10.9880 | 1.3780 | 1.5980 | .4590 | .3740 | .4380 | .1050 | 1.3780 | .6570 | 106.3595 | 15.4680 | 13.3385 | 4.4429 | 3.6202 | 4.2397 |
| 1972 | 9.8080 | 10.4100 | 1.1470 | 1.3260 | .4350 | .3620 | .2470 | .1030 | 1.1470 | .6020 | 106.1378 | 13.5196 | 11.6945 | 4.4352 | 3.6909 | 2.5184 |
| 1973 | 10.2300 | 10.8930 | 1.2010 | 1.4220 | .4530 | .3660 | .2740 | .1080 | 1.2010 | .6630 | 106.4809 | 13.9003 | 11.7400 | 4.4282 | 3.5777 | 2.6784 |
| 1974 | 10.3600 | 10.9970 | 1.2680 | 1.4900 | .4820 | .3700 | .3000 | .1160 | 1.2680 | .6370 | 106.1486 | 14.3822 | 12.2394 | 4.6525 | 3.5714 | 2.8958 |
| 1975 | 10.3600 | 11.1590 | 1.3650 | 1.7070 | .4880 | .4100 | .3360 | .1310 | 1.3650 | .7990 | 107.7124 | 16.4768 | 13.1757 | 4.7104 | 3.9575 | 3.2432 |
| 1976 | 9.2060 | 9.8640 | 1.2160 | 1.4670 | .5130 | .2560 | .3270 | .1200 | 1.2150 | .6580 | 107.1475 | 15.9353 | 13.2088 | 5.5725 | 2.7808 | 3.5520 |
| 1977 | 10.2180 | 11.0360 | 1.3880 | 1.6990 | .5620 | .3480 | .3570 | .1210 | 1.3880 | .8180 | 108.0055 | 16.6275 | 13.5839 | 5.5001 | 3.4058 | 3.4938 |
| 1978 | 10.3150 | 11.1380 | 1.4090 | 1.7180 | .5710 | .3480 | .3570 | .1330 | 1.4080 | .8180 | 107.9302 | 16.6554 | 13.6597 | 5.5356 | 3.3737 | 3.4610 |
| 1979 | 10.3300 | 11.1120 | 1.3880 | 1.6890 | .5520 | .3440 | .3580 | .1340 | 1.3880 | .7820 | 107.5702 | 16.3504 | 13.4366 | 5.3437 | 3.3301 | 3.4656 |
| 1980 | 9.8990 | 10.6600 | 1.3610 | 1.6760 | .5470 | .3040 | .3640 | .1460 | 1.3610 | .7610 | 107.6876 | 16.9310 | 13.7489 | 5.5258 | 3.0710 | 3.6771 |
| 1981 | 10.3910 | 11.2280 | 1.4710 | 1.8010 | .5800 | .3210 | .4020 | .1670 | 1.4710 | .8370 | 108.0550 | 17.3323 | 14.1565 | 5.5818 | 3.0892 | 3.8687 |
| 1982 | 10.3560 | 11.1510 | 1.4860 | 1.7920 | .6050 | .2930 | .4180 | .1700 | 1.4860 | .7950 | 107.6767 | 17.3040 | 14.3492 | 5.8420 | 2.8293 | 4.0363 |
| 1983 | 10.6050 | 11.4760 | 1.5900 | 1.9450 | .6610 | .3170 | .4360 | .1760 | 1.5900 | .8710 | 108.2131 | 18.3404 | 14.9929 | 6.2329 | 2.9892 | 4.1113 |
| 1984 | 10.5490 | 11.6590 | 1.6930 | 2.1010 | .7050 | .3260 | .4620 | .2000 | 1.6930 | 1.1100 | 110.5223 | 19.9166 | 16.0489 | 6.6831 | 3.0903 | 4.3796 |
| 1985 | 10.1720 | 11.1460 | 1.6750 | 2.0120 | .7350 | .2420 | .4800 | .2170 | 1.6750 | .9740 | 109.5753 | 19.7798 | 16.4668 | 7.2257 | 2.3791 | 4.7188 |
| 1986 | 10.5330 | 11.8210 | 1.8160 | 2.2470 | .7990 | .2590 | .5240 | .2340 | 1.8160 | 1.2880 | 112.2282 | 21.3330 | 17.2411 | 7.5857 | 2.4589 | 4.9748 |
| 1987 | 10.7360 | 12.2450 | 1.8530 | 2.2960 | .7650 | .2580 | .5760 | .2540 | 1.8530 | 1.5090 | 114.0555 | 21.3860 | 17.2597 | 7.1256 | 2.4031 | 5.3651 |

S7. KERALA

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | 1.7230 | 2.0310 | .3190 | .3620 | .1470 | .0330 | .0100 | .1290 | .3190 | .3080 | 117.8758 | 21.0099 | 18.5142 | 8.5316 | 1.9153 | .5804 |
| 1953 | 1.7330 | 2.0870 | .3240 | .4220 | .1470 | .0350 | .0100 | .1290 | .3240 | .3540 | 120.4270 | 24.3508 | 18.6959 | 8.4824 | 2.0196 | .5770 |
| 1954 | 1.7450 | 2.0930 | .3300 | .4460 | .1570 | .0360 | .0110 | .1250 | .3300 | .3480 | 119.9427 | 25.5587 | 18.9112 | 8.9971 | 2.0630 | .6304 |
| 1955 | 1.7920 | 2.1760 | .3240 | .4380 | .1580 | .0310 | .0110 | .1240 | .3240 | .3840 | 121.4286 | 24.4420 | 18.0804 | 8.8170 | 1.7299 | .6138 |
| 1956 | 1.8100 | 2.1530 | .3320 | .4440 | .1660 | .0310 | .0110 | .1240 | .3320 | .3430 | 118.9503 | 24.5304 | 18.3425 | 9.1713 | 1.7127 | .6077 |
| 1957 | 1.8180 | 2.1850 | .3400 | .4880 | .1720 | .0320 | .0110 | .1250 | .3400 | .3670 | 120.1870 | 26.8427 | 18.7019 | 9.4609 | 1.7602 | .6051 |
| 1958 | 1.8350 | 2.2150 | .3520 | .5070 | .1800 | .0320 | .0140 | .1260 | .3520 | .3800 | 120.7084 | 27.6294 | 19.1826 | 9.8093 | 1.7439 | .7629 |
| 1959 | 1.8820 | 2.2790 | .3520 | .5070 | .1800 | .0320 | .0140 | .1260 | .3520 | .3970 | 121.0946 | 26.9394 | 18.7035 | 9.5643 | 1.7003 | .7439 |
| 1960 | 1.9240 | 2.3490 | .3190 | .4560 | .1390 | .0470 | .0020 | .1310 | .3190 | .4250 | 122.0894 | 23.7006 | 16.5800 | 7.2245 | 2.4428 | .1040 |
| 1961 | 1.9320 | 2.3410 | .3270 | .4660 | .1460 | .0480 | .0020 | .1310 | .3270 | .4090 | 121.1698 | 24.1201 | 16.9255 | 7.5569 | 2.4845 | .1035 |
| 1962 | 2.0090 | 2.4470 | .3360 | .4760 | .1540 | .0500 | .0020 | .1310 | .3360 | .4380 | 121.8019 | 23.6934 | 16.7247 | 7.6655 | 2.4888 | .0996 |
| 1963 | 2.0220 | 2.4620 | .3470 | .4880 | .1620 | .0520 | .0020 | .1320 | .3470 | .4400 | 121.7606 | 24.1345 | 17.1612 | 8.0119 | 2.5717 | .0989 |
| 1964 | 2.0370 | 2.4890 | .3520 | .4940 | .1700 | .0560 | .0040 | .1220 | .3520 | .4520 | 122.1895 | 24.2514 | 17.2803 | 8.3456 | 2.7491 | .1964 |
| 1965 | 2.0640 | 2.5510 | .3620 | .5090 | .1770 | .0600 | .0040 | .1210 | .3620 | .4870 | 123.5950 | 24.6609 | 17.5388 | 8.5756 | 2.9070 | .1938 |
| 1966 | 2.0910 | 2.6220 | .3930 | .5270 | .1900 | .0730 | .0050 | .1870 | .3930 | .5310 | 125.3945 | 25.2033 | 18.7948 | 9.0866 | 3.4912 | .2391 |
| 1967 | 2.1290 | 2.7570 | .4110 | .5720 | .1930 | .0710 | .0060 | .1440 | .4110 | .6280 | 129.4974 | 26.8671 | 19.3048 | 9.0653 | 3.3349 | .2818 |
| 1968 | 2.1590 | 2.8530 | .4180 | .5880 | .1990 | .0710 | .0060 | .1420 | .4180 | .6940 | 132.1445 | 27.2348 | 19.3608 | 9.2172 | 3.2886 | .2779 |
| 1969 | 2.1660 | 2.9160 | .4230 | .5890 | .2040 | .0720 | .0050 | .1420 | .4230 | .7500 | 134.6260 | 27.1930 | 19.5291 | 9.4183 | 3.3241 | .2308 |
| 1970 | 2.1720 | 2.9330 | .4310 | .6010 | .2110 | .0730 | .0050 | .1420 | .4310 | .7610 | 135.0368 | 27.6703 | 19.8435 | 9.7145 | 3.3610 | .2302 |
| 1971 | 2.1870 | 2.9580 | .4390 | .6120 | .2170 | .0740 | .0060 | .1420 | .4390 | .7710 | 135.2538 | 27.9835 | 20.0732 | 9.9223 | 3.3836 | .2743 |
| 1972 | 2.1970 | 2.9870 | .4460 | .6230 | .2240 | .0750 | .0060 | .1420 | .4460 | .7900 | 135.9581 | 28.3569 | 20.3004 | 10.1957 | 3.4137 | .2731 |
| 1973 | 2.2020 | 2.9990 | .4570 | .6380 | .2320 | .0760 | .0060 | .1440 | .4570 | .7970 | 136.1944 | 28.9737 | 20.7539 | 10.5359 | 3.4514 | .2725 |
| 1974 | 2.2080 | 3.0280 | .4640 | .6520 | .2380 | .0760 | .0060 | .1450 | .4650 | .8200 | 137.1377 | 29.5290 | 21.0145 | 10.7790 | 3.4420 | .2717 |
| 1975 | 2.1390 | 2.9810 | .2280 | .3270 | .0860 | .0580 | .0000 | .0310 | .2280 | .8420 | 139.3642 | 15.2875 | 10.6592 | 4.0206 | 2.7115 | .0000 |
| 1976 | 2.2010 | 2.9330 | .2210 | .3730 | .0930 | .0520 | .0000 | .0300 | .2210 | .7320 | 133.2576 | 16.9468 | 10.0409 | 4.2254 | 2.3626 | .0000 |
| 1977 | 2.2010 | 2.9240 | .2280 | .3540 | .1010 | .0540 | .0000 | .0300 | .2280 | .7230 | 132.8487 | 16.0836 | 10.3589 | 4.5888 | 2.4534 | .0000 |
| 1978 | 2.2040 | 2.8860 | .2280 | .3540 | .1030 | .0570 | .0000 | .0690 | .2300 | .6820 | 130.9437 | 16.0617 | 10.3448 | 4.6733 | 2.5862 | .0000 |
| 1979 | 2.1950 | 2.8540 | .2310 | .3980 | .1070 | .0580 | .0000 | .0670 | .2310 | .6590 | 130.0228 | 18.1321 | 10.5239 | 4.8747 | 2.6424 | .0000 |
| 1980 | 2.1800 | 2.8620 | .2380 | .3810 | .1050 | .0560 | .0000 | .0770 | .2380 | .6820 | 131.2844 | 17.4771 | 10.9174 | 4.8165 | 2.5688 | .0000 |
| 1981 | 2.1700 | 2.9050 | .2400 | .3830 | .1060 | .0570 | .0000 | .0770 | .2400 | .7350 | 133.8710 | 17.6498 | 11.0599 | 4.8848 | 2.6267 | .0000 |
| 1982 | 2.1800 | 2.8620 | .2590 | .3890 | .1090 | .0620 | .0000 | .0880 | .2590 | .6820 | 131.2844 | 17.8440 | 11.8807 | 5.0000 | 2.8440 | .0000 |
| 1983 | 2.1800 | 2.8610 | .2660 | .3960 | .1040 | .0360 | .0310 | .0950 | .2660 | .6810 | 131.2385 | 18.1651 | 12.2018 | 4.7706 | 1.6514 | 1.4220 |
| 1984 | 2.1840 | 2.8740 | .2710 | .4230 | .0980 | .0380 | .0340 | .1010 | .2710 | .6900 | 131.5934 | 19.3681 | 12.4084 | 4.4872 | 1.7399 | 1.5568 |
| 1985 | 2.1910 | 2.8660 | .2960 | .3990 | .1000 | .0440 | .0380 | .1140 | .2960 | .6750 | 130.8079 | 18.2109 | 13.5098 | 4.5641 | 2.0082 | 1.7344 |
| 1986 | 2.2070 | 2.8700 | .2990 | .4260 | .1020 | .0440 | .0450 | .1080 | .2990 | .6630 | 130.0408 | 19.3022 | 13.5478 | 4.6217 | 1.9937 | 2.0390 |
| 1987 | 2.2110 | 2.9000 | .3060 | .3930 | .1070 | .0450 | .0500 | .1040 | .3060 | .6890 | 131.1624 | 17.7748 | 13.8399 | 4.8394 | 2.0353 | 2.2614 |

S8. MADHYA PRADESH

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | 14.5340 | 16.1520 | .7950 | .8140 | .3750 | .1230 | .2620 | .0350 | .7950 | 1.6180 | 111.1325 | 5.6007 | 5.4699 | 2.5802 | .8463 | 1.8027 |
| 1953 | 15.0160 | 16.6190 | .8200 | .8340 | .3540 | .1590 | .2650 | .0400 | .8200 | 1.6030 | 110.6753 | 5.5541 | 5.4608 | 2.3575 | 1.0589 | 1.7648 |
| 1954 | 15.2760 | 16.9610 | .8280 | .8430 | .3770 | .1330 | .2790 | .0390 | .8280 | 1.6850 | 111.0304 | 5.5185 | 5.4203 | 2.4679 | .8706 | 1.8264 |
| 1955 | 15.5420 | 17.3590 | .8150 | .8280 | .3660 | .1170 | .2940 | .0380 | .8150 | 1.8170 | 111.6909 | 5.3275 | 5.2439 | 2.3549 | .7528 | 1.8916 |
| 1956 | 15.3410 | 17.4290 | .8200 | .8300 | .3830 | .1080 | .2910 | .0350 | .8200 | 2.0880 | 113.6106 | 5.4103 | 5.3452 | 2.4966 | .7040 | 1.8969 |
| 1957 | 15.0660 | 16.3890 | .9740 | .9880 | .3930 | .2400 | .2960 | .0420 | .9740 | 1.3230 | 108.7814 | 6.5578 | 6.4649 | 2.6085 | 1.5930 | 1.9647 |
| 1958 | 15.5140 | 17.5250 | .8290 | .8380 | .3820 | .1240 | .2960 | .0360 | .8290 | 2.0110 | 112.9625 | 5.4016 | 5.3436 | 2.4623 | .7993 | 1.9080 |
| 1959 | 15.8220 | 17.9730 | .9160 | .9310 | .4330 | .1210 | .3210 | .0360 | .9130 | 2.1510 | 113.5950 | 5.8842 | 5.7894 | 2.7367 | .7648 | 2.0288 |
| 1960 | 16.1040 | 18.1940 | .9230 | .9380 | .4400 | .1220 | .3240 | .0370 | .9230 | 2.0900 | 112.9781 | 5.8246 | 5.7315 | 2.7322 | .7576 | 2.0119 |
| 1961 | 16.2510 | 18.5060 | .9440 | .9600 | .4560 | .1250 | .3280 | .0350 | .9440 | 2.2550 | 113.8761 | 5.9073 | 5.8089 | 2.8060 | .7692 | 2.0183 |
| 1962 | 16.3530 | 18.4070 | 1.0210 | 1.0360 | .4630 | .1740 | .3420 | .0420 | 1.0210 | 2.0540 | 112.5604 | 6.3352 | 6.2435 | 2.8313 | 1.0640 | 2.0914 |
| 1963 | 16.5210 | 18.7430 | 1.0350 | 1.0550 | .4940 | .1400 | .3610 | .0390 | 1.0350 | 2.2220 | 113.4495 | 6.3858 | 6.2648 | 2.9901 | .8474 | 2.1851 |
| 1964 | 16.7350 | 18.9630 | 1.0770 | 1.0990 | .5440 | .1270 | .3640 | .0420 | 1.0770 | 2.2280 | 113.3134 | 6.5671 | 6.4356 | 3.2507 | .7589 | 2.1751 |
| 1965 | 16.5280 | 17.7860 | .9760 | 1.0000 | .4610 | .1180 | .3450 | .0520 | .9760 | 1.2580 | 107.6113 | 6.0503 | 5.9051 | 2.7892 | .7139 | 2.0874 |
| 1966 | 17.2050 | 18.3360 | 1.0890 | 1.1130 | .4690 | .1960 | .3700 | .0530 | 1.0890 | 1.1310 | 106.5737 | 6.4690 | 6.3296 | 2.7260 | 1.1392 | 2.1505 |
| 1967 | 17.7970 | 19.6520 | 1.1430 | 1.1620 | .5580 | .1290 | .4100 | .0440 | 1.1430 | 1.8550 | 110.4231 | 6.5292 | 6.4224 | 3.1354 | .7248 | 2.3038 |
| 1968 | 18.2740 | 19.9130 | 1.3100 | 1.3630 | .6250 | .1770 | .4490 | .0580 | 1.3090 | 1.6390 | 108.9690 | 7.4587 | 7.1687 | 3.4202 | .9686 | 2.4570 |
| 1969 | 18.2820 | 20.7180 | 1.4310 | 1.4710 | .6690 | .1750 | .5180 | .0690 | 1.4310 | 2.4360 | 113.3246 | 8.0462 | 7.8274 | 3.6593 | .9572 | 2.8334 |
| 1970 | 18.3520 | 20.5620 | 1.4810 | 1.5230 | .7100 | .1300 | .5620 | .0780 | 1.4800 | 2.2100 | 112.0423 | 8.2988 | 8.0700 | 3.8688 | .7084 | 3.0623 |
| 1971 | 18.4610 | 20.8920 | 1.6430 | 1.7050 | .7660 | .1540 | .6200 | .1030 | 1.6420 | 2.4310 | 113.1683 | 9.2357 | 8.8998 | 4.1493 | .8342 | 3.3584 |
| 1972 | 18.4970 | 20.7420 | 1.6990 | 1.7620 | .7790 | .1460 | .6440 | .1300 | 1.6990 | 2.2450 | 112.1371 | 9.5259 | 9.1853 | 4.2115 | .7893 | 3.4816 |
| 1973 | 18.5590 | 21.2120 | 1.6450 | 1.7330 | .7130 | .1190 | .6750 | .1370 | 1.6450 | 2.6530 | 114.2950 | 9.3378 | 8.8636 | 3.8418 | .6412 | 3.6370 |
| 1974 | 18.5160 | 20.5120 | 1.6350 | 1.7010 | .6790 | .1520 | .6700 | .1350 | 1.6350 | 1.9960 | 110.7799 | 9.1866 | 8.8302 | 3.6671 | .8209 | 3.6185 |
| 1975 | 18.7150 | 21.3560 | 1.8040 | 1.8960 | .8010 | .1320 | .7260 | .1450 | 1.8040 | 2.6410 | 114.1117 | 10.1309 | 9.6393 | 4.2800 | .7053 | 3.8792 |
| 1976 | 18.5340 | 20.8570 | 1.9820 | 2.0500 | .8740 | .1790 | .7750 | .1540 | 1.9820 | 2.3230 | 112.5337 | 11.0608 | 10.6939 | 4.7157 | .9658 | 4.1815 |
| 1977 | 18.7980 | 21.5080 | 2.1530 | 2.2380 | .9720 | .1430 | .8570 | .1800 | 2.1530 | 2.7100 | 114.4164 | 11.9055 | 11.4533 | 5.1708 | .7607 | 4.5590 |
| 1978 | 18.8470 | 21.7470 | 2.3150 | 2.4130 | 1.0640 | .1400 | .8970 | .1670 | 2.3150 | 2.9000 | 115.3871 | 12.8031 | 12.2831 | 5.6455 | .7428 | 4.7594 |
| 1979 | 18.4000 | 20.8260 | 2.1390 | 2.2280 | .9150 | .1400 | .9200 | .1640 | 2.1390 | 2.4260 | 113.1848 | 12.1087 | 11.6250 | 4.9728 | .7609 | 5.0000 |
| 1980 | 18.7020 | 21.4020 | 2.3320 | 2.4530 | 1.0340 | .1360 | .9870 | .1750 | 2.3320 | 2.7000 | 114.4370 | 13.1162 | 12.4693 | 5.5288 | .7272 | 5.1775 |
| 1981 | 18.8410 | 21.7570 | 2.4210 | 2.5110 | 1.0840 | .1350 | 1.0000 | .2020 | 2.4210 | 2.9160 | 115.4769 | 13.3273 | 12.8496 | 5.7534 | .7165 | 5.3076 |
| 1982 | 19.0270 | 22.2150 | 2.6560 | 2.7440 | 1.1600 | .1860 | 1.1230 | .1860 | 2.6560 | 3.1880 | 116.7551 | 14.4216 | 13.9591 | 6.0966 | .9776 | 5.9021 |
| 1983 | 19.2230 | 22.6280 | 2.7720 | 2.8670 | 1.2120 | .1490 | 1.1920 | .2190 | 2.7720 | 3.4050 | 117.7132 | 14.9144 | 14.4202 | 6.3049 | .7751 | 6.2009 |
| 1984 | 19.2050 | 22.4060 | 3.0100 | 3.1050 | 1.2670 | .2050 | 1.2840 | .2540 | 3.0100 | 3.2010 | 116.6675 | 16.1677 | 15.6730 | 6.5972 | 1.0674 | 6.6858 |
| 1985 | 19.4130 | 23.0160 | 2.9870 | 3.0880 | 1.2960 | .1450 | 1.2970 | .2490 | 2.9870 | 3.6030 | 118.5597 | 15.9069 | 15.3866 | 6.6759 | .7469 | 6.6811 |
| 1986 | 19.1020 | 22.2140 | 3.3450 | 3.4560 | 1.3940 | .1980 | 1.4290 | .3240 | 3.3450 | 3.1120 | 116.2915 | 18.0923 | 17.5113 | 7.2977 | 1.0365 | 7.4809 |
| 1987 | 19.3060 | 22.6940 | 3.3310 | 3.4370 | 1.3680 | .1520 | 1.4760 | .3350 | 3.3310 | 3.3880 | 117.5489 | 17.8028 | 17.2537 | 7.0859 | .7873 | 7.6453 |

S9. MAHARASHTRA

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | 17.6240 | 18.5800 | 1.0060 | 1.1570 | .2400 | .1810 | .5490 | .0360 | 1.0060 | .9560 | 105.4244 | 6.5649 | 5.7081 | 1.3618 | 1.0270 | 3.1151 |
| 1960 | 17.8790 | 18.8230 | 1.0720 | 1.2200 | .2430 | .1930 | .5950 | .0410 | 1.0720 | .9440 | 105.2799 | 6.8236 | 5.9959 | 1.3591 | 1.0795 | 3.3279 |
| 1961 | 18.0530 | 19.0940 | 1.0810 | 1.2330 | .2420 | .1870 | .6110 | .0430 | 1.0810 | 1.0410 | 105.7664 | 6.8299 | 5.9879 | 1.3405 | 1.0358 | 3.3845 |
| 1962 | 18.0120 | 18.9630 | 1.1260 | 1.2780 | .2550 | .2000 | .6320 | .0400 | 1.1260 | .9510 | 105.2798 | 7.0953 | 6.2514 | 1.4157 | 1.1104 | 3.5088 |
| 1963 | 18.1780 | 19.1740 | 1.1500 | 1.3140 | .2510 | .2070 | .6510 | .0420 | 1.1500 | .9960 | 105.4792 | 7.2285 | 6.3263 | 1.3808 | 1.1387 | 3.5813 |
| 1964 | 18.2540 | 19.2160 | 1.1910 | 1.3640 | .2480 | .2130 | .6830 | .0470 | 1.1910 | .9620 | 105.2701 | 7.4723 | 6.5246 | 1.3586 | 1.1669 | 3.7416 |
| 1965 | 18.1330 | 18.9720 | 1.2060 | 1.3880 | .2490 | .1900 | .7110 | .0560 | 1.2060 | .8390 | 104.6269 | 7.6546 | 6.6509 | 1.3732 | 1.0478 | 3.9210 |
| 1966 | 18.2130 | 19.1900 | 1.2160 | 1.4130 | .2440 | .2130 | .6960 | .0620 | 1.2170 | .9770 | 105.3643 | 7.7582 | 6.6765 | 1.3397 | 1.1695 | 3.8214 |
| 1967 | 18.2670 | 19.1970 | 1.2770 | 1.4810 | .2790 | .2190 | .7210 | .0580 | 1.2770 | .9300 | 105.0911 | 8.1075 | 6.9907 | 1.5273 | 1.1989 | 3.9470 |
| 1968 | 18.3670 | 19.3670 | 1.3750 | 1.5570 | .2760 | .2240 | .7970 | .0780 | 1.3750 | 1.0000 | 105.4445 | 8.4772 | 7.4863 | 1.5027 | 1.2196 | 4.3393 |
| 1969 | 18.4620 | 19.4350 | 1.4310 | 1.6230 | .3120 | .2250 | .8210 | .0730 | 1.4310 | .9730 | 105.2703 | 8.7910 | 7.7511 | 1.6900 | 1.2187 | 4.4470 |
| 1970 | 18.3040 | 19.3040 | 1.3470 | 1.5700 | .3120 | .2250 | .8210 | .0690 | 1.4270 | 1.0000 | 105.4633 | 8.5774 | 7.3590 | 1.7045 | 1.2292 | 4.4854 |
| 1971 | 17.0360 | 18.1150 | 1.3670 | 1.6220 | .3070 | .2130 | .7710 | .0770 | 1.3670 | 1.0790 | 106.3336 | 9.5210 | 8.0242 | 1.8021 | 1.2503 | 4.5257 |
| 1972 | 16.0600 | 16.9800 | 1.2760 | 1.4680 | .2580 | .1960 | .7130 | .1090 | 1.2760 | .9200 | 105.7285 | 9.1407 | 7.9452 | 1.6065 | 1.2204 | 4.4396 |
| 1973 | 18.3240 | 19.4860 | 1.4720 | 1.7640 | .2990 | .2220 | .8400 | .1110 | 1.4720 | 1.1620 | 106.3414 | 9.6267 | 8.0332 | 1.6317 | 1.2115 | 4.5842 |
| 1974 | 18.2060 | 19.5060 | 1.6120 | 1.9320 | .3390 | .2020 | .9660 | .1050 | 1.6120 | 1.3000 | 107.1405 | 10.6119 | 8.8542 | 1.8620 | 1.1095 | 5.3059 |
| 1975 | 18.2620 | 19.6630 | 1.8020 | 2.1710 | .3590 | .2460 | 1.0840 | .1120 | 1.8020 | 1.4010 | 107.6717 | 11.8881 | 9.8675 | 1.9658 | 1.3471 | 5.9358 |
| 1976 | 18.2050 | 19.7860 | 1.8330 | 2.2420 | .3710 | .2540 | 1.0920 | .1160 | 1.8330 | 1.5810 | 108.6844 | 12.3153 | 10.0687 | 2.0379 | 1.3952 | 5.9984 |
| 1977 | 18.2260 | 19.8290 | 1.8920 | 2.3060 | .3990 | .2730 | 1.1010 | .1230 | 1.8960 | 1.6030 | 108.7951 | 12.6523 | 10.3808 | 2.1892 | 1.4979 | 6.0408 |
| 1978 | 18.2480 | 19.9150 | 1.9270 | 2.3060 | .3990 | .2730 | 1.1010 | .1230 | 1.8960 | 1.6670 | 109.1352 | 12.6370 | 10.5601 | 2.1865 | 1.4961 | 6.0335 |
| 1979 | 18.1830 | 19.9650 | 1.9270 | 2.4550 | .4120 | .2820 | 1.1410 | .1280 | 1.9640 | 1.7820 | 109.8004 | 13.5016 | 10.5978 | 2.2659 | 1.5509 | 6.2751 |
| 1980 | 18.2990 | 20.1330 | 1.9640 | 2.5160 | .4120 | .2820 | 1.1410 | .1280 | 1.9640 | 1.8340 | 110.0224 | 13.7494 | 10.7328 | 2.2515 | 1.5411 | 6.2353 |
| 1981 | 18.3140 | 20.3860 | 1.9640 | 2.6860 | .4120 | .2820 | 1.1410 | .1280 | 1.9640 | 2.0720 | 111.3137 | 14.6664 | 10.7240 | 2.2496 | 1.5398 | 6.2302 |
| 1982 | 18.3020 | 19.9570 | 1.9270 | 2.6860 | .4170 | .2850 | 1.0970 | .1280 | 1.9270 | 1.6550 | 109.0427 | 14.6760 | 10.5289 | 2.2784 | 1.5572 | 5.9939 |
| 1983 | 18.3020 | 21.1300 | 1.9640 | 2.6860 | .4130 | .2830 | 1.1410 | .1270 | 1.9640 | 2.8280 | 115.4519 | 14.6760 | 10.7311 | 2.2566 | 1.5463 | 6.2343 |
| 1984 | 18.0470 | 20.4260 | 1.9640 | 2.6860 | .4120 | .2820 | 1.1410 | .1280 | 1.9640 | 2.3790 | 113.1822 | 14.8834 | 10.8827 | 2.2829 | 1.5626 | 6.3224 |
| 1985 | 18.1850 | 20.5370 | 1.8810 | 2.4670 | .4100 | .2810 | 1.0630 | .1270 | 1.8810 | 2.3520 | 112.9337 | 13.5661 | 10.3437 | 2.2546 | 1.5452 | 5.8455 |
| 1986 | 18.1060 | 20.1200 | 1.8810 | 2.3430 | .4100 | .2810 | 1.0630 | .1270 | 1.8810 | 2.0140 | 111.1234 | 12.9405 | 10.3888 | 2.2644 | 1.5520 | 5.8710 |
| 1987 | 18.1120 | 20.7430 | 1.8810 | 2.3810 | .4100 | .2810 | 1.0630 | .1270 | 1.8810 | 2.6310 | 114.5263 | 13.1460 | 10.3854 | 2.2637 | 1.5515 | 5.8690 |

S10. GUJARAT

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | 9.2750 | 9.8190 | .6200 | .6810 | .0660 | .0210 | .5140 | .0200 | .6200 | .5440 | 105.8652 | 7.3423 | 6.6846 | .7116 | .2264 | 5.5418 |
| 1960 | 9.3970 | 9.7670 | .6850 | .7340 | .0660 | .0130 | .5680 | .0360 | .6830 | .3700 | 103.9374 | 7.8110 | 7.2896 | .7024 | .1383 | 6.0445 |
| 1961 | 9.5640 | 10.1270 | .7500 | .7890 | .1050 | .0180 | .5900 | .0360 | .7500 | .5630 | 105.8867 | 8.2497 | 7.8419 | 1.0979 | .1882 | 6.1690 |
| 1962 | 9.5190 | 9.9770 | .6660 | .6970 | .0970 | .0180 | .5320 | .0200 | .6660 | .4580 | 104.8114 | 7.3222 | 6.9965 | 1.0190 | .1891 | 5.5888 |
| 1963 | 9.4130 | 9.8870 | .7090 | .7410 | .0980 | .0180 | .5650 | .0290 | .7100 | .4740 | 105.0356 | 7.8721 | 7.5321 | 1.0411 | .1912 | 6.0023 |
| 1964 | 9.6610 | 10.1340 | .8840 | .9130 | .1220 | .0330 | .7000 | .0290 | .8840 | .4730 | 104.8960 | 9.4504 | 9.1502 | 1.2628 | .3416 | 7.2456 |
| 1965 | 9.6880 | 10.1880 | 1.0410 | 1.0720 | .1400 | .0300 | .8610 | .0100 | 1.0410 | .5000 | 105.1610 | 11.0652 | 10.7453 | 1.4451 | .3097 | 8.8873 |
| 1966 | 9.7460 | 10.1990 | 1.0170 | 1.0570 | .1670 | .0330 | .8060 | .0110 | 1.0170 | .4530 | 104.6481 | 10.8455 | 10.4351 | 1.7135 | .3386 | 8.2701 |
| 1967 | 9.8020 | 10.4200 | 1.1080 | 1.1660 | .1990 | .0340 | .8470 | .0090 | 1.1080 | .6180 | 106.3048 | 11.8955 | 11.3038 | 2.0302 | .3469 | 8.6411 |
| 1968 | 9.5920 | 10.1820 | 1.1500 | 1.2500 | .1990 | .0340 | .8660 | .0090 | 1.1790 | .5900 | 106.1510 | 13.0317 | 11.9892 | 2.0746 | .3545 | 9.0284 |
| 1969 | 9.4280 | 10.0450 | 1.2080 | 1.3070 | .1970 | .0280 | .9170 | .0090 | 1.1500 | .6170 | 106.5443 | 13.8630 | 12.8129 | 2.0895 | .2970 | 9.7263 |
| 1970 | 9.4230 | 10.0450 | 1.3710 | 1.4940 | .2070 | .0300 | .9620 | .0100 | 1.2090 | .6220 | 106.6009 | 15.8548 | 14.5495 | 2.1968 | .3184 | 10.2091 |
| 1971 | 9.7620 | 10.4790 | 1.4070 | 1.5250 | .2310 | .0400 | 1.1160 | .0200 | 1.4070 | .7170 | 107.3448 | 15.6218 | 14.4130 | 2.3663 | .4098 | 11.4321 |
| 1972 | 9.6020 | 10.2590 | 1.3410 | 1.5210 | .1930 | .0350 | 1.0930 | .0200 | 1.3410 | .6570 | 106.8423 | 15.8404 | 13.9658 | 2.0100 | .3645 | 11.3830 |
| 1973 | 9.7600 | 10.4920 | 1.4020 | 1.5910 | .2420 | .0250 | 1.1190 | .0150 | 1.4020 | .7320 | 107.5000 | 16.3012 | 14.3648 | 2.4795 | .2561 | 11.4652 |
| 1974 | 8.2050 | 8.8500 | 1.3500 | 1.5230 | .2270 | .0200 | 1.0900 | .0130 | 1.3500 | .6450 | 107.8611 | 18.5619 | 16.4534 | 2.7666 | .2438 | 13.2846 |
| 1975 | 9.6470 | 10.4490 | 1.5140 | 1.7090 | .2840 | .0250 | 1.1900 | .0150 | 1.5140 | .8020 | 108.3135 | 17.7154 | 15.6940 | 2.9439 | .2591 | 12.3354 |
| 1976 | 9.5240 | 10.3530 | 1.5670 | 1.7740 | .3040 | .0320 | 1.2230 | .0080 | 1.5670 | .8290 | 108.7043 | 18.6266 | 16.4532 | 3.1919 | .3360 | 12.8412 |
| 1977 | 9.5420 | 10.3890 | 1.7150 | 1.9360 | .3270 | .0330 | 1.3460 | .0090 | 1.7150 | .8470 | 108.8765 | 20.2892 | 17.9732 | 3.4270 | .3458 | 14.1061 |
| 1978 | 9.5710 | 10.4550 | 1.7810 | 2.0200 | .3270 | .0330 | 1.3460 | .0090 | 1.7150 | .8840 | 109.2362 | 21.1054 | 18.6083 | 3.4166 | .3448 | 14.0633 |
| 1979 | 9.5720 | 10.6050 | 1.9320 | 2.2110 | .3460 | .0400 | 1.5380 | .0100 | 1.9320 | 1.0330 | 110.7919 | 23.0986 | 20.1839 | 3.6147 | .4179 | 16.0677 |
| 1980 | 9.5770 | 10.6950 | 2.0030 | 2.3340 | .3670 | .0410 | 1.5880 | .0090 | 2.0020 | 1.1180 | 111.6738 | 24.3709 | 20.9147 | 3.8321 | .4281 | 16.5814 |
| 1981 | 9.6700 | 10.9030 | 2.1550 | 2.5230 | .4210 | .0400 | 1.6900 | .0050 | 2.1550 | 1.2330 | 112.7508 | 26.0910 | 22.2854 | 4.3537 | .4137 | 17.4767 |
| 1982 | 9.6700 | 10.1890 | 2.1550 | 2.5220 | .4210 | .0400 | 1.6890 | .0050 | 2.1550 | .5190 | 105.3671 | 26.0807 | 22.2854 | 4.3537 | .4137 | 17.4664 |
| 1983 | 9.5830 | 10.4230 | 2.2400 | 2.6140 | .4300 | .0410 | 1.7640 | .0050 | 2.2400 | .8400 | 108.7655 | 27.2775 | 23.3747 | 4.4871 | .4278 | 18.4076 |
| 1984 | 9.5830 | 10.2640 | 2.2400 | 2.6140 | .4300 | .0410 | 1.7640 | .0050 | 2.2400 | .6810 | 107.1063 | 27.2775 | 23.3747 | 4.4871 | .4278 | 18.4076 |
| 1985 | 9.6170 | 9.6830 | 2.2710 | 2.7970 | .4890 | .0410 | 1.7370 | .0040 | 2.2710 | .0660 | 100.6863 | 29.0839 | 23.6144 | 5.0847 | .4263 | 18.0618 |
| 1986 | 9.4020 | 10.3840 | 2.0390 | 2.3810 | .3590 | .0250 | 1.6530 | .0020 | 2.0390 | .9820 | 110.4446 | 25.3244 | 21.6869 | 3.8183 | .2659 | 17.5814 |
| 1987 | 9.4020 | 10.3840 | 2.0390 | 2.3810 | .3590 | .0250 | 1.6530 | .0020 | 2.0390 | .9820 | 110.4446 | 25.3244 | 21.6869 | 3.8183 | .2659 | 17.5814 |

S11. BIHAR

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 8.8460 | 10.7990 | 2.2380 | 2.2380 | .6550 | .4600 | .1840 | .8660 | 2.2380 | 1.9530 | 122.0778 | 25.2996 | 25.2996 | 7.4045 | 5.2001 | 2.0800 |
| 1951 | 8.6000 | 10.7620 | 1.6440 | 1.6440 | .6260 | .3160 | .2000 | .4490 | 1.6440 | 2.1620 | 125.1395 | 19.1163 | 19.1163 | 7.2791 | 3.6744 | 2.3256 |
| 1952 | 8.1770 | 10.7050 | 1.8800 | 1.8860 | .6830 | .4060 | .2280 | .5680 | 1.8790 | 2.5280 | 130.9160 | 23.0647 | 22.9913 | 8.3527 | 4.9651 | 2.7883 |
| 1953 | 7.7490 | 10.1760 | 1.7020 | 1.7020 | .5660 | .3350 | .2180 | .5830 | 1.7020 | 2.4270 | 131.3202 | 21.9641 | 21.9641 | 7.3042 | 4.3231 | 2.8133 |
| 1954 | 7.6200 | 9.5110 | 1.6150 | 1.6150 | .4200 | .2580 | .1810 | .7560 | 1.6150 | 1.8910 | 124.8163 | 21.1942 | 21.1942 | 5.5118 | 3.3858 | 2.3753 |
| 1955 | 7.5420 | 9.7990 | 1.7620 | 1.7620 | .6150 | .3020 | .1610 | .6840 | 1.7620 | 2.2570 | 129.9257 | 23.3625 | 23.3625 | 8.1543 | 4.0042 | 2.1347 |
| 1956 | 7.6760 | 10.0340 | 1.7540 | 1.7540 | .6060 | .2380 | .2100 | .6990 | 1.7530 | 2.3580 | 130.7191 | 22.8504 | 22.8504 | 7.8947 | 3.1006 | 2.7358 |
| 1957 | 7.1780 | 9.4700 | 1.8810 | 1.8810 | .6550 | .2620 | .2830 | .6800 | 1.8810 | 2.2920 | 131.9309 | 26.2051 | 26.2051 | 9.1251 | 3.6500 | 3.9426 |
| 1958 | 7.8760 | 10.9510 | 2.0360 | 2.0360 | .5740 | .4100 | .2730 | .7800 | 2.0360 | 3.0750 | 139.0427 | 25.8507 | 25.8507 | 7.2880 | 5.2057 | 3.4662 |
| 1959 | 7.8870 | 10.8040 | 1.7850 | 1.7850 | .5890 | .2940 | .2580 | .6450 | 1.7860 | 2.9170 | 136.9849 | 22.6322 | 22.6322 | 7.4680 | 3.7277 | 3.2712 |
| 1960 | 8.0320 | 11.1070 | 2.0620 | 2.0620 | .6510 | .3230 | .2610 | .8260 | 2.0620 | 3.0750 | 138.2844 | 25.6723 | 25.6723 | 8.1051 | 4.0214 | 3.2495 |
| 1961 | 8.3500 | 11.1330 | 1.9420 | 2.1870 | .5610 | .2240 | .3590 | .8310 | 1.9420 | 2.7830 | 133.3293 | 26.1916 | 23.2575 | 6.7186 | 2.6826 | 4.2994 |
| 1962 | 8.3440 | 11.0820 | 1.9840 | 2.2040 | .5970 | .2890 | .3100 | .7880 | 1.9840 | 2.7380 | 132.8140 | 26.4142 | 23.7776 | 7.1548 | 3.4636 | 3.7152 |
| 1963 | 8.5460 | 11.0490 | 1.9990 | 2.2260 | .6440 | .2570 | .3140 | .7840 | 1.9990 | 2.5030 | 129.2886 | 26.0473 | 23.3911 | 7.5357 | 3.0073 | 3.6742 |
| 1964 | 8.5440 | 10.8310 | 1.9800 | 2.2080 | .5960 | .2000 | .3130 | .8720 | 1.9800 | 2.2870 | 126.7673 | 25.8427 | 23.1742 | 6.9757 | 2.3408 | 3.6634 |
| 1965 | 8.3380 | 10.7600 | 1.9910 | 2.2510 | .6320 | .1750 | .2890 | .8950 | 1.9910 | 2.4220 | 129.0477 | 26.9969 | 23.8786 | 7.5798 | 2.0988 | 3.4661 |
| 1966 | 7.4220 | 9.2250 | 1.6010 | 2.0100 | .6340 | .1380 | .3840 | .4450 | 1.6010 | 1.8030 | 124.2926 | 27.0816 | 21.5710 | 8.5422 | 1.8593 | 5.1738 |
| 1967 | 8.2340 | 10.5950 | 2.0110 | 2.4600 | .7280 | .1800 | .4080 | .6950 | 2.0110 | 2.3610 | 128.6738 | 29.8761 | 24.4231 | 8.8414 | 2.1861 | 4.9551 |
| 1968 | 8.3250 | 10.8940 | 2.1740 | 2.6970 | .7920 | .1870 | .4590 | .7360 | 2.1740 | 2.5690 | 130.8589 | 32.3964 | 26.1141 | 9.5135 | 2.2462 | 5.5135 |
| 1969 | 8.3950 | 11.0630 | 2.2740 | 2.7400 | .8150 | .1870 | .4900 | .7870 | 2.2790 | 2.6680 | 131.7808 | 32.6385 | 27.0876 | 9.7082 | 2.2275 | 5.8368 |
| 1970 | 8.4540 | 11.0700 | 2.1600 | 2.7330 | .8140 | .1690 | .5510 | .6230 | 2.1600 | 2.6160 | 130.9439 | 32.3279 | 25.5500 | 9.6286 | 1.9991 | 6.5176 |
| 1971 | 8.2760 | 10.6840 | 2.3840 | 2.7870 | .8740 | .1440 | .5820 | .7840 | 2.3840 | 2.4080 | 129.0962 | 33.6757 | 28.8062 | 10.5607 | 1.7400 | 7.0324 |
| 1972 | 8.0530 | 10.3830 | 2.2780 | 2.6880 | .9210 | .1110 | .6760 | .5720 | 2.2780 | 2.3300 | 128.9333 | 33.3789 | 28.2876 | 11.4367 | 1.3784 | 8.3944 |
| 1973 | 8.3730 | 10.7670 | 2.3200 | 2.7970 | .8970 | .0820 | .7170 | .6230 | 2.3200 | 2.3940 | 128.5919 | 33.4050 | 27.7081 | 10.7130 | .9793 | 8.5632 |
| 1974 | 8.3440 | 10.8690 | 2.5230 | 3.0550 | .8880 | .1060 | .8580 | .6720 | 2.5230 | 2.5250 | 130.2613 | 36.6131 | 30.2373 | 10.6424 | 1.2704 | 10.2828 |
| 1975 | 8.4700 | 11.2870 | 2.7600 | 3.3630 | .8960 | .1180 | 1.0710 | .6750 | 2.7600 | 2.8170 | 133.2586 | 39.7048 | 32.5856 | 10.5785 | 1.3932 | 12.6446 |
| 1976 | 8.3500 | 11.3250 | 2.8790 | 3.6040 | .9520 | .1260 | 1.1820 | .6180 | 2.8790 | 2.9750 | 135.6287 | 43.1617 | 34.4790 | 11.4012 | 1.5090 | 14.1557 |
| 1977 | 8.5780 | 11.5650 | 2.9130 | 3.7800 | .9960 | .1320 | 1.1020 | .6830 | 2.9130 | 2.9870 | 134.8216 | 44.0662 | 33.9590 | 11.6111 | 1.5388 | 12.8468 |
| 1978 | 8.5320 | 11.3810 | 2.9600 | 3.7070 | 1.0740 | .1140 | 1.0170 | .7560 | 2.9590 | 2.8490 | 133.3919 | 43.4482 | 34.6929 | 12.5879 | 1.3361 | 11.9198 |
| 1979 | 7.9010 | 10.4130 | 2.7720 | 3.3900 | .9200 | .1050 | 1.0570 | .6880 | 2.7720 | 2.5120 | 131.7934 | 42.9060 | 35.0842 | 11.6441 | 1.3289 | 13.3781 |
| 1980 | 8.3150 | 11.1480 | 2.9530 | 3.6320 | 1.0940 | .0960 | .9950 | .7670 | 2.9530 | 2.8330 | 134.0710 | 43.6801 | 35.5141 | 13.1569 | 1.1545 | 11.9663 |
| 1981 | 7.8610 | 10.6280 | 3.0010 | 3.5820 | 1.1700 | .1000 | .9960 | .7350 | 3.0010 | 2.7670 | 135.1991 | 45.5667 | 38.1758 | 14.8836 | 1.2721 | 12.6701 |
| 1982 | 8.2780 | 9.6410 | 2.3190 | 3.3500 | .9140 | .0940 | .8550 | .4560 | 2.3190 | 1.3630 | 116.4653 | 40.4687 | 28.0140 | 11.0413 | 1.1355 | 10.3286 |
| 1983 | 7.5800 | 10.2590 | 2.5170 | 3.5700 | 1.0090 | .0980 | .9560 | .4540 | 2.5170 | 2.6790 | 135.3430 | 47.0976 | 33.2058 | 13.3113 | 1.2929 | 12.6121 |
| 1984 | 7.6430 | 10.3090 | 2.7950 | 3.7840 | 1.0050 | .1310 | 1.0720 | .5870 | 2.7950 | 2.6660 | 134.8816 | 49.5094 | 36.5694 | 13.1493 | 1.7140 | 14.0259 |
| 1985 | 7.6990 | 10.5170 | 2.8080 | 3.8190 | .9730 | .1210 | 1.0460 | .6680 | 2.8080 | 2.8180 | 136.6022 | 49.6038 | 36.4723 | 12.6380 | 1.5716 | 13.5862 |
| 1986 | 7.6120 | 10.4320 | 2.9570 | 3.8310 | 1.1060 | .1160 | 1.0660 | .6690 | 2.9570 | 2.8200 | 137.0468 | 50.3284 | 38.8466 | 14.5297 | 1.5239 | 14.0042 |
| 1987 | 7.4800 | 10.3270 | 3.1940 | 4.0540 | 1.1250 | .0930 | 1.1750 | .8010 | 3.1940 | 2.8470 | 138.0615 | 54.1979 | 42.7005 | 15.0401 | 1.2433 | 15.7086 |

S12. ORISSA

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 5.5920 | 5.9220 | 1.0070 | 1.0170 | .1720 | .5460 | .0470 | .2420 | 1.0070 | .3300 | 105.9013 | 18.1867 | 18.0079 | 3.0758 | 9.7639 | .8405 |
| 1951 | 5.5980 | 6.0370 | 1.0080 | 1.0210 | .1740 | .5460 | .0470 | .2420 | 1.0090 | .4390 | 107.8421 | 18.2387 | 18.0064 | 3.1083 | 9.7535 | .8396 |
| 1952 | 5.6750 | 6.0100 | .7740 | .8440 | .2190 | .2740 | .0280 | .2530 | .7740 | .3350 | 105.9031 | 14.8722 | 13.6388 | 3.8590 | 4.8282 | .4934 |
| 1953 | 5.6460 | 6.0320 | .6960 | .8600 | .2160 | .2630 | .0280 | .1880 | .6960 | .3860 | 106.8367 | 15.2320 | 12.3273 | 3.8257 | 4.6582 | .4959 |
| 1954 | 5.5420 | 5.9830 | .7620 | .8900 | .2210 | .2300 | .0350 | .2750 | .7620 | .4410 | 107.9574 | 16.0592 | 13.7495 | 3.9877 | 4.1501 | .6315 |
| 1955 | 5.5420 | 5.9830 | .9660 | 1.1280 | .2220 | .4890 | .0380 | .2160 | .9660 | .4410 | 107.9574 | 20.3537 | 17.4305 | 4.0058 | 8.8235 | .6857 |
| 1956 | 5.5420 | 5.9830 | .9660 | 1.1280 | .2220 | .4890 | .0380 | .2160 | .9660 | .4410 | 107.9574 | 20.3537 | 17.4305 | 4.0058 | 8.8235 | .6857 |
| 1957 | 5.5420 | 5.9830 | .9660 | 1.1280 | .2220 | .4890 | .0380 | .2160 | .9660 | .4410 | 107.9574 | 20.3537 | 17.4305 | 4.0058 | 8.8235 | .6857 |
| 1958 | 5.5420 | 5.9830 | .9660 | 1.1280 | .2220 | .4890 | .0380 | .2160 | .9660 | .4410 | 107.9574 | 20.3537 | 17.4305 | 4.0058 | 8.8235 | .6857 |
| 1959 | 5.5420 | 5.9830 | .9660 | 1.1280 | .2220 | .4890 | .0380 | .2160 | .9660 | .4410 | 107.9574 | 20.3537 | 17.4305 | 4.0058 | 8.8235 | .6857 |
| 1960 | 5.9880 | 6.4820 | .9770 | 1.1420 | .2250 | .4950 | .0380 | .2190 | .9770 | .4940 | 108.2498 | 19.0715 | 16.3160 | 3.7575 | 8.2665 | .6346 |
| 1961 | 5.8110 | 6.3670 | .9770 | 1.1420 | .2250 | .4950 | .0380 | .2190 | .9770 | .5560 | 109.5681 | 19.6524 | 16.8129 | 3.8720 | 8.5183 | .6539 |
| 1962 | 5.8440 | 6.9470 | .9770 | 1.1420 | .2250 | .4950 | .0380 | .2190 | .9770 | 1.1030 | 118.8741 | 19.5414 | 16.7180 | 3.8501 | 8.4702 | .6502 |
| 1963 | 5.9810 | 7.2210 | .9770 | 1.1420 | .2250 | .4950 | .0380 | .2190 | .9770 | 1.2400 | 120.7323 | 19.0938 | 16.3351 | 3.7619 | 8.2762 | .6353 |
| 1964 | 5.9890 | 7.4460 | .9770 | 1.1420 | .2250 | .4950 | .0380 | .2190 | .9770 | 1.4570 | 124.3279 | 19.0683 | 16.3132 | 3.7569 | 8.2652 | .6345 |
| 1965 | 5.9930 | 7.4460 | .9770 | 1.1420 | .1530 | .3370 | .0260 | .1490 | .6640 | 1.4530 | 124.2450 | 19.0556 | 16.3024 | 2.5530 | 5.6232 | .4338 |
| 1966 | 5.9590 | 7.4460 | .9770 | 1.1420 | .1710 | .3740 | .0290 | .1660 | .7390 | 1.4870 | 124.9539 | 19.1643 | 16.3954 | 2.8696 | 6.2762 | .4867 |
| 1967 | 6.0440 | 7.3540 | .8340 | 1.1500 | .1910 | .4230 | .0320 | .1880 | .8340 | 1.3100 | 121.6744 | 19.0271 | 13.7988 | 3.1602 | 6.9987 | .5295 |
| 1968 | 6.0690 | 7.9540 | .9400 | 1.3420 | .1690 | .3740 | .0290 | .1660 | .9400 | 1.8850 | 131.0595 | 22.1124 | 15.4885 | 2.7846 | 6.1625 | .4778 |
| 1969 | 6.0940 | 7.9540 | .7900 | 1.0520 | .2350 | .5210 | .0400 | .2310 | 1.0270 | 1.8600 | 130.5218 | 17.2629 | 12.9636 | 3.8563 | 8.5494 | .6564 |
| 1970 | 6.1190 | 8.4400 | .8200 | 1.1140 | .2630 | .5830 | .0450 | .2580 | 1.1490 | 2.3210 | 137.9310 | 18.2056 | 13.4009 | 4.2981 | 9.5277 | .7354 |
| 1971 | 5.7650 | 6.8750 | .8510 | 1.1710 | .5480 | .1730 | .1300 | .0000 | .8510 | 1.1100 | 119.2541 | 20.3122 | 14.7615 | 9.5056 | 3.0009 | 2.2550 |
| 1972 | 5.6220 | 6.9360 | .8510 | 1.2600 | .5480 | .1930 | .1410 | .0000 | .9170 | 1.3140 | 123.3725 | 22.4120 | 15.1370 | 9.7474 | 3.4329 | 2.5080 |
| 1973 | 5.9730 | 7.2850 | .9170 | 1.1880 | .5580 | .1850 | .1350 | .0000 | .8780 | 1.3120 | 121.9655 | 19.8895 | 15.3424 | 9.3420 | 3.0973 | 2.2602 |
| 1974 | 5.7100 | 7.1340 | .8780 | 1.2760 | .6060 | .2310 | .0910 | .0000 | .9280 | 1.4240 | 124.9387 | 22.3468 | 15.3765 | 10.6130 | 4.0455 | 1.5937 |
| 1975 | 6.1370 | 7.7330 | .9280 | 1.4820 | .6550 | .2330 | .1270 | .0000 | 1.0150 | 1.5960 | 126.0062 | 24.1486 | 15.1214 | 10.6730 | 3.7966 | 2.0694 |
| 1976 | 5.8770 | 7.2090 | 1.0150 | 1.3830 | .6740 | .2720 | .1040 | .0000 | 1.0490 | 1.3320 | 122.6646 | 23.5324 | 17.2707 | 11.4684 | 4.6282 | 1.7696 |
| 1977 | 5.9970 | 7.9310 | 1.0490 | 1.4490 | .6920 | .2790 | .1000 | .0000 | 1.0710 | 1.9340 | 132.2495 | 24.1621 | 17.4921 | 11.5391 | 4.6523 | 1.6675 |
| 1978 | 6.0970 | 8.2750 | 1.0710 | 1.5860 | .7610 | .2400 | .1470 | .0000 | 1.1480 | 2.1780 | 135.7225 | 26.0128 | 17.5660 | 12.4815 | 3.9364 | 2.4110 |
| 1979 | 5.9700 | 8.1660 | 1.1480 | 1.6470 | .7840 | .2060 | .1900 | .0000 | 1.1810 | 2.1960 | 136.7839 | 27.5879 | 19.2295 | 13.1323 | 3.4506 | 3.1826 |
| 1980 | 6.1300 | 8.7460 | 1.1810 | 1.7110 | .8010 | .2070 | .2070 | .0000 | 1.2150 | 2.6160 | 142.6754 | 27.9119 | 19.2659 | 13.0669 | 3.3768 | 3.3768 |
| 1981 | 6.1300 | 8.7420 | 1.2150 | 2.0060 | .8010 | .2070 | .2070 | .0000 | 1.2150 | 2.6120 | 142.6101 | 32.7243 | 19.8206 | 13.0669 | 3.3768 | 3.3768 |
| 1982 | 6.1300 | 8.3260 | 1.2150 | 2.0060 | .8010 | .2070 | .2070 | .0000 | 1.2150 | 2.1960 | 135.8238 | 32.7243 | 19.8206 | 13.0669 | 3.3768 | 3.3768 |
| 1983 | 5.9900 | 9.5630 | 1.8450 | 2.0060 | 1.1870 | .3140 | .3440 | .0000 | 1.8450 | 3.5730 | 159.6494 | 33.4891 | 30.8013 | 19.8164 | 5.2421 | 5.7429 |
| 1984 | 6.2880 | 8.7740 | 1.4660 | 2.0300 | .8660 | .2570 | .3430 | .0000 | 1.4660 | 2.4860 | 139.5356 | 32.2837 | 23.3142 | 13.7723 | 4.0872 | 5.4548 |
| 1985 | 6.3230 | 9.2590 | 1.6730 | 2.1590 | .8530 | .2340 | .5860 | .0000 | 1.6730 | 2.9360 | 146.4337 | 34.1452 | 26.4590 | 13.4904 | 3.7008 | 9.2678 |
| 1986 | 6.2670 | 9.2700 | 1.6730 | 2.0880 | .8530 | .2340 | .5860 | .0000 | 1.6730 | 3.0030 | 147.9177 | 33.3174 | 26.6954 | 13.6110 | 3.7338 | 9.3506 |
| 1987 | 5.9540 | 9.0920 | 1.6730 | 2.0620 | .8530 | .2340 | .5860 | .0000 | 1.6730 | 3.1380 | 152.7041 | 34.6322 | 28.0988 | 14.3265 | 3.9301 | 9.8421 |

S13. PUNJAB & HARYANA (SEPARATED LATER AS 13A AND 13B)

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 6.7252 | 7.9660 | 2.5612 | 2.9708 | 1.6571 | .0030 | .9280 | .0200 | 2.6080 | 1.2408 | 118.4500 | 44.1742 | 38.0836 | 24.6402 | .0446 | 13.7988 |
| 1951 | 6.3472 | 7.3932 | 2.6076 | 3.1384 | 1.8420 | .0070 | .9860 | .0140 | 2.8490 | 1.0460 | 116.4797 | 49.4454 | 41.0827 | 29.0207 | .1103 | 15.5344 |
| 1952 | 6.4148 | 7.5496 | 2.8492 | 3.2200 | 1.8420 | .0070 | .9860 | .0140 | 2.8490 | 1.1348 | 117.6903 | 50.1964 | 44.4160 | 28.7148 | .1091 | 15.3707 |
| 1953 | 6.7576 | 8.0700 | 2.9916 | 3.3200 | 1.9450 | .0030 | 1.0240 | .0190 | 2.9920 | 1.3124 | 119.4211 | 49.1299 | 44.2702 | 28.7824 | .0444 | 15.1533 |
| 1954 | 6.9684 | 8.8628 | 3.2496 | 3.5800 | 2.1050 | .0060 | 1.1210 | .0170 | 3.2490 | 1.8944 | 127.1856 | 51.3748 | 46.6334 | 30.2078 | .0861 | 16.0869 |
| 1955 | 7.1176 | 9.4000 | 3.2248 | 3.6164 | 2.1360 | .0060 | 1.0670 | .0170 | 3.2240 | 2.2824 | 132.0670 | 50.8093 | 45.3074 | 30.0101 | .0843 | 14.9910 |
| 1956 | 7.2432 | 9.5144 | 2.9836 | 3.6572 | 1.9810 | .0060 | .9860 | .0120 | 2.9840 | 2.2712 | 131.3563 | 50.4915 | 41.1917 | 27.3498 | .0828 | 13.6128 |
| 1957 | 7.2280 | 9.4560 | 2.9568 | 3.6584 | 2.0070 | .0060 | .9260 | .0170 | 2.9570 | 2.2280 | 130.8246 | 50.6143 | 40.9076 | 27.7670 | .0830 | 12.8113 |
| 1958 | 7.3952 | 9.9108 | 2.9444 | 3.8056 | 1.9930 | .0070 | .9280 | .0160 | 2.9440 | 2.5156 | 134.0167 | 51.4604 | 39.8150 | 26.9499 | .0947 | 12.5487 |
| 1959 | 7.3916 | 9.5980 | 2.9636 | 3.8232 | 1.9910 | .0030 | .9370 | .0330 | 2.9640 | 2.2064 | 129.8501 | 51.7236 | 40.0942 | 26.9360 | .0406 | 12.6766 |
| 1960 | 7.4220 | 9.7318 | 3.0948 | 3.8850 | 2.0510 | .0030 | .9960 | .0440 | 3.0950 | 2.3098 | 131.1210 | 52.3444 | 41.6977 | 27.6341 | .0404 | 13.4196 |
| 1961 | 7.5288 | 9.7363 | 3.2103 | 3.9982 | 2.1960 | .0070 | .9790 | .0290 | 3.2100 | 2.2075 | 129.3207 | 53.1054 | 42.6403 | 29.1680 | .0930 | 13.0034 |
| 1962 | 7.5843 | 10.0290 | 3.2660 | 4.2344 | 2.2130 | .0070 | 1.0230 | .0240 | 3.2660 | 2.4447 | 132.2337 | 55.8311 | 43.0626 | 29.1787 | .0923 | 13.4884 |
| 1963 | 7.6093 | 9.7467 | 3.3930 | 4.3295 | 2.2460 | .0100 | 1.0420 | .0950 | 3.3930 | 2.1374 | 128.0893 | 56.8975 | 44.5902 | 29.5165 | .1314 | 13.6938 |
| 1964 | 7.6485 | 10.1214 | 3.3850 | 4.4945 | 2.2760 | .0060 | 1.0570 | .0460 | 3.3850 | 2.4729 | 132.3318 | 58.7632 | 44.2570 | 29.7575 | .0784 | 13.8197 |
| 1965 | 7.4105 | 9.3940 | 3.5511 | 4.6885 | 2.2940 | .0080 | 1.1680 | .0810 | 3.5510 | 1.9835 | 126.7661 | 63.2683 | 47.9198 | 30.9561 | .1080 | 15.7614 |
| 1966 | 7.2930 | 9.7700 | 3.5690 | 5.1020 | 2.2630 | .0070 | 1.2700 | .0280 | 3.5680 | 2.4770 | 133.9641 | 69.9575 | 48.9373 | 31.0298 | .0960 | 17.4140 |
| 1967 | 7.5062 | 10.5912 | 3.3710 | 5.2446 | 2.1820 | .0030 | 1.2590 | .0200 | 3.4660 | 3.0850 | 141.0994 | 69.8702 | 44.9095 | 29.0693 | .0400 | 16.7728 |
| 1968 | 7.2130 | 9.3408 | 3.9640 | 5.3869 | 2.2010 | .0020 | 1.7370 | .0240 | 3.9640 | 2.1278 | 129.4995 | 74.6832 | 54.9563 | 30.5143 | .0277 | 24.0815 |
| 1969 | 7.5744 | 10.4402 | 4.2430 | 6.2380 | 2.2560 | .0170 | 1.9610 | .0700 | 4.2440 | 2.8658 | 137.8353 | 82.3564 | 56.0176 | 29.7845 | .2244 | 25.8898 |
| 1970 | 7.6180 | 10.6350 | 4.4200 | 6.4725 | 2.2430 | .0010 | 2.1660 | .0100 | 4.4200 | 3.0170 | 139.6036 | 84.9632 | 58.0205 | 29.4434 | .0131 | 28.4327 |
| 1971 | 7.6430 | 10.7720 | 4.5200 | 6.7022 | 2.3340 | .0010 | 2.1480 | .0370 | 4.5190 | 3.1290 | 140.9394 | 87.6907 | 59.1391 | 30.5377 | .0131 | 28.1041 |
| 1972 | 7.6350 | 11.1200 | 4.5720 | 7.0476 | 2.3340 | .0050 | 2.3230 | .0110 | 5.2730 | 3.4850 | 145.6451 | 92.3065 | 59.8821 | 30.5697 | .0655 | 30.4257 |
| 1973 | 7.6800 | 11.1660 | 4.7120 | 7.2246 | 2.3010 | .0010 | 2.3990 | .0120 | 4.7120 | 3.4860 | 145.3906 | 94.0703 | 61.3542 | 29.9609 | .0130 | 31.2370 |
| 1974 | 7.6110 | 10.7460 | 4.9620 | 7.3660 | 2.4420 | .0010 | 2.5090 | .0110 | 4.9620 | 3.1350 | 141.1904 | 96.7810 | 65.1951 | 32.0851 | .0131 | 32.9654 |
| 1975 | 7.7820 | 11.7060 | 4.8750 | 7.6630 | 2.4190 | .0010 | 2.4460 | .0080 | 4.8750 | 3.9240 | 150.4241 | 98.4708 | 62.6446 | 31.0846 | .0129 | 31.4315 |
| 1976 | 7.8130 | 11.5670 | 4.9920 | 7.7780 | 2.4420 | .0020 | 2.5360 | .0130 | 4.9920 | 3.7540 | 148.0481 | 99.5520 | 63.8935 | 31.2556 | .0256 | 32.4587 |
| 1977 | 7.8160 | 11.8250 | 4.9520 | 7.9710 | 2.4390 | .0008 | 2.4810 | .0270 | 4.9520 | 4.0090 | 151.2922 | 101.9831 | 63.3572 | 31.2052 | .0102 | 31.7426 |
| 1978 | 7.8270 | 12.1520 | 5.1790 | 8.4850 | 2.5110 | .0020 | 2.6380 | .0290 | 5.1790 | 4.3250 | 155.2574 | 108.4068 | 66.1684 | 32.0813 | .0256 | 33.7038 |
| 1979 | 7.7390 | 11.3970 | 5.6970 | 8.8310 | 2.7150 | .0010 | 2.9360 | .0160 | 5.6970 | 3.6580 | 147.2671 | 114.1104 | 73.6142 | 35.0821 | .0129 | 37.9377 |
| 1980 | 7.7930 | 12.2250 | 5.5160 | 9.0900 | 2.5910 | .0010 | 2.9050 | .0190 | 5.5160 | 4.4320 | 156.8716 | 116.6431 | 70.7815 | 33.2478 | .0128 | 37.2770 |
| 1981 | 7.8700 | 12.7550 | 5.6560 | 9.4210 | 2.5050 | .0000 | 3.1290 | .0220 | 5.6560 | 4.8850 | 162.0712 | 119.7078 | 71.8679 | 31.8297 | .0000 | 39.7586 |
| 1982 | 7.7980 | 12.2210 | 5.9060 | 9.7070 | 2.7230 | .0000 | 3.1700 | .0130 | 5.9160 | 4.4230 | 156.7197 | 124.4806 | 75.7374 | 34.9192 | .0000 | 40.6514 |
| 1983 | 7.8120 | 12.6650 | 5.7990 | 9.8670 | 2.2630 | .0010 | 3.1220 | .0130 | 5.7990 | 4.8530 | 162.1224 | 126.3057 | 74.2320 | 28.9683 | .0128 | 39.9642 |
| 1984 | 7.8050 | 12.5250 | 5.8100 | 9.8510 | 2.6020 | .0010 | 3.1920 | .0140 | 5.8100 | 4.7200 | 160.4741 | 126.2140 | 74.4395 | 33.3376 | .0128 | 40.8969 |
| 1985 | 7.8100 | 12.7590 | 5.9260 | 10.1920 | 2.5930 | .0010 | 3.3230 | .0110 | 5.9260 | 4.9490 | 163.3675 | 130.4994 | 75.8771 | 33.2010 | .0128 | 42.5480 |
| 1986 | 7.8230 | 12.8780 | 6.0650 | 10.5020 | 2.6430 | .0010 | 3.4130 | .0080 | 6.0650 | 5.0550 | 164.6172 | 134.2452 | 77.5278 | 33.7850 | .0128 | 43.6278 |
| 1987 | 7.3900 | 12.0120 | 6.3530 | 10.6040 | 2.6340 | .0010 | 3.6620 | .0560 | 6.3530 | 4.6220 | 162.5440 | 143.4912 | 85.9675 | 35.6428 | .0135 | 49.5535 |

S13A HARYANA

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 3.4230 | 4.5990 | 1.2960 | 1.7360 | .9910 | .0040 | .2890 | .0090 | 1.2930 | 1.1760 | 134.3558 | 50.7157 | 37.8615 | 28.9512 | .1169 | 8.4429 |
| 1967 | 3.5141 | 5.1503 | 1.1320 | 1.7800 | .8890 | .0030 | .2260 | .0130 | 1.1320 | 1.6362 | 146.5610 | 50.6531 | 32.2131 | 25.2981 | .0854 | 6.4312 |
| 1968 | 3.2728 | 4.0535 | 1.3120 | 1.5640 | .9070 | .0020 | .3850 | .0180 | 1.3120 | .7807 | 123.8542 | 47.7878 | 40.0880 | 27.7133 | .0611 | 11.7636 |
| 1969 | 3.5475 | 4.9408 | 1.4080 | 2.1580 | .9500 | .0170 | .4370 | .0040 | 1.4080 | 1.3933 | 139.2755 | 60.8316 | 39.6899 | 26.7794 | .4792 | 12.3185 |
| 1970 | 3.5650 | 4.9570 | 1.5320 | 2.2300 | .9510 | .0010 | .5750 | .0050 | 1.5320 | 1.3920 | 139.0463 | 62.5526 | 42.9734 | 26.6760 | .0281 | 16.1290 |
| 1971 | 3.5670 | 5.0480 | 1.5650 | 2.3250 | .9650 | .0010 | .5940 | .0050 | 1.5650 | 1.4810 | 141.5195 | 65.1808 | 43.8744 | 27.0535 | .0280 | 16.6526 |
| 1972 | 3.5550 | 5.1880 | 1.6320 | 2.4770 | .9520 | .0050 | .6710 | .0030 | 1.6320 | 1.6330 | 145.9353 | 69.6765 | 45.9072 | 26.7792 | .1406 | 18.8748 |
| 1973 | 3.5660 | 5.1500 | 1.7360 | 2.5840 | 1.0120 | .0010 | .7190 | .0050 | 1.7360 | 1.5840 | 144.4195 | 72.4621 | 48.6820 | 28.3791 | .0280 | 20.1626 |
| 1974 | 3.5190 | 4.8420 | 1.7790 | 2.5960 | 1.0310 | .0010 | .7434 | .0040 | 1.7790 | 1.3230 | 137.5959 | 73.7710 | 50.5541 | 29.2981 | .0284 | 21.1253 |
| 1975 | 3.6240 | 5.4510 | 1.7540 | 2.7320 | 1.0360 | .0010 | .7426 | .0040 | 1.7540 | 1.8270 | 150.4139 | 75.3863 | 48.3996 | 28.5872 | .0276 | 19.6634 |
| 1976 | 3.6460 | 5.2820 | 1.7980 | 2.6980 | 1.0564 | .0005 | .7340 | .0080 | 1.7980 | 1.6360 | 144.8711 | 73.9989 | 49.3143 | 28.9742 | .0137 | 20.1317 |
| 1977 | 3.6450 | 5.4350 | 1.8740 | 2.7760 | 1.0964 | .0008 | .7680 | .0060 | 1.8740 | .7900 | 149.1100 | 76.1591 | 51.4129 | 30.0796 | .0219 | 21.0700 |
| 1978 | 3.6500 | 5.5220 | 1.9170 | 2.9790 | 1.1170 | .0020 | .7950 | .0040 | 1.9170 | 1.8720 | 151.2877 | 81.6164 | 52.5205 | 30.6027 | .0548 | 21.7808 |
| 1979 | 3.5570 | 4.8620 | 2.1740 | 3.1310 | 1.2000 | .0010 | .9690 | .0050 | 2.1740 | 1.3050 | 136.6882 | 88.0236 | 61.1189 | 33.7363 | .0281 | 27.2421 |
| 1980 | 3.6020 | 5.4620 | 2.1340 | 3.3090 | 1.1610 | .0010 | .9660 | .0060 | 2.1340 | 1.8600 | 151.6380 | 91.8656 | 59.2449 | 32.2321 | .0278 | 26.8184 |
| 1981 | 3.6600 | 5.8260 | 2.2480 | 3.4550 | 1.1830 | .0000 | 1.0560 | .0100 | 2.2480 | 2.1660 | 159.1803 | 94.3989 | 61.4208 | 32.3224 | .0000 | 28.8525 |
| 1982 | 3.5960 | 5.3060 | 2.3560 | 3.5590 | 1.2610 | .0000 | 1.0900 | .0050 | 2.3660 | 1.7100 | 147.5528 | 98.9711 | 65.5172 | 35.0667 | .0000 | 30.3115 |
| 1983 | 3.6000 | 5.6880 | 2.1900 | 3.5940 | 1.1850 | .0010 | 1.0000 | .0040 | 2.1900 | 2.0880 | 158.0000 | 99.8333 | 60.8333 | 32.9167 | .0278 | 27.7778 |
| 1984 | 3.6160 | 5.5120 | 2.1890 | 3.5040 | 1.2030 | .0010 | .9800 | .0040 | 1.1890 | 1.8960 | 152.4336 | 96.9027 | 60.5365 | 33.2688 | .0277 | 27.1018 |
| 1985 | 3.06130 | 5.6010 | 2.2360 | 3.6780 | 1.1810 | .0010 | 1.0470 | .0070 | 2.2360 | 1.9880 | 155.0235 | 101.7991 | 61.8876 | 32.6875 | .0277 | 28.9787 |
| 1986 | 3.6210 | 5.6610 | 2.3480 | 3.9120 | 1.2030 | .0010 | 1.1400 | .0040 | 2.3480 | 2.0400 | 156.3380 | 108.0365 | 64.8440 | 33.2229 | .0276 | 31.4830 |
| 1987 | 3.2300 | 4.6860 | 2.5790 | 3.8830 | 1.2200 | .0010 | 1.3550 | .0030 | 2.5790 | 1.4560 | 145.0774 | 120.2167 | 79.8452 | 37.7709 | .0310 | 41.9505 |

| | NSA | GCA | NIA | GIA | TC | TA | W | OS | TS | ASMO | CI | IRA | IRB | IRG | IRH | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 3.8700 | 5.1710 | 2.2760 | 3.3660 | 1.2720 | .0030 | .9810 | .0190 | 2.2750 | 1.3010 | 133.6176 | 86.9767 | 58.8114 | 32.8682 | .0775 | 25.3488 |
| 1967 | 3.9921 | 5.4409 | 2.2390 | 3.4646 | 1.2930 | .0000 | 1.0334 | .0070 | 2.3340 | 1.4488 | 136.2917 | 86.7864 | 56.0858 | 32.3890 | .0000 | 25.8861 |
| 1968 | 3.9402 | 5.2873 | 2.6520 | 3.8229 | 1.2940 | .0000 | 1.3520 | .0060 | 2.6520 | 1.3471 | 134.1886 | 97.0230 | 67.3062 | 32.8410 | .0000 | 34.3130 |
| 1969 | 4.0269 | 5.4994 | 2.8350 | 4.0800 | 1.3060 | .0000 | 1.5240 | .0060 | 2.8360 | 1.4725 | 136.5666 | 101.3186 | 70.4015 | 32.4319 | .0000 | 37.8455 |
| 1970 | 4.0530 | 5.6780 | 2.8880 | 4.2425 | 1.2920 | .0000 | 1.5910 | .0050 | 2.8880 | 1.6250 | 140.0938 | 104.6755 | 71.2559 | 31.8776 | .0000 | 39.2549 |
| 1971 | 4.0760 | 5.7240 | 2.9550 | 4.3772 | 1.3690 | .0000 | 1.5540 | .0320 | 2.9540 | 1.6480 | 140.4318 | 107.3896 | 72.4975 | 33.5868 | .0000 | 38.1256 |
| 1972 | 4.0800 | 5.9320 | 2.9400 | 4.5706 | 1.3820 | .0000 | 1.6520 | .0080 | 3.6410 | 1.8520 | 145.3922 | 112.0245 | 72.0588 | 33.8725 | .0000 | 40.4902 |
| 1973 | 4.1140 | 6.0160 | 2.9760 | 4.6446 | 1.2890 | .0000 | 1.6800 | .0070 | 2.9760 | 1.9020 | 146.2324 | 112.8974 | 72.3384 | 31.3320 | .0000 | 40.8362 |
| 1974 | 4.0920 | 5.9040 | 3.1830 | 4.7700 | 1.4110 | .0000 | 1.7660 | .0070 | 3.1830 | 1.8120 | 144.2815 | 116.5689 | 77.7859 | 34.4819 | .0000 | 43.1574 |
| 1975 | 4.1580 | 6.2550 | 3.1210 | 4.9310 | 1.3830 | .0000 | 1.7340 | .0040 | 3.1210 | 2.0970 | 150.4329 | 118.5907 | 75.0601 | 33.2612 | .0000 | 41.7027 |
| 1976 | 4.1670 | 6.2850 | 3.1940 | 5.0800 | 1.3860 | .0010 | 1.8020 | .0050 | 3.1940 | 2.1180 | 150.8279 | 121.9102 | 76.6499 | 33.2613 | .0240 | 43.2445 |
| 1977 | 4.1710 | 6.3900 | 3.0780 | 5.1950 | 1.3430 | .0000 | 1.7130 | .0210 | 3.0780 | 2.2190 | 153.2007 | 124.5505 | 73.7953 | 32.1985 | .0000 | 41.0693 |
| 1978 | 4.1770 | 6.6300 | 3.2620 | 5.5060 | 1.3940 | .0000 | 1.8430 | .0250 | 3.2620 | 2.4530 | 158.7264 | 131.8171 | 78.0943 | 33.3732 | .0000 | 44.1226 |
| 1979 | 4.1820 | 6.5350 | 3.5230 | 5.7000 | 1.5150 | .0000 | 1.9670 | .0110 | 3.5230 | 2.3530 | 156.2649 | 136.2984 | 84.2420 | 36.2267 | .0000 | 47.0349 |
| 1980 | 4.1910 | 6.7630 | 3.3820 | 5.7810 | 1.4300 | .0000 | 1.9390 | .0130 | 3.3820 | 2.5720 | 161.3696 | 137.9384 | 80.6967 | 34.1207 | .0000 | 46.2658 |
| 1981 | 4.2100 | 6.9290 | 3.4080 | 5.9660 | 1.3220 | .0000 | 2.0730 | .0120 | 3.4080 | 2.7190 | 164.5843 | 141.7102 | 80.9501 | 31.4014 | .0000 | 49.2399 |
| 1982 | 4.2020 | 6.9150 | 3.5500 | 6.1480 | 1.4620 | .0000 | 2.0800 | .0080 | 3.5500 | 2.7130 | 164.5645 | 146.3113 | 84.4836 | 34.7930 | .0000 | 49.5002 |
| 1983 | 4.2120 | 6.9770 | 3.6090 | 6.2730 | 1.4780 | .0000 | 2.1220 | .0090 | 3.6090 | 2.7650 | 165.6458 | 148.9316 | 85.6838 | 35.0902 | .0000 | 50.3799 |
| 1984 | 4.1890 | 7.0130 | 3.6210 | 6.3470 | 1.3990 | .0000 | 2.2120 | .0100 | 3.6210 | 2.8240 | 167.4147 | 151.5159 | 86.4407 | 33.3970 | .0000 | 52.8050 |
| 1985 | 4.1970 | 7.1580 | 3.6900 | 6.5140 | 1.4120 | .0000 | 2.2760 | .0040 | 3.6900 | 2.9610 | 170.5504 | 155.2061 | 87.9199 | 33.6431 | .0000 | 54.2292 |
| 1986 | 4.2020 | 7.2170 | 3.7170 | 6.5900 | 1.4400 | .0000 | 2.2730 | .0040 | 3.7170 | 3.0150 | 171.7515 | 156.8301 | 88.4579 | 34.2694 | .0000 | 54.0933 |
| 1987 | 4.1570 | 7.3260 | 3.7740 | 6.7210 | 1.4140 | .0000 | 2.3070 | .0530 | 3.7740 | 3.1690 | 176.2329 | 161.6791 | 90.7866 | 34.0149 | .0000 | 55.4968 |

RAINFALL STATISTICS

(in millimetres)

| N = | 625.3 | 714.1 | 1324.2 | 1209 | 1328 | 1038 | 976.8 | 994.3 | 740 | 3560.2 | 877.9 | 800.9 | 698.2 | 334.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Punjab | Haryana | Bihar Plateau | Bihar Plains | Madhya Pradesh (East) | Madhya Pradesh (West) | Andhra Pradesh Coastal | Andhra Pradesh Telengana | Andhra Pradesh Rayala-seema | Karnataka Coastal | Karnataka North | Karnataka South | Rajasthan East | Rajasthan West |
| 1951 | 438.4 | | 1,148.6 | 900.2 | 1,328.4 | 984.5 | 942.6 | N.A. | 480.6 | N.A. | 868.9 | N.A. | 391.4 | 163.3 |
| 1952 | 578.6 | | 1,362.5 | 1,214.1 | 1,220.7 | 833.9 | 828.0 | N.A. | 627.1 | N.A. | 804.2 | N.A. | 725.2 | 296.7 |
| 1953 | 628.7 | | 1,476.8 | 1,396.5 | 1,322.6 | 942.6 | 950.7 | N.A. | 584.0 | N.A. | 1,150.6 | N.A. | 447.0 | 224.3 |
| 1954 | 690.6 | | 1,001.8 | 1,084.3 | 1,167.4 | 1,093.2 | 1,051.3 | N.A. | 668.0 | N.A. | 933.2 | N.A. | 625.9 | 274.6 |
| 1955 | 939.8 | | 1,028.2 | 1,215.9 | 1,540.3 | 1,296.9 | 1,140.0 | N.A. | 757.7 | N.A. | 930.9 | N.A. | 861.8 | 407.4 |
| 1956 | 766.6 | | 1,501.6 | 1,514.1 | 1,523.0 | 1,227.3 | 1,361.7 | N.A. | 909.6 | 3,284.2 | 1,089.4 | N.A. | 889.7 | 420.4 |
| 1957 | 739.6 | | 1,140.0 | 961.5 | 1,117.6 | 890.5 | 937.0 | 934.7 | 554.2 | 3,010.9 | 798.1 | 1,259.9 | 714.0 | 265.2 |
| 1958 | 803.5 | | 1,194.1 | 1,176.5 | 1,390.0 | 1,113.4 | 1,358.6 | 1,083.0 | 670.5 | 3,647.2 | 739.7 | 1,438.0 | 827.4 | 299.2 |
| 1959 | 685.8 | | 1,539.5 | 1,148.7 | 1,460.1 | 1,205.1 | 1,077.8 | 1,160.1 | 591.6 | 4,500.1 | 741.1 | 1,457.8 | 739.2 | 368.3 |
| 1960 | 694.2 | | 1,274.1 | 1,175.3 | 1,349.0 | 986.2 | 896.2 | 888.4 | 629.0 | 3,449.4 | 718.0 | 1,208.9 | 624.2 | 256.0 |
| 1961 | 619.8 | | 1,552.2 | 1,179.1 | 1,870.1 | 1,489.6 | 1,032.1 | 1,092.5 | 553.7 | 5,604.1 | 772.2 | 1,693.7 | 926.2 | 412.2 |
| 1962 | 593.1 | | 1,065.2 | 1,113.5 | 1,022.4 | 946.9 | 1,200.2 | 1,166.2 | 662.0 | 3,984.5 | 795.3 | 1,535.3 | 660.4 | 269.6 |
| 1963 | 431.2 | | 1,407.2 | 1,297.6 | 1,243.6 | 978.3 | 956.6 | 1,118.5 | 548.5 | 3,096.5 | 748.5 | 1,129.8 | 608.8 | 209.4 |
| 1964 | 634.3 | | 1,291.0 | 1,151.4 | 1,458.5 | 976.7 | 1,038.0 | 905.1 | 728.5 | 3,109.3 | 892.5 | 1,377.1 | 639.2 | 357.5 |
| 1965 | 369.0 | | 1,062.0 | 969.0 | 802.2 | 616.2 | 782.4 | 857.4 | 500.1 | 2,873.4 | 553.6 | 886.8 | 432.6 | 239.6 |
| 1966 | 547.1 | | 952.5 | 659.6 | 984.8 | 698.4 | 1,002.5 | 858.8 | 785.9 | 3,012.0 | 763.0 | 1,129.0 | 453.2 | 275.7 |
| 1967 | 530.3 | 665.0 | 1,229.8 | 1,047.2 | 1,511.9 | 947.8 | 858.3 | 928.2 | 658.0 | 3,276.8 | 649.6 | 978.2 | 787.7 | 378.2 |
| 1968 | 459.7 | 316.6 | 1,311.5 | 1,165.2 | 1,161.7 | 950.6 | 721.7 | 767.7 | 609.9 | 3,293.0 | 762.8 | 741.1 | 545.7 | 178.0 |
| 1969 | 601.4 | 780.3 | 1,272.1 | 1,334.5 | 1,245.1 | 1,102.9 | 1,215.0 | 1,199.2 | 697.7 | 3,130.5 | 896.8 | 784.4 | 638.2 | 124.0 |
| 1970 | 727.5 | 791.1 | 1,361.3 | 1,204.8 | 1,494.7 | 1,162.4 | 908.8 | 1,135.1 | 826.1 | 4,119.6 | 913.5 | 779.6 | 779.7 | 318.5 |
| 1971 | 650.6 | 931.7 | 1,975.1 | 1,591.3 | 1,587.7 | 1,138.9 | 892.2 | 732.0 | 599.0 | 3,435.7 | 783.3 | 880.4 | 850.7 | 237.2 |
| 1972 | 503.8 | 742.2 | 1,111.1 | 844.9 | 1,217.0 | 805.1 | 995.2 | 651.7 | 673.3 | 2,608.5 | 677.4 | 839.1 | 397.3 | 202.8 |
| 1973 | 782.6 | 923.1 | 1,559.3 | 1,373.6 | 1,401.5 | 1,430.7 | 760.4 | 990.0 | 609.6 | 3,223.5 | 810.7 | 796.2 | 982.7 | 473.4 |
| 1974 | 323.8 | 451.1 | 1,226.8 | 1,365.6 | 1,007.5 | 975.8 | 775.0 | 944.2 | 788.5 | 3,861.7 | 826.2 | 692.2 | 646.9 | 173.5 |
| 1975 | 734.7 | 939.2 | 1,406.7 | 1,205.1 | 1,539.4 | 1,097.2 | 1,133.6 | 1,156.1 | 923.7 | 5,060.8 | 1,272.1 | 857.0 | 883.3 | 620.1 |
| 1976 | 880.8 | 894.3 | 1,246.7 | 1,272.0 | 1,077.7 | 1,132.8 | 1,131.7 | 959.2 | 607.5 | 2,971.6 | 775.7 | 476.2 | 842.5 | 483.2 |
| 1977 | 758.2 | 758.2 | 1,707.0 | 1,341.9 | 1,330.2 | 1,028.2 | 904.2 | 850.7 | 883.0 | 3,700.3 | 869.8 | 925.3 | 925.8 | 514.5 |
| 1978 | 729.1 | 756.4 | 1,674.7 | 1,349.9 | 1,370.3 | 1,174.6 | 1,111.3 | 1,277.9 | 918.1 | 4,095.3 | 996.2 | 819.1 | 765.7 | 448.5 |
| 1979 | 462.3 | 363.2 | 995.2 | 1,118.2 | 854.5 | 840.9 | 920.5 | 834.5 | 740.4 | 2,828.3 | 895.9 | 1,019.9 | 519.3 | 338.8 |
| 1980 | 824.2 | 532.8 | 1,344.1 | 1,335.2 | 1,539.2 | 965.4 | 958.6 | 857.1 | 519.6 | 3,352.1 | 694.4 | 797.2 | 570.2 | 243.3 |
| 1981 | 580.3 | 516.6 | 1,375.8 | 1,271.5 | 1,128.6 | 931.3 | 936.4 | 1,098.5 | 799.6 | 3,482.8 | 954.1 | 787.5 | 684.4 | 259.8 |
| 1982 | 661.9 | 758.7 | 999.4 | 901.0 | 1,337.9 | 1,091.2 | 815.0 | 977.0 | 618.0 | 3,553.0 | 794.1 | 569.4 | 717.6 | 343.0 |
| 1983 | 797.7 | 1060.7 | 1,266.9 | 1,053.3 | 1,352.0 | 1,186.0 | 1,154.8 | 1,484.9 | 1,037.3 | 3,921.8 | 954.0 | 881.0 | 790.4 | 572.3 |
| 1984 | 726.2 | 579.2 | 1,541.2 | 1,496.1 | 1,247.5 | 905.0 | 690.6 | 730.5 | 604.9 | 2,983.3 | 691.4 | 693.5 | 578.1 | 262.0 |
| 1985 | 660.4 | 716.8 | 1,237.2 | 1,422.8 | 1,342.7 | 1,129.0 | 983.4 | 726.6 | 607.9 | 3,026.0 | 655.8 | 466.3 | 642.2 | 253.9 |
| 1986 | 660.3 | 520.1 | 1,283.8 | 1,304.0 | 1,257.6 | 979.5 | 1,003.8 | 983.7 | 542.9 | 2,812.8 | 706.6 | 780.0 | 604.6 | 246.6 |
| 1987 | 383.3 | 375.6 | 1,287.0 | 1,815.2 | 1,180.5 | 867.0 | 1,105.0 | 1,009.1 | 879.9 | 2,936.4 | 862.3 | 828.3 | 411.7 | 173.0 |

NA = Not Available

RAINFALL STATISTICS

(in millimetres)

| N = | 846.3 | 609.2 | 1041.3 | 940.2 | 1018.2 | 2773.7 | 713.3 | 840.3 | 1126.4 |
|---|---|---|---|---|---|---|---|---|---|
| YEAR | GUJARAT | | UTTAR PRADESH | | TAMIL | MAHARASHTRA | | | |
| | Gujarat | Saurashtra and Kutch | East U.P. | West U.P. | NADU | Konkan | Madhya Maharashtra | Marathwada | Vidarbha |
| 1951 | | | | | 806.5 | | | | |
| 1952 | | | | | 682.8 | | | | |
| 1953 | | | 1,243.6 | 983.6 | 891.8 | | | | |
| 1954 | | | 912.1 | 1,043.9 | 988.8 | | | | |
| 1955 | | | 1,394.0 | 1,186.4 | 1,032.8 | | | | |
| 1956 | | | 1,991.9 | 1,218.9 | 973.1 | | | | |
| 1957 | | | 896.1 | 1,078.0 | 883.8 | | | | |
| 1958 | | | 1,006.4 | 1,230.5 | 825.5 | | | | |
| 1959 | 1,526.4 | 1,061.0 | 843.9 | 938.3 | 889.3 | 3,737.6 | 1,122.3 | N.A. | 1,496.2 |
| 1960 | 716.1 | 355.9 | 1,135.1 | 1,178.5 | N.A. | 3,018.1 | 898.4 | N.A. | 1,002.2 |
| 1961 | 982.4 | 773.7 | 1,163.5 | 1,257.0 | 922.5 | 3,864.1 | 1,036.2 | 920.8 | 1,355.8 |
| 1962 | 798.1 | 372.8 | 984.8 | 906.5 | 958.1 | 3,350.3 | 970.1 | 960.6 | 1,046.5 |
| 1963 | 1,050.1 | 427.1 | 933.0 | 1,034.0 | 1,099.2 | 3,636.3 | 904.0 | 1,011.1 | 1,098.2 |
| 1964 | 1,072.9 | 652.8 | 976.4 | 1,055.6 | 836.7 | 3,181.2 | 975.2 | 814.7 | 994.3 |
| 1965 | 660.1 | 515.0 | 659.5 | 750.6 | 924.4 | 2,755.6 | 830.3 | 790.2 | 720.7 |
| 1966 | 806.7 | 381.8 | 704.3 | 893.0 | 1,155.3 | 2,191.1 | 868.7 | 754.6 | 960.1 |
| 1967 | 1,020.4 | 721.7 | 1,016.3 | 1,189.9 | 957.1 | 2,721.6 | 993.6 | 862.3 | 974.0 |
| 1968 | 607.9 | 414.7 | 779.2 | 809.0 | 842.3 | 2,113.9 | 790.1 | 786.2 | 932.8 |
| 1969 | 632.7 | 368.6 | 1,109.9 | 1,015.4 | 981.3 | 2,798.2 | 764.2 | 765.9 | 918.6 |
| 1970 | 1,209.6 | 877.5 | 1,335.5 | 1,037.9 | 979.7 | 2,820.8 | 705.9 | 1,019.9 | 1,241.0 |
| 1971 | 763.8 | 558.5 | 1,524.9 | 1,151.6 | 1,034.2 | 2,147.6 | 506.9 | 652.8 | 893.1 |
| 1972 | 549.6 | 200.4 | 562.8 | 569.3 | 1,182.8 | 1,517.7 | 335.7 | 392.4 | 665.0 |
| 1973 | 1,131.9 | 481.1 | 1,128.5 | 1,065.1 | 912.9 | 2,810.7 | 709.8 | 949.3 | 1,190.4 |
| 1974 | 456.0 | 249.2 | 917.8 | 705.3 | 660.5 | 3,065.5 | 733.9 | 659.9 | 868.8 |
| 1975 | 1,158.1 | 646.5 | 1,278.7 | 1,084.6 | 961.4 | 3,030.2 | 827.2 | 1,152.7 | 1,274.7 |
| 1976 | 1,477.9 | 606.7 | 1,016.7 | 923.2 | 876.3 | 2,816.5 | 778.5 | 637.3 | 993.4 |
| 1977 | 1,142.5 | 596.3 | 915.5 | 978.5 | 1,338.2 | 2,967.6 | 688.5 | 752.9 | 1,093.1 |
| 1978 | 794.4 | 539.0 | 1,086.4 | 1,154.6 | 1,093.6 | 2,830.6 | 698.9 | 804.0 | 1,305.4 |
| 1979 | 745.4 | 1,039.4 | 591.0 | 576.6 | 1,082.9 | 2,048.6 | 723.1 | 925.8 | 1,109.6 |
| 1980 | 777.5 | 681.2 | 1,585.1 | 978.8 | 714.5 | 2,629.9 | 649.7 | 790.5 | 1,024.5 |
| 1981 | 943.6 | 794.8 | 1,114.4 | 767.1 | 1,051.6 | 2,996.5 | 781.3 | 890.3 | 1,237.8 |
| 1982 | 802.5 | 476.8 | 1,251.1 | 910.6 | 715.8 | 2,508.3 | 612.9 | 627.2 | 902.8 |
| 1983 | 1,047.7 | 909.0 | 1,224.4 | 1,226.8 | 1,083.2 | 3,807.3 | 723.4 | 1,220.8 | 1,274.4 |
| 1984 | 751.0 | 477.5 | 1,173.1 | 944.9 | 1,113.7 | 2,403.2 | 626.4 | 545.9 | 736.2 |
| 1985 | 537.7 | 325.7 | 1,272.2 | 1,024.9 | 1,169.6 | 3,102.2 | 504.5 | 553.1 | 900.1 |
| 1986 | 407.2 | 326.2 | 944.4 | 775.3 | 840.3 | 1,780.7 | 517.8 | 640.9 | 1,173.8 |
| 1987 | 347.0 | 116.0 | 771.4 | 572.5 | 935.7 | 2,858.9 | 659.5 | 836.1 | 842.7 |

# PRODUCTION AND CONSUMPTION OF FERTILISERS IN INDIA

F.K. Wadia

*The purpose of this paper is to review progress in the production and consumption of chemical fertilisers and the related policy measures in India. Commencing from negligible quantities in 1951-52 consumption of fertilisers increased to over eleven million tonnes by 1990-91 while production was lower, at about nine million tonnes. Imports have continued to be resorted to. Policy measures taken to increase production and consumption have included subsidies to the fertiliser industry as also on the sale of the produce to the farmers.*

## BEGINNINGS

The first reference to the lack of use of chemical fertilisers in India was mentioned by Dr. J.A. Voelcker, Consulting Chemist to the Royal Agricultural Society of England, in his report to the Government of India in 1893 on the Improvement of Indian Agriculture. He mentions inhibitions on the part of Indian farmers to the use of even bone manure, partly due to prejudice, but also due to the lack of knowledge of its utilisation and phosphatic value. Referring to the use of artificial manures (fertilisers), Dr. Voelcker had stated that "if natural manures, such as bones, are not yet likely to be used, still less so are artificial manures. Not only have no sources of the raw material been discovered which would pay for working, but the acid (sulphuric acid or oil of vitriol), required for their manufacture, cost .... too much: Over and above would be the cost of carriage both of raw and manufactured material. Once again, the real difficulty comes in, who is to pay for these? Only crops giving a high return could possibly meet the outlay, and, owing to lowness of prices for produce, the tendency of planters towards economy in artificial manures has of late been marked" [Voelcker, 1893, p. 117]. He pointed out that "the few wants and scanty means of the cultivators, and the smallness of the holdings ..... make it necessary to consider measures of improvement from a special point of view. This has not been sufficiently borne in mind by those who ..... advocated 'improved' implements and chemical manures for Indian agriculture" [Voelcker, 1893, p. 34]. Further, he observed: "Improvement in the system of land tenure, improvement of land by expenditure of public and private capital on it, and similar measures may alleviate the condition of the Indian cultivator, but they will not give him larger crops, and they will not provide the food that the people must have to live upon. For this the soil itself must be looked to, as it alone can produce the crops, and manure alone can enable it to bring forth the necessary increment. The question of manure supply is accordingly indissolubly bound up with the well-being and even the bare existence of the people of India" [Voelcker, 1893, Pp. 41-42].

In 1917, the Board of Agriculture appointed a Committee to enquire into the efficacy of manuring soil with phosphates and the possibility of procuring superphosphate at a figure which would render its application profitable to the cultivator. The Committee reported that evidence collected in Bengal, Assam, Burma and Madras had revealed that there was a marked deficiency of phosphates and experiments with phosphatic manuring had resulted in very beneficial results to agriculture particularly in respect of paddy. The Committee also reported that, where sufficient supplies of phosphatic manures were not available, the supply of superphosphate in the immediate future appeared to be important and recommended that special facilities should be considered to expedite either local manufacture or the import of this commodity [Ginwala, 1929, p. 58].

Sir Edwin Poscoe, Director, Geological Survey of India, in his Memorandum to the Royal Commission on Agriculture on 'India's Resources in Mineral Fertilisers'(1927) mentioned that 'no nitrate of soda' (chili salt petre) was 'produced in India'. However, small quantities ranging from 245 tonnes to 8,466 tonnes were imported into the country between 1,921 and 1,928. (All figures in this article are converted into metric measure for facility of comparison). But nitrate of potash (salt petre), was produced in Bihar, Punjab, Rajputana, United Provinces, Bengal, Madras and in Central India. The production ranged from 4,000 tonnes to 20,000 tonnes between 1919 and 1928, and nearly all of it was exported. Its use in the tea districts

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of north-east India was fairly extensive [Poscoe, 1929, p. 9].

He also mentioned that all sulphate of ammonia manufactured in India was obtained from the coke-ovens which served the iron and steel industry with metallurgical coke. Small quantities were produced by the East India Railways Company's collieries in the Giridih Coalfields, the Bengal Iron and Steel Company's plant at Kulti and at the Tata Iron and Steel Company's works at Jamshedpur. The sulphuric acid used in the preparation of ammonium sulphate in the coke ovens from the by-products of coal distillation, was largely imported until 1919. With increasing production of the acid at numerous plants in India, imports of sulphuric acid was replaced by import of sulphur. The production of sulphuric acid rose from 11,886 tonnes in 1919 to 29,908 tonnes by 1928 [Poscoe, 1929, Pp. 9-10]. From 1923 onwards, the consumption of ammonium sulphate increased and, by 1927, was beginning to exceed 20,000 tonnes. This was partly due to the extension of a system of local agencies in agricultural areas, where sulphate of ammonia and other manures could be purchased in much the same way as kerosene oil [Poscoe, 1929, p. 16].

*Report of the Indian Tariff Board regarding the Removal of the Import Duty on Sulphur, March 1924*

With the increasing use of sulphur in the manufacture of sulphuric acid, as also for other industrial uses, the Government of India referred to the Indian Tariff Board, in 1923, the question of import duty on sulphur. The Board recommended the removal of the prevalent import duty on sulphur of Rs 15 a tonne. "The reason in favour of this proposal are, we think, strong. Sulphur is not produced in India and is not likely to be produced and no domestic interest will therefore be prejudiced. On the other hand, the removal of the duty will be of substantial benefit to the chemical industry and the manufacture of fertilisers as well as to other industries" [Rainy, 1924, p. 4]. The Board argued: "In all Provinces, the Agricultural Department of Government are anxious to stimulate and extend the use of fertilisers by the cultivator, and under the present tariff such fertilisers are admitted free of duty. Cheaper sulphuric acid would do something to promote the manufacture of chemical manures in India and, by lowering their price, make it possible for the raiyat to buy them. In this branch of manufacture, the fertiliser which is produced on the largest scale in India is sulphate of ammonia. ... It is unfortunate that only a small proportion of India's production of this valuable chemical manure is consumed in the country. The bulk of it is exported to Java and Mauritius for use in the sugar plantations and to Ceylon. In these markets, the Indian product has, of course, to compete with fertilisers imported from other countries, and the question of price is all important if India is to hold its own. A reduction in the cost of manufacture of sulphate of ammonia would also be beneficial in another direction. Since it is a bye-product produced in the manufacture of coke, any profits that are made are taken in reduction of the cost of producing coke, and thence ultimately of pig iron and steel" [Rainy, 1924, Pp. 2-3].

*Royal Commission on Agriculture in India, Report, 1928*

The Royal Commission on Agriculture (1928) referred to the very marked increase both in the production and consumption of ammonium sulphate. Of the 4,500 tonnes produced in 1919, all but 480 tonnes were exported and there were no imports. In 1925, of the estimated 15,000 tonnes, 6,500 tonnes were retained in India. "With three exceptions, all the producers of sulphate of ammonia in India have joined the British Sulphate of Ammonia Federation which, through its agents, is conducting active propaganda to promote the use of artificial fertilisers and has established a number of local agencies in agricultural areas in several provinces. The manner in which this source of supply is being developed is very satisfactory and it is still more satisfactory that a market for increasing quantities of the sulphate of ammonia produced in India is being found in the country. The importance of the price factor need hardly be stressed for, though the present average price of Rs 140 per tonne free on rail at Calcutta is much lower than that which prevailed immediately after the war, it is sufficiently high to preclude the application of sulphate of ammonia to any except the most valuable

of the cultivators' crops such as sugarcane or garden crops" [Linlithgow, 1928, Pp. 89-90].

The Commission concluded that the development of the manufacture of, and the local market for, sulphate of ammonia in the country was satisfactory. No further investigation under government auspices of the possibilities of manufacturing synthetic nitrogen in India was required. The establishment by the Government of India of a central fertiliser organisation subsidised by firms dealing with fertilisers was not acceptable to the Commission. The Commission, however, approved of the establishment by fertiliser firms of their own research stations working in cooperation with the agricultural departments and other bodies interested in the fertiliser question. As regards natural phosphates, which were reported to be found in Trichinopoly district of Madras and in South Bihar, the Commission was of the view that "in neither tract do these phosphates exist in a form in which they can be utilised economically for the manufacture of superphosphate; and their employment in agriculture has been limited to applications of the crude material in pulverised form. This source of supply does not offer any important possibilities" [Linlithgow, 1928, p. 93].

*Report of the Tariff Board on the Heavy Chemical Industry, 1929*

In July 1928, the Government of India referred to the Tariff Board the question of protection being given to the heavy chemicals industry viz., Sulphuric acid, Hydrochloric acid, Nitric acid, Magnesium Sulphate, Ferrous Sulphate, Potash Alum, Aluminium Sulphate, Sodium Sulphide, Zinc Chloride, Copper Sulphate and Glavber's salt. The Tariff Board submitted its Report in May 1929. In addition to the above chemicals, the Board discussed two artificial fertilisers, viz. ammonium sulphate and super phosphate, in the manufacture of which sulphuric acid was also essential [Ginwala, 1929, p. 1]. It reviewed the progress of production of ammonium sulphate from Indian coke oven gases which had risen from 12,755 tonnes in 1924 to 15,300 tonnes by 1928. Approximate consumption had risen from 2,545 tonnes to 33,595 tonnes during the same period, the additional quantum being supplemented by imports. Ammonium sulphate in India was sold formally by the British Sulphate of Ammonia Federation and later on behalf of a combine by Nitram Limited. The combine consisted largely of British manufacturers but the majority of firms operating coke oven plants in India, including all the Steel and Iron works were also members of the combine. The Board was of the view that no assistance was called for in respect of the ammonium sulphate industry. "But, having regard to the fact that ammonium sulphate was already produced in India on a considerable scale ..... the price at which it was sold in India should be substantially reduced with a view to the encouragement of agriculture and extension of the market for fertilisers." The prevailing price in India was considerably above the level in England, though the purchasing power of the Indian ryot was much below that of the English farmer.

The Board found that the manufacture of superphosphate was a suitable industry for the grant of protection; that, inspite of competition from compound fertilisers, there would be a sufficiently large market in India for superphosphate and that establishing a local industry would help materially to reduce its price. Hence, it recommended a bounty payable on the first 1,000 tonnes of superphosphate produced in a year by any factory whose annual output was not less than 2,000 tonnes. A minimum output was proposed because the Board considered it undesirable to encourage establishment of small uneconomic units which would be unable to survive the withdrawal of the bounty. The proposed rate of bounty was 12 annas (75 p.) per unit of soluble phosphoric anhydride. The payment of bounty was subject generally to the conditions laid down in the Steel Industry (Protection) Act, 1924 and the maximum liability of Government was fixed at Rs 7 lakh annually for a period of seven years [Ginwala, 1929, Pp. 109-110].Government gave effect to these proposals.

PRODUCTION, CONSUMPTION, AND IMPORTS

*Foodgrains Policy Committee (1943)*

The Foodgrains Policy Committee (1943) recommended the setting up of a 'large state-owned,

state-managed factory to manufacture ammonium sulphate. Two plants for the manufacture of this fertiliser were set up by the time the Second World War was over. A synthetic ammonia plant (The Mysore Chemicals and Fertilisers Ltd.) was set up at Belagula in Mysore State (Karnataka) to produce 20 tonnes of sulphate per day (6,000 tonnes per annum). In Travancore (Kerala), the Fertilisers and Chemicals, Travancore Ltd. (FACT) was set up at Alwaye with a production capacity of 150 tonnes per day (45,000 tonnes per annum).

*Report of the Technical Mission to Advise on Production of Artificial Fertilisers, Nov. 1944*

In June 1944, Government appointed a Technical Mission to (i) investigate and report to the Government of India on the technical problems involved in the manufacture of Sulphate of Ammonia in British India in quantities up to 355,600 tonnes per annum; (ii) recommend, in the light of the raw materials and power available in India, the most economic method of manufacture; (iii) indicate the approximate capital cost of the plant or plants to be installed, and calculate the approximate cost of operations and production of finished Sulphate of Ammonia; (iv) recommend the most suitable site or sites for the erection of the plants concerned, taking into action the raw materials available and the most economic distribution of the finished products; (v) estimate the amount and approximate value of plant which it will be necessary to import from outside India making the fullest possible use of materials and labour available in India; (vi) if, for any reason, it should appear that nitrogenous fertiliser, in a form other than Sulphate of Ammonia can be more satisfactorily manufactured under Indian conditions generally or locally, consider and recommend from a technical point of view, the most economic method of manufacture of such alternative fertiliser; and (vii) estimate the capital and operating cost of manufacture of such alternative nitrogenous fertiliser [Gowing, 1944, p. 1].

The Mission submitted its Report in November 1944. Having regard to the raw materials and power available in India, the Mission were of the opinion that the most economic method of manufacture was that employing water-gas made from coke to produce the necessary ammonia, followed by conversion to sulphate by the gypsum or anhydrite process. It recommended that coke should be obtained from the Bihar-Bengal coalfields and gypsum or anhydrite from Khewra in the Punjab, that the whole production should be carried out in a single factory and that, taking into account the raw materials available and the most economic distribution of the finished product together with all other relevant factors, such as water supply, power supply, transport, etc., the best site was in the Gangetic Plain. In particular, it recommended Harduaganj in the United Provinces (an alternative at Sindri could be considered). The approximate cost of such a factory was estimated at Rs 10.1 crore, about half of which would be the cost of imported plant and equipment. The approximate cost of the finished product was estimated at Rs 112 per tonne at the factory. The Mission considered whether nitrogenous fertiliser in a form other than sulphate of ammonia could be more satisfactorily manufactured under Indian conditions generally or locally, but reached the conclusions that no fertiliser other than sulphate of ammonia should be considered for the present purpose.

The Mission further recommended that (a) work should be instituted to determine the suitability of ammonium nitrate as a fertiliser for Indian conditions, in order to take advantage for future nitrogenous fertiliser requirements of a material which should be cheaper to produce; (b) in the event of extensions to the scheme of production being contemplated, the possibility of utilising lower grade non-coking coal for gas production be investigated; (c) a survey should be undertaken to investigate the quantity of anhydrite in the Salt Range in order that this raw material could be used in preference to gypsum, thereby effecting certain economies in the manufacture of sulphate of ammonia; funds were already allocated for this purpose, and it was hoped that the results would be available before detailed design of the plant was undertaken; (d) that consideration should be given, in the event of anhydrite not being available, to the desirability of developing the production of gypsum in Rajputana in order to utilise

a second source of supply; and (e) that a scheme be instituted for training the technical staff necessary for running the factory. This would involve sending selected candidates overseas to obtain experience in fertiliser factories of the type proposed for India [Gowing, 1944, Pp. 40-41].

In 1945, Government decided to put up a factory at Sindri in Bihar for manufacturing 350,000 tonnes of ammonium sulphate per annum using the gypsum process. Arrangements for the design and construction of this factory was taken in hand during 1947 and the work was completed by the end of 1951.

*Report of Heavy Chemicals and Electro-Chemical Industries Panels, May-June 1946*

In March 1945, Government appointed two Panels, viz., the Heavy Chemicals Panel and the Electro-Chemical Industries Panel to examine (i) the scope and extent of development, including the type of products recommended; and the estimated requirements of capital goods together with such details of those requirements as may be available in India and how much should be imported from abroad; (ii) whether the industry should be under Government ownership either on grounds of national interest or because private capital was unlikely to take it up, and if so, whether it should be wholly or partly managed by Government; (iii) in the latter case, whether the whole of the capital was likely to be available by public investment, and, if not, the extent to which Government assistance might be required; (iv) the location of the industry; (v) the relative incidence of the import duty on the finished goods in comparison with the duty on the raw materials from which they could be manufactured; (vi) if the industry is to be under private ownership and management, what controls if any should be exercised by Government; (vii) the stages by which the industry should be developed. (viii) should the industry cater for the export market, or be developed on the cottage industry basis and if so to what extent [Ghosh/Ram, 1946, Pp. (i)-(ii)].

In view of the commonality of the subjects, the two Panels agreed to have joint meetings and discuss all subjects together. A combined Report was submitted. Noting that the three elements required by plants were nitrogen, phosphorous and potassium, the Panels recommended that nitrogen may be made available in the form of ammonium sulphate, ammonium nitrate, urea, calcium nitrate or as ammonium phosphate; phosphorous in its salts, superphosphate and ammonium phosphate; and potassium in potassium nitrate and chloride. The Panels did not consider the production of ammonium sulphate because it was already examined by the Government of India in 1944. About 6,100 tonnes were being made in Belagula, 20,000 tonnes from coke-ovens in Bihar and according to the new schemes, 50,800 tonnes in Travancore and 355,600 tonnes at Sindri, were going to be manufactured. As regards urea, the Panels recommended that to begin with, a plant of 10,160 tonnes capacity per year be installed at Sindri by the Government of India along with the Sindri ammonia plant. The Panels did not make any recommendation for the setting up of an ammonium nitrate plant in view of the fact that the question of its suitability for use as a fertiliser was still undecided. With regard to potassium nitrate as a fertiliser, the Panels understood that large quantities were collected on a cottage industry basis in Bihar, U.P., Punjab, Patiala, Bikaner, and Bharatpur, the total production being more than 15,240 tonnes per year. The Panels recommended that this industry should be organised properly by the Provincial and State Governments. The manufacture of calcium nitrate could be taken up when cheap nitric acid became available.

The Panels mentioned that the main sources of phosphatic fertilisers in the country were phosphatic rocks and bones. In India, superphosphate was prepared by treating bones with sulphuric acid; this was a very wasteful method since the other constituents of bones like glue, gelatine, grease, and fat were not utilised. Therefore, to establish the bone-superphosphate industry on a sound footing, a large scale factory with facilities for recovery of glue and gelatine before the bones were treated with sulphuric acid was necessary. At the same time, the possibility of using bone-meal itself as a fertiliser should be examined. This would save sulphuric acid. Rock phosphate was available in quantities as apatite in Singbhum area and as phosphatic nodules in the Trichinopoly

district. No sustained efforts had been made to work up these deposits. The Panels recommended a five-year target of over 100,000 tonnes per year for superphosphates. Further, Government of India should put up an experimental plant for manufacture of 10 tonnes of phosphorous per day and concentrated phosphates by the electro-thermal process. In order to conserve the phosphate resources of the country, it was necessary to prohibit the export of bones and bonemeal out of India.

The raw material for potash fertilisers available in the country, was potassium nitrate, about 15,240 tonnes of which were produced from large tracts of saline earth in Bihar, U.P., Punjab, Bikaner, Patiala, and Bharatpur. Production could be increased, if necessary, without any difficulty. Cost of production was high due probably to want of proper organisation. The matter could be examined in consultation with the Provincial and State Governments [Ghosh/Ram, 1946, Pp. 30-32].

*Report of the Indian Tariff Board on Phosphates and Phosphoric Acid, May 1946*

In May 1946, the Tariff Board also gave its recommendations regarding the phosphates and phosphoric acid industry. According to the Board, phosphoric acid and di-sodium phosphates could be used for the manufacture of fertilisers. In 1946, there was only one factory in India - Star Chemicals at Bombay which had commenced operations in 1943 - manufacturing phosphoric acid and phosphates. There would be demand for specific protective duty on all imports of phosphoric acid, sodium phosphates and acid calcium phosphate. Government should also ensure that manufacturers of phosphoric acid and its sodium and calcium salts got sulphuric acid at a rate not exceeding Rs 160 per ton (Rs 157.47 per tonne). Further, manufacturers of phosphoric acid and its salts should be given all facilities for obtaining reaction vessels of stainless steel and other plants and machinery to enable them to prepare these chemicals of commercial as well as pure BP quality [Shanmukhan Chetty 1946, Pp. 16-17].

The Board recommended that an enquiry should be carried out as to the requirements of different types of fertilisers, having regard to the actual soil and climatic conditions in different parts of the country and requirements of different crops. Any plans for future development of the fertiliser industry could be modified in the light of the results of such investigation.

In Table I, we show the production of chemical fertilisers as it was in 1947, namely, the time of Independence.

TABLE 1. PRODUCTION OF FERTILISERS IN 1947

(Tonnes)

| | | |
|---|---|---|
| A. Ammonium Sulphate | | 26,488.42 |
| (i) Bye-product coke-oven Plants | | 6,705.93 |
| (ii) Mysore Chemicals and Fertilisers, Belagula | | |
| | | 33,194.35 |
| B. Superphosphates | | 47,754.35 |
| C. Potash Fertiliser | | 28.45 |
| | Total | 80,977.15 |

*The First Five Year Plan, 1951-56*

The First Plan reviewed the past development of the fertiliser industry (separately for nitrogenous, phosphatic and potassic fertilisers), the position of the industry at the advent of the Plan, and the programmes of expansion expected by the end of 1951-56. The installed capacity (1951) of the 13 factories regularly engaged in the production of superphosphate had increased from 82,300 tonnes in 1949 to 148,190 tonnes by 1951. Production had also increased from 14,015 tonnes in 1947 to 34,214 tonnes during the first nine months of 1950. The requirements were estimated at 325,000 tonnes of $P_2O_5$ (equivalent to 2.03 million tonnes of 16 per cent superphosphate) per year at the minimum.

Production of ammonium sulphate was first achieved as a by-product of coking ovens. There were four such units in West Bengal and Bihar with a rated capacity of about 26,500 tonnes of ammonium sulphate per annum. Synthetic ammonia production and its conversion to ammonium sulphate was first started in Mysore in 1938 at Belagula with a rated capacity of 6,700 tonnes of ammonium sulphate per annum. In 1947, a larger plant with a rated capacity of over 46,000 tonnes of ammonium sulphate per annum

was put up near Alwaye in Travancore (FACT), the synthetic ammonia manufactured being converted into the sulphate partly by the use of gypsum and partly by reaction with sulphuric acid produced from sulphur; it came into production in 1950-51. When the Government factory at Sindri came into production in 1952-53, the rated capacity had reached 435,550 tonnes of ammonium sulphate per annum on the basis of 330 working days. Nevertheless, the bulk of ammonium sulphate consumed was being imported; in 1951-52, the imports amounted to about 68,500 tonnes. Besides, substantial quantities of sodium nitrate and other nitrogenous fertilisers were also imported.

It was estimated that, in the prevailing circumstances of Indian agriculture, a quantity of 457,000 tonnes of nitrogen equivalent to 2.29 million tonnes of ammonium sulphate should be adequate. In fact, the actual consumption was only around 150,000/175,000 tonnes of ammonium sulphate. In the circumstance, the target of annual consumption of synthetic nitrogen by the end of 1952-53 was placed at 91.44 thousand tonnes of nitrogen, equivalent to 457,000 tonnes of ammonium sulphate and by the end of 1955-56 at 122,000 tonnes of nitrogen, equivalent to 60,000 tonnes of ammonium sulphate.

The most important problem of the industry was the difficulty of obtaining adequate quantities of sulphur for producing sulphuric acid required in ammonium sulphate manufacture. FACT Ltd. had arrangements for making use of gypsum from Trichinopoly but the quality of this deposit was somewhat unsatisfactory and its economic mining difficult.

Table 2 gives the programmes of development envisaged during the First Five Year Plan for nitrogenous fertilisers (ammonium sulphate).

There would still be a gap of the order of 122,000 tonnes between the capacity and estimated requirements which would have to be made good by imports. The Plan recommended the early implementation of the scheme for the expansion of fertiliser production at Sindri on which a project report was prepared under the Technical Cooperation Administration of the USA (TCA) for 1952. The expansion scheme for Sindri envisaged the production of about 100 tonnes of urea and 110 tonnes of ammonium nitrate per day making use of by-product coke oven gases and waste carbon dioxide from the operations.

TABLE 2. INSTALLED CAPACITY OF PLANTS FOR NITROGENOUS FERTILISERS BASED ON 330 WORKING DAYS
(In tonnes of Ammonium Sulphate)

| | 1950-51 | 1952-53 | 1955-56 |
|---|---|---|---|
| By-product Coke Oven Plant | 26,488 | 27,505 | 27,505 |
| Mysore Chemicals and Fertilisers, Belagula | 6,706 | 6,706 | 13,412 |
| Fertilisers and Chemicals (Travancore) Ltd. Alwaye | 46,738 | 46,738 | 93,477 |
| Sindri Fertilisers and Chemicals Ltd. | -- | 355,618 | 355,618 |
| Total | 79,933 | 436,566 | 490,011 |

Source: *First Five Year Plan*, Planning Commission.

Existence, in India, of sulphur or pyrites, required for the manufacture of sulphuric acid used for the ammonium sulphate production, was not known until then. Hence, reliance was on imports. Gypsum could also be used as an alternative raw material and Government had made arrangements for its supply to the Sindri factory from Bikaner and Jodhpur as supplies were unavailable from Khewra, Punjab (Pakistan), on the basis of which the factory was set up. Gypsum was also required for the cement industry. Therefore, before the ammonium sulphate capacity could be expanded further, it was necessary to ensure that the limited resources of gypsum were husbanded carefully. Since other nitrogenous fertilisers besides ammonium sulphate were also proposed, the Plan recommended that (i) early investigations should be undertaken by the Indian Council of Agricultural Research for collecting comparative data regarding the efficacy of different nitrogenous fertilisers - ammonium nitrate, nitro prills and nitro chalk, ammonium chloride, ammonium phosphate, urea and calcium cynamide - under different soil conditions and for different crops. Simultaneously, the National Laboratories and the Development Wing of the Ministry of Commerce and Industry should investigate the feasibility of manufacturing these alternative nitrogenous fertilisers at suitable places in the country and

determine the economics of their production. With the additional hydro-electric power resources becoming available from the Hirakud, DVC and Bhakra-Nangal projects, the question of locating some of the nitrogenous fertiliser industries in those places, required close examination; (ii) The National Chemical Laboratory should undertake immediate investigations into the development of processes for utilising, if possible, indigenous raw materials, such as magnesium sulphate and sodium sulphate, for the manufacture of ammonium sulphate; and (iii) The Geological Survey of India should undertake detailed prospecting and estimation of available reserves of gypsum and pyrites in different parts of the country. Table 3 summarises the programme of development of the nitrogenous fertiliser industry envisaged during the period of the First Plan.

TABLE 3. PROGRAMME OF DEVELOPMENT OF NITROGENOUS FERTILISERS, 1951-56

| | Unit | 1950-51 | 1955-56 |
|---|---|---|---|
| Factories | number | 6 | 7 |
| Annual Rated Capacity | tonnes | 79,933 | 490,011 |
| Actual Production | tonnes | 47,047 | 457,222 |
| Estimated Consumption | tonnes | 254,013 | 609,630 |

Source: *Programmes of Industrial Development, 1951-56*, Planning Commission, 1953.

In the case of phosphatic fertilisers, the indigenous production of superphosphates was entirely in the form of single superphosphate manufactured from imported rock phosphate. In 1951, there were 14 plants in existence with an annual rated capacity of nearly 127,000 tonnes. The sizes of these units by world standards were small. This got reflected in higher costs of production more particularly so because the sulphuric acid units which supplied acid for superphosphate manufacture were also small. The factories had been able to survive mainly because of the indirect protection received in the form of import control and pooled distribution of domestic production. The factories were however expanding their capacity and by the end of 1951-52 there were four units with capacities of over 15,000 tonnes of superphosphates per annum operating in the country. The production of superphosphates had steadily risen from 21,700 tonnes in 1948 to 62,010 tonnes in 1951. Very small quantities of superphosphates were imported; only about 2.7 thousand tonnes in 1951-52.

According to the Plan, the requirements of phosphatic fertilisers expressed in terms of $P_2O_5$, and reckoned on the basis of the application of nitrogen and $P_2O_5$ in proportions suitable to each crop all over the country should be placed at over a million tonnes. In comparison, the actual consumption was only 50,000 - 60,000 tonnes of superphosphate annually. Considerable inducement and financial subsidies were found necessary to bring the consumption of superphosphate even to that level. Taking into account the low consumption and the difficult sulphur supply position since the outbreak of the Korean war, it was envisaged that about 200,000 tonnes would be consumed by 1955-56.

Superphosphate produced in the country was distributed to different consuming centres from a pool organised by the Central Government and at prices recommended by the Tariff Board. The Pool was abolished from 15th August 1952. The problems of the superphosphate industry were the shortage of sulphur and the high cost of production. Hence, there was need to switch over to alternate methods of producing phosphatic fertilisers. A number of recommendations were made for the expansion of the superphosphate industry. These included (i) manufacture of alternative phosphatic fertilisers, (ii) manufacture of Kotka Phosphate, (iii) survey and utilisation of domestic rock phosphate, (iv) better organisation of collection and processing of bones, (v) development of the superphosphate industry in the public sector, and (vi) standardisation of alternate phosphatic fertilisers. The Indian Standards Institution were expected to fix suitable standards for phosphatic fertilisers on citrate soluble basis. The programme of development of the phosphatic fertiliser industry envisaged for the First Plan period is shown in Table 4.

TABLE 4. PROGRAMME OF DEVELOPMENT OF PHOSPHATIC FERTILISERS, 1951-56

| | Unit | 1950-51 | 1955-56 |
|---|---|---|---|
| Factories | number | 14 | 17 |
| Annual Rated Capacity | tonnes | 125,442 | 212,715 |
| Actual Production | tonnes | 55,973 | 182,889 |
| Consumption | tonnes | 59,337 | 203,210 |

Source: *Programmes of Industrial Development, 1951-56*, Planning Commission, 1953

Potassic fertilisers in India were commonly derived from the natural deposits of potassium nitrate occurring in Bihar, U.P., Punjab, Patiala, Bikaner, and Bharatpur, which were extracted and purified by crude methods on a cottage or small scale basis, Production was about 15,000 tonnes per annum before Independence, but the bulk of such units went to Pakistan and production in Bihar, U.P. and other parts was not sufficient to meet the demand. As a by-product of salt manufacture, it was possible to produce nearly 85,000 tonnes of $K_2O$ from all the salt works in the country. Actual production was however, limited to the quantity recovered in the Tata Chemical Works at Mithapur. Molasses obtained as a by-product of the sugar industry could also be utilised for the manufacture of potassic fertilisers. Although potash salt had not been recovered on any large scale from molasses in India, advantage had been taken of the existence of potassium salts in molasses by using distillery slops containing such salts for fertilising suitable crops in the neighbourhood of distilleries.

The estimated annual requirements of potash fertilisers on the basis of using them only for the most essential crops were roughly 37,500 tonnes of all potash fertilisers reckoned together and expressed as $K_2O$. Potash salts were generally marketed in the form of ready mixtures containing definite proportions of K.P. and N. The First Plan document recommended that (i) as the demand for potash salts was expected to increase to about 38 thousand tonnes expressed as $K_2O$, it should be possible to recover nearly 54 thousand tonnes expressed as $K_2O$ from all the salt works in the country. The bigger salt manufacturers should be encouraged to put up by-product recovery plants for production of potassium chloride; (ii) The State Governments of Bihar, U.P., Pepsu and Rajasthan should take necessary steps to organise cottage scale manufacture of potassium nitrate on a cooperative basis so as to increase the output of the product and also to bring down its cost; (iii) To enable potassium salts to be recovered and made available for use in distant places, it was necessary to recover such potassium salts from molasses as well as distillery slops by adopting suitable processes which may be standardised by the manufacturers of sugar and alcohol in consultation with the National Chemical Laboratory; (iv) In the event of potassium salt supplies from the above sources being found inadequate, the possibilities of recovering potash salts from the flue gases of cement furnaces might also require consideration, [Planning Commission, 1953(b), Pp. 128-130].

*Report of the Fertiliser Production Committee, 1954*

In 1954, Government thought it necessary to expand the indigenous capacity for production of fertilisers. It was estimated that fresh capacity for producing 2.54 lakh tonnes per annum (in terms of nitrogen) would be needed to be set up by 1961. As a first step immediate action for planning and creating additional capacity for 1.73 lakh tonnes of nitrogen per annum was necessary. Therefore, in October 1954, Government constituted a Committee (i) to suggest possible locations for the new fertiliser factories for the production of ammonium sulphate, ammonium sulphate-nitrate and urea having regard to all relevant considerations including adequacy of transport and the proximity of consumer points; (ii) to indicate the quantities of one or more of these fertilisers that could be produced at each location on an economic basis, the processes to be adopted and the probable cost of production; (iii) to estimate roughly the capital and working cost of the plants recommended at the different locations; (iv) to make recommendations regarding the requirements and the provision of technical personnel for staffing the new plants; and (v) to suggest the best method of further processing the Committee's recommendations [Mukherji, 1955, p. 137]. The Committee was also informed that one of the new fertiliser production units would have to be set up in the Bhakra-Nangal area in conjunction with a project for production of heavy water. The Committee submitted an Interim Report for the Nangal factory in January 1955 and the Final Report in June 1955.

In its Interim Report, the Committee recommended that the optimum capacity of the nitrogen production unit at Nangal should be of the order of 71,000 tonnes of nitrogen per year. A suitable type of ammonium nitrate fertiliser could be produced which could cater to the area covered by Jammu and Kashmir, Himachal Pradesh, the

Punjab, Pepsu, Delhi, and the North-Western portion of Rajasthan commanded by the Bhakra-Nangal irrigation system. The nitrogen content in the end-product should be kept as high as possible consistent with explosion risks. Arrangements should be made for the installation of the required power generating capacity at Bhakra-Nangal to make available to the new fertiliser-cum-heavy water factory a dependable all-the-year-round power supply of about 160,000 kw at a load factor of 90 per cent. A specific rate at which electricity would be supplied by the Bhakra Dam authorities should be simultaneously negotiated.

The plant should be designed to produce 70,000 tonnes of nitrogen per year along with 7.62 tonnes of heavy water. The ammonia synthesis process should be based on electrolytic decomposition of water; and the end product should be ammonium nitrate diluted with clay and chalk in the proportions of Ammonium Nitrate 60, Clay 26, and Chalk 14 per cent. The nitrogen content of the end product would thus be 21 per cent and its total annual production 340,000 tonnes. This production capacity was based on the assumption that the required quantity of Bhakra hydro-electric power (160,000 kw at a load factor of 90 per cent) could be made available at a cheap enough rate to warrant adoption of the electrolysis process for ammonia synthesis; in any case, the power rate should not be more than 2.6 pies per unit. In case the supply of the required quantum of power was not available, depending on the amount of minimum firm power supply that could be assured, either the production capacity at 71,000 tonnes of nitrogen a year be retained, but the plant be designed to achieve a high stream efficiency (say, 98 per cent); or the production capacity be reduced from 71,000 tonnes to 61,000 tonnes of nitrogen a year [Mukherji, 1955, p. 5].

In its final Report, the Committee recommended that the production of the balance of 101,000 tonnes of nitrogen (out of the total target of 173,000 tonnes to be achieved by 1961) should be arranged for, partly in the form of urea (66,000 tonnes with nitrogen content of 45 per cent) and partly in the form of sulphate nitrate (279,000 tonnes with nitrogen content of 26 per cent). The double salt to be manufactured in the new unit(s) should conform to the specifications given in the report; and urea production should be associated with the manufacture of double salt so as to permit the adoption of the 'once through' process.

The Committee recommended that if a fair price not exceeding Rs 3.13 per thousand cu.ft. could be negotiated for the 2.3 million cu.ft. of refinery gas which Stanvac were prepared to supply from their oil refinery at Trombay (Bombay), a unit at Trombay may be established designed to produce 142.25 tonnes ammonia per day by processing the available gas and 140,000 tonnes of double salt per year as the end-product having a nitrogen content of 36,578 tonnes per year. Another unit designed to produce about 47,000 tonnes of urea and 203,000 tonnes of double salt per year (with a total nitrogen content of 74,000 tonnes per year) at Neyveli in Madras State or, failing Neyveli, at Vijayawada in Andhra. If a fair price could not be negotiated for the Bombay gas, the entire urea and double salt production (with a total nitrogen content of 101,605 tonnes per year) should be established at Neyveli, or failing Neyveli at Vijayawada.

In order to bring the production target of 173,000 tonnes of nitrogen per year closer to the Ministry of Agriculture's estimate of total additional nitrogen requirements by 1961 of about 254,000 tonnes per year, the Committee recommended setting up of (i) a unit to produce 66,000 tonnes of urea and 224,000 tonnes of double salt per year (with a total nitrogen capacity of 87,888 tonnes per year) at Neyveli, or failing Neyveli, at Vijayawada; (ii) a unit to produce 254,000 tonnes of double salt per year (with a nitrogen capacity of 66,000 tonnes per year) at Itarsi in Madhya Pradesh. Consideration could be given for the extra production of the 82,000 tonnes of nitrogen a year to be established through the production of alternative nitrogenous fertilisers cheaper than double salt, particularly nitro-limestone for which product the three best locations were Rourkela in Orissa (assuming availability of the hydrogen fraction of the steel plant coke oven gas), Mirzapur in Uttar Pradesh and Bhadravati in Mysore. Indigenous gypsum should be utilised for the sulphur radical required for the manufacture of ammonium sulphate component of double salt. The Committee recommended the utilisation of Saurashtra gypsum at Bombay, Trichinopoly gypsum at Neyveli; and

Rajasthan gypsum at Vijayawada and Itarsi.

Preference was indicated for the partial oxidation process for conversion of Bombay refinery gas. The ammonia synthesis plant should be so designed as to be capable of processing both refinery gas and mineral oil fractions or any hydro-carbon stream. Direct gassification of South Arcot lignite, Singareni coal and Madhya Pradesh coal was recommended for ammonia synthesis at Neyveli, Vijayawada and Itarsi, respectively [Mukherji, 1955, Pp. 273-279].

*Progress During the First Plan*

The First Plan targets of expansion of capacity for nitrogenous fertilisers were not fulfilled. The Sindri Fertiliser Factory started production of the iron oxide catalyst required in the water gas shift reaction for the generation of hydrogen needed for ammonia synthesis. Another development at Sindri was the construction of a coke-oven battery with a daily capacity of 610 tonnes and equipped with an up-to-date recovery system for the by-products from the coke- oven gas. The Government appointed a team of technical experts with the aid of TCA to examine the possibilities of stepping up fertiliser production at Sindri on the basis of the coke-oven gases expected to be available at the rate of 10.0 million cu.ft. per day as a by-product from the coke-ovens. The technical team after visiting fertiliser factories manufacturing ammonium nitrate, urea and other fertilisers in various countries, recommended the desirability of producing ammonia by reforming coke-oven gas and further converting it to sulphate-nitrate and urea. These recommendations were accepted by the Government, and work on the project commenced only during 1954-55.

As regards FACT, the construction of a plant for the production of 8,128 tonnes of ammonium chloride per annum was completed by the end of 1954. But doubling of the capacity was considerably delayed because preliminary studies were needed in order to decide the types of nitrogenous fertilisers to be produced and the processes to be adopted with a view to improving the economics of the plant. A Technical Committee appointed by the Government reported on the expansion scheme in 1954-55, and suggested that (a) a part of the output amounting to about 18,289 tonnes should be produced in the form of ammonium phosphate (N 16 per cent and $P_2O_5$ 20 per cent); (b) the production of ammonium sulphate should be expanded from 48,770 to 60,963 tonnes; and (c) while in the first instance only the hydrogen required for the expanded production of ammonia need be produced electrolytically, the entire requirements should before the end of the Second Plan, be obtained by this process with a view to reducing the cost of production. Government accepted the suggestions and a loan from the Industrial Finance Corporation of India was arranged for financing the expenditure during the Second Plan.

Not much progress was made on the expansion project of the Mysore Chemicals and Fertilisers. During 1953-54, the Company erected the ammonia compressor and circulator and the Industrial Finance Corporation of India was approached for financial assistance for the completion of the scheme.

The industry also faced a number of problems; difficulties in procuring sulphur, high ruling prices of fuel oil, shortage of transport facilities and resultant accumulation of stocks with the factories.

As regards phosphatic fertilisers, the First Plan had envisaged a capacity target of 212,715 tonnes and a production target of 203,210 tonnes by 1955-56. The actual capacity in existence by the end of March 1956 was estimated at 215,525 tonnes per annum. Actual production was much lower at 78,519 tonnes in terms of superphosphates (table 7).

In view of the absence of deposits of sulphur within the country, a suggestion was made that the possibilities of manufacturing dicalcium phosphate and kotka phosphate, which would eliminate or partially reduce the consumption of sulphuric acid, should be explored and further that standard specifications should be formulated for these alternative fertilisers in terms of citrate soluble $P_2O_5$ instead of water soluble $P_2O_5$. Work on these suggestions were undertaken at the National Chemical Laboratory, the Indian Standards Institution, and the Delhi Cloth and General Mills Chemical Works. The results of the experiments had shown the practicability of manufacture of kotka phosphate and dicalcium phosphate. Commercial production was however

held up because the supply position of sulphur required in the production of superphosphates had improved [Planning Commission, 1956(a), Pp. 181-182].

No specific targets for capacity and production of potassic fertilisers were proposed in the First Plan. But recommendations for increasing production through salt manufacturers, organisation of cottage scale manufacture of potassium nitrate in Bihar, U.P., Pepsu, and Rajasthan and recovery of potassium salts from molasses and distillery slops were made. No progress worthy of note was made on these recommendations during the Plan period [Planning Commission, 1956(a), p. 138].

Consumption of ammonium sulphate continued to rise during the Plan period. This was largely due to (a) reduction in the issue price of ammonium sulphate from Rs 324.79 to Rs 285.42 per tonne; (b) introduction of uniform freight rate as a result of which ammonium sulphate was available at Rs 310 per tonne at any rail-head in the country; (c) reduction in the distribution charges and the availability of the fertiliser at Rs 339.55 per tonne at the farmer's door; (d) grant of credit facilities to the farmers for purchase of fertilisers on a substantial scale; (e) effective demonstrations and publicity carried out by the staff of the Agricultural Departments and by the National Extension Service; and (f) extensive adoption of the Japanese method of cultivation in the country for the rice crop [Planning Commission, 1953, Pp. 175-177]. The gap between consumption and production was met through imports (Table 5).

TABLE 5. CONSUMPTION OF FERTILISERS IN TERMS OF AMMONIUM SULPHATE IN 1951-56

(tonnes)

| Year | Production | Imports | Consumption |
|---|---|---|---|
| 1951-52 | 53,551 | 141,968 | 286,933 |
| 1952-53 | 223,838 | 219,082 | 281,243 |
| 1953-54 | 324,746 | 89,133 | 333,264 |
| 1954-55 | 345,683 | 86,433 | 469,568 |
| 1955-56 | 393,762 | 247,702 | 650,851 |

Source: *Report of the Fertiliser Distribution Enquiry Committee*, 1960, Department of Agriculture.

Consumption of superphosphate was substantially lower than was estimated. After the abolition of the superphosphate pool in August 1952, the consumption decreased mainly due to difficulties in regard to marketing arrangements. Consumption of superphosphates in 1955-56 was expected to be about 122 thousand tonnes as against the original estimate of 203 thousand tonnes. But, it was substantially lower at 13,000 tonnes (Table 6).

TABLE 6. PRODUCTION AND IMPORTS OF SUPERPHOSPHATES

(tonnes)

| Year | Production | Imports | Consumption |
|---|---|---|---|
| 1951-52 | 62,101 | 53,791 | 6,900 |
| 1952-53 | 47,281 | 15,798 | 4,600 |
| 1953-54 | 87,770 | 45,110 | 8,300 |
| 1954-55 | 91,098 | 79,946 | 15,000 |
| 1955-56 | 78,519 | 53,936 | 13,000 |

Source: *Fertiliser Statistics* (various issues)

### *Second Five Year Plan (1956-61)*

In 1954, a Standing Committee on Manures and Fertilisers, set up by the Government framed estimates of fertiliser consumption in the country for the period 1953-54 to 1960-61 (Table 7).

TABLE 7. ESTIMATES OF CONSUMPTION OF FERTILISERS, 1953-54 TO 1960-61

(tonnes)

| Year | Nitrogen | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| 1953-54 | 101,605 | 12,193 | 60,963 |
| 1954-55 | 137,167 | 18,289 | 81,824 |
| 1955-56 | 177,809 | 25,401 | 10,161 |
| 1956-57 | 213,371 | 40,642 | 12,193 |
| 1957-58 | 254,013 | 60,963 | 15,421 |
| 1958-59 | 304,815 | 86,364 | 20,321 |
| 1959-60 | 365,778 | 121,926 | 25,401 |
| 1960-61 | 441,982 | 152,408 | 30,482 |

Source: *Report of the Fertiliser Production Committee*, 1955.

At the same time, the Ministry of Food and Agriculture had estimated requirements of nitrogenous fertilisers during the period of the Second Plan. These are shown in Table 8.

TABLE 8. REQUIREMENTS OF NITROGENOUS FERTILISERS

| Year | Tonnes of Fixed Nitrogen |
|---|---|
| 1956-57 | 152,408 |
| 1957-58 | 193,050 |
| 1958-59 | 243,852 |
| 1959-60 | 304,815 |
| 1960-61 | 375,940 |

Source: *Second Five Year Plan*, Planning Commission.

Apart from ammonium sulphate, the Ministry of Food and Agriculture had accepted nitro-limestone (20.5 per cent nitrogen), sulphate-nitrate (26.5 per cent nitrogen) and urea (44-46 per cent nitrogen) as by and large suitable. However, their application had to be restricted to certain regions until more experiments had been carried out on the suitability of soils for their application and on methods of improving storage conditions.

The Plan in the Public Sector included the completion of the expansion of the Sindri Fertiliser Factory and setting up of new factories. The expansion of the Sindri Fertiliser Factory was expected to be completed by 1957, leading to an augmentation of the installed capacity from 71,000 tonnes (356,000 tonnes in terms of ammonium sulphate) to 119,000 tonnes of fixed nitrogen. The additional production corresponding to 48,000 tonnes of fixed nitrogen was to consist of 150,000 tonnes of sulphate-nitrate and 24,000 tonnes of urea. The consumption of gypsum at Sindri was to be increased by about 152,000 tonnes when full production under the expansion scheme was achieved. The total investment of about Rs 8.4 crore expected to be incurred on the expansion during the Second Plan was to be met from a loan of Rs 4.4 crore provided by the Central Government and from the internal resources of the Company. It was also decided to expand the fertiliser industry further under the Second Plan at the following locations (Table 9).

TABLE 9. EXPANSION PROGRAMMES FOR FERTILISER FACTORIES 1956-61

| Location of Factories | Annual Capacity as Fixed Nitrogen (tonnes) | Fertiliser to be Produced | | Estimated Capital Investment (Rs Crore) |
|---|---|---|---|---|
| | | Fertiliser | Tonnes | |
| Nangal | 71,124 | Ammonium Nitrate (Pure or Diluted) | 203,210 | 22.00 |
| Nayveli | 71,124 | Sulphate Nitrate | 203,210 | 19.00 |
| | | Urea | 40,642 | |
| Rourkela | 81,284 | Nitro-Limestone | 449,094 | 16.00 |
| Bhilai, Durgapur | 7,316 | By-product Ammonium Sulphate | 35,867 | * |

* Included under provisions for the steel plants in the public sector at Bhilai/Durgapur.
Source: *Second Five Year Plan*, Planning Commission.

In the private sector, the Plan included (a) doubling of capacity by 1958 at FACT, (b) a modified soda-ash plant at Sahu Chemicals which was expected to come into production by 1958, and (c) by-product ammonium sulphate from expansion of TISCO and IISCO. An investment of Rs 2.5 crore was expected on the expansion of FACT. The production of nitrogenous fertilisers from domestic sources expected during 1956-61 is shown in Table 10.

TABLE 10. EXPECTED PRODUCTION OF NITROGENOUS FERTILISERS, 1956-61

(tonnes)

| Year | Annual Installed Capacity* | | | Total Production* |
|---|---|---|---|---|
| | Public Sector | Private Sector | Total | |
| 1956-57 | 71,124 | 15,241 | 86,365 | 77,220 |
| 1957-58 | 118,878 | 15,241 | 134,119 | 103,637 |
| 1958-59 | 118,878 | 25,401 | 144,279 | 142,247 |
| 1959-60 | 271,285 | 38,610 | 309,895 | 177,809 |
| 1960-61 | 349,521 | 38,610 | 388,131 | 294,655 |

* tonnes of fixed nitrogen. Source: As at Table 9.

The Ministry of Food and Agriculture had estimated the requirements of phosphatic fertilisers (including bonemeal) by the end of the Second Plan at 121,926 tonnes of $P_2O_5$ or 731,556 tonnes as Superphosphates. However, for the Second Plan, a capacity of about 50 thousand tonnes was visualised in terms of superphosphate and the balance in other types of phosphatic fertilisers. Further expansion of synthetic phosphatic fertilisers industry during the period of the Second Plan would not be necessary if the deficit could be made good by bonemeal. Otherwise, various alternative fertilisers like dicalcium phosphate, and concentrated phosphatic fertilisers like double and triple superphosphate would have to be considered. Manufacture of dicalcium phosphate would provide a means of utilising the chlorine resulting from the manufacture of caustic soda by the electrolytic process. Hence, the Food and Agriculture Ministry should take early steps to popularise dicalcium phosphate as a fertiliser. The National Fertiliser Association of India should also take up a concerted drive for popularising the use of phosphatic fertilisers, as also balanced fertiliser mixtures. The manufacture of concentrated fertilisers not requiring the use of sulphuric acid should be encouraged. To keep the costs low, future development should envisage substantially bigger plants, with a minimum daily capacity of not less than 100 tonnes.

Table 11 gives the proposed installed capacity and production of the phosphatic fertilisers during the Second Plan period.

TABLE 11. PRODUCTION OF PHOSPHATIC FERTILISERS, 1956-61
(tonnes in terms of $P_2O_5$)

| | 1955-56 | 1960-61 |
|---|---|---|
| *Annual Installed Capacity* | | |
| (a) Superphosphate | 35,562 | 84,637 |
| (b) Ammonium Phosphate | - | 3,759 |
| Total (including Others) | 35,562 | 121,926 |
| *Annual Production* | | |
| (a) Superphosphate | 20,321 | 84,637 |
| (b) Ammonium Phosphate | - | 3,759 |
| Total (including Others) | 20,321 | 121,926 |

Source: *Second Five Year Plan*, Planning Commission.

The requirements of potassic fertilisers were estimated by the Ministry of Food and Agriculture at 30,481 tonnes of $K_2O$ by 1960-61 as against 10,160 tonnes in 1955-56. It was necessary to implement the recommendations made in the First Plan for potassic fertilisers with a view to reducing dependence on imports.

*Development Council for Heavy Chemicals (Acids and Fertilisers)*

The Development Council for Heavy Chemicals (Acids and Fertilisers) was set up in 1953 under provisions of the Industries Development and Regulation Act, 1951. The Council was expected to make recommendations regarding the targets of production, norms of efficiency, measures of securing fuller utilisation of installed capacity and better economy in the cost of production, etc. The representatives of Government, Industry and Labour were the members of the Development Council. The Council met four or five times each year and made recommendations to the Government on different aspects of the fertiliser industry. Thus in 1956-57, the Council recommended the establishment of the production of phosphorous by the electro-thermal process by at least one unit with 25 tonnes capacity per day and popularising by the Ministry of Food and Agriculture of di-calcium phosphate as fertiliser. In 1957-58, the Council recommended (i) enhancement of the target for nitrogenous fertilisers in view of the raising of the foodgrains target, (ii) measures for increasing the offtake of super-phosphate, and (iii) indigenous production of di-calcium phosphate. During 1958-59, the Council drew up programmes of development for phosphatic fertilisers and nitrogenous fertilisers in connection with the preparation of the annual plan for 1958-59 by the Planning Commission. It was considered advisable to spend foreign exchange on the production of nitrogenous fertilisers rather than spending the same on its import. The Council also recommended that in the initial stages the product of Nangal and Rourkela be marketed with 26 per cent N instead of the dilution of ammonium nitrate with limestone containing 20.5 per cent nitrogen

and thereafter to progressively increase the nitrogen content upto 33 per cent N [Ministry of Commerce and Industry, 1959, Pp. 44-45].

*Fertiliser Technical Committee, 1960*

In 1959-60, the Government set up a Technical Committee for Fertiliser Production to prepare preliminary reports on a number of sites with a view to determining the types and quantities of fertilisers that could be produced, having regard to the facilities available in those places and the pattern of production indicated by the Department of Agriculture for the Third Five Year Plan, the order of capital costs likely to be involved and the probable cost of production. The Committee submitted reports in 1960 for setting up plants in the following States (Table 12).

TABLE 12. CAPACITY FOR THE NEW FACTORIES

| Place | Capacity (tonnes 'N') | Product |
|---|---|---|
| Itarsi (Madhya Pradesh) | 50,802.50 | Urea |
| Gorakhpur (Uttar Pradesh) | 71,123.50 | Urea |
| Mangalore (Karnataka) | 71,123.50 | Urea and Ammonium Sulphate |
| Kothagudem (Andhra Pradesh) | 81,284.00 | Urea and Nitrophosphate |
| Namrup (Assam) | 33,021.63 | Urea and Ammonium Sulphate |
| Hanumangarh (Rajasthan) | 81,284.00 | Ammonium Sulphate |

Source: *Annual Report, 1960-61*, Ministry of Commerce and Industry.

Based on the recommendations of the Committee, licences were issued to private parties for setting up fertiliser factories in Madhya Pradesh and Rajasthan. Preliminary work for the fertiliser projects at Namrup (Assam) and Gorakhpur (U.P.) in the public sector was taken in hand. Arrangements were made to import plant and machinery for the Trombay Fertiliser factory. Licence was also issued for setting up a fertiliser factory based on naphtha at Vizag in the private sector [Ministry of Commerce and Industry, 1961, p. 76].

*Fertiliser Corporation of India*

The Fertiliser Corporation of India was formed on January 1, 1961, integrating the fertiliser units in the public sector and bringing them under a unified control. This was done in order to secure coordination in policy and ensure efficient and economic expansion and working of fertiliser factories in the public sector. As a result of this integration, the constituent units of the Corporation were the two operating factories at Sindri in Bihar and Nangal in Punjab and the three projected factories at Trombay in Maharashtra, Nahorkatiya (Namrup) in Assam and Gorakhpur in Uttar Pradesh.

*Progress During the Second Plan*

The Second Plan envisaged expansion of capacity for nitrogenous fertilisers from 86,365 tonnes of nitrogen in 1956-57 to 388,131 tonnes in 1960-61 and the production from 77,220 tonnes of nitrogen in 1956-57 to 294,655 tonnes in 1960-61. This increase was expected to be achieved by the expansion of the Sindri Fertiliser Factory and FACT and the establishment of new fertiliser factories at Nangal, Neyveli and Rourkela. It was also expected that additional quantities of ammonium sulphate would be obtained as by-product at the steel plants and that ammonium chloride would be produced by Sahu Chemicals in conjunction with the production of soda ash.

The expansion scheme of Sindri envisaged the production of urea and ammonium sulphate/nitrate or double salt. This scheme was completed in 1959 as against the end of 1957 set as the target date. Even so, no extra output was achieved at Sindri in the remainder of the Plan period for several reasons such as the low performance of the lean gas plant, shortage of coal of suitable quality, lack of spare parts as well as the caking characteristics and acidic nature of the double salt produced.

The expansion scheme of FACT was delayed by 18 to 24 months, and no additional output was produced during the Second Plan period. The scheme for the production of 10,161 tonnes of nitrogen as ammonium chloride (and 40,642 tonnes of soda ash) of Sahu Chemicals was completed by the end of 1959 but, because of

technical difficulties, no significant production was achieved during the rest of the plan period. At Nangal, the construction schedule was delayed by a year owing to the foreign exchange crisis of 1957 and the need to negotiate deferred payment arrangements for plant and machinery. The plant was brought into partial production (1/3 capacity) in February 1961. The completion of both the factories at Rourkela and Neyveli was also delayed due to foreign exchange difficulties.

The capacity at the beginning of each year and the yearwise production of nitrogenous fertilisers are shown in Table 13.

TABLE 13. CAPACITY AND PRODUCTION OF NITROGENOUS/FERTILISERS, 1956-61

(tonnes)

| Year | Capacity | Production |
|---|---|---|
| 1956-57 | 87,685 | 78,752 |
| 1957-58 | 87,685 | 77,710 |
| 1958-59 | 87,685 | 80,062 |
| 1959-60 | 87,685 | 73,916 |
| 1960-61 | 160,841 | 98,709 |

Source: Fertiliser Statistics (Various issues)

The lag in production gave rise to large deficits which had to be made up by imports (Table 14).

TABLE 14. IMPORTS OF NITROGENOUS FERTILISERS, 1956-61

(Q : quantity in '000 tonnes
V : Value in Lakh Rupees)

| Year | Ammonium Sulphate | | Urea | | Ammonium Sulphate/ Nitrate | | Calcium Ammonium Nitrate | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Q | V | Q | V | Q | V | Q | V | V |
| 1956-57 | 233.69 | 644.90 | 10.06 | 63.40 | 14.53 | 61.70 | 2.03 | 6.80 | 776.80 |
| 1957-58 | 347.08 | 1,049.10 | 60.25 | 369.00 | 30.38 | 116.40 | 22.45 | 55.60 | 1,587.80 |
| 1958-59 | 162.57 | 369.40 | 89.41 | 468.00 | 68.28 | 213.50 | 33.02 | 80.20 | 1,131.10 |
| 1959-60* | 382.03 | 773.00 | 101.40 | 387.00 | 76.20 | 205.00 | 77.21 | 162.00 | 1,588.40 |
| 1960-61† | 362.43 | 751.00 | 56.80 | 255.10 | 19.81 | 45.30 | 76.20 | 158.70 | 1,213.50 |

* Other imports included nitrophosphate (10,161 tonnes, valued at Rs 35 lakh) and ammonium phosphate (10,872 tonnes, valued at Rs 26.40 lakh).

† 1,016 tonnes of nitrophosphate valued at Rs 3.40 lakh was also imported.

The total investment in the nitrogenous fertiliser industry during the Second Plan period was of the order of Rs 47 crore of which about Rs 17.5 crore was in foreign exchange. The public sector outlay out of this investment was Rs 44 crore [Planning Commission, 1962(a), Pp. 339-341].

The capacity and production of the phosphatic fertiliser industry was expected to rise to about 122,000 tonnes of $P_2O_5$ by 1960-61. It was expected that the target would be achieved by the production of about 84,600 tonnes of $P_2O_5$ as single superphosphate, 3,760 tonnes of $P_2O_5$ as ammonium phosphate and the balance as triple superphosphate and dicalcium phosphate. However the targets were not achieved due to lack of demand for these fertilisers.

Little systematic attempt was made to develop the manufacture of potassic fertilisers in India. The indigenous production was in the small scale sector and the annual total was estimated to be around 2,000 tonnes as muriate of potash. Practically all the requirement of potassic fertilisers were met by imports.

### *Third Five Year Plan, 1961-66*

The fertiliser industry fell under Schedule B of the Industrial Policy Resolution of April 1956. In the Third Plan, it was ranked on par with iron and steel which was given the 'core' status in the Second Plan.

It was proposed that in addition to the completion of fertiliser projects carried over from the Second Plan, further capacity for nitrogenous fertilisers should be established in the public sector. Among the new Central Public sector projects were (a) The Trombay Fertiliser Project which was planned for utilising refinery gases and naphtha, with a capacity of about 91,444 tonnes of nitrogen. The pattern of production was to be that half of the available ammonia would be

converted into urea by a partial recycle process and the balance of ammonia would be utilised for the manufacture of nitrophosphate by nitric acid treatment of rock phosphate. The phosphate content of the complex fertiliser would be rendered partially water soluble by the use of sulphuric acid. (b) The Assam Fertiliser Project which was to be set up at Namrup in Assam based on 'associated gas' available from the Naharkatiya oil fields. The overall capacity of the plant was scheduled for 33,000 tonnes of nitrogen based on the production of 50,800 tonnes of urea and 50,800 tonnes of ammonium sulphate by the acid neutralisation process, the acid being produced from imported sulphur. (c) The Gorakhpur Fertiliser Project with a capacity of 81,284 tonnes of nitrogen per annum and the end-product was to be urea produced by the total recycle process. The raw material for this factory was to be petroleum naphtha from the refinery at Barauni, a distance of 200 miles from the fertiliser plant.

There was also the scheme for further expansion of FACT by about 30,500 tonnes of nitrogen, to produce ammonium sulphate/ammonium phosphate and ammonium chloride. Additional production of by-product ammonium sulphate was expected with the expansion schemes of the steel plants. One more public sector nitrogenous fertiliser factory with a capacity of about 81,000 tonnes of nitrogen was also included.

In the private sector, licences were granted for expansion or setting up of new factories near Madras, Varanasi, Singarani, Itarsi and in Rajasthan. In addition, a private enterprise scheme in partnership with the West Bengal Government was expected to be set up at Durgapur with a capacity of about 59,000 tonnes of nitrogen. The Government of Gujarat had also proposed the setting up of a factory with a capacity of about 98,000 tonnes of nitrogen in collaboration with the private sector. Other locations considered suitable for building up nitrogen plants were Mangalore in Mysore State, Tuticorin in Madras State and the Koyna area in Maharashtra State [Planning Commission, 1962(a), Pp. 342-347].

Requirements of fertilisers were estimated as under (Table 15). Programmes for indigenous production and for imports, both of fertilisers and of the raw materials needed, were based on the above estimates.

TABLE 15. ESTIMATES OF FERTILISER REQUIREMENTS, 1961-66
(000 tonnes)

| Year | Nitrogen | Phosphatic ($P_2O_5$) | Pottasic ($K_2O$) |
|---|---|---|---|
| 1960-61 | 233.69 | 71.12 | 25.40 |
| 1961-62 | 406.42 | 101.61 | 83.32 |
| 1962-63 | 533.43 | 152.41 | 101.61 |
| 1963-64 | 660.43 | 228.61 | 132.09 |
| 1964-65 | 812.84 | 304.82 | 162.57 |
| 1965-66 | 1,016.05 | 406.42 | 203.21 |

Source: *The Third Five Year Plan*, Planning Commission.

The development of nitrogenous fertilisers was facilitated by the availability of waste gases from the petroleum refineries and coke-oven plants, the associated gas liberated in the mining of crude petroleum and, most important of all petroleum naphtha. In order to attain the million tonne target for nitrogen, the pattern of production of the end-products tentatively visualised are shown in Table 16.

TABLE 16. PATTERN OF PRODUCTION OF NITROGENOUS PRODUCTS

| End-Product | 1965-66 (000 tonnes of Nitrogen) |
|---|---|
| Ammonium Sulphate | 233.69 |
| Ammonium Sulphate/Nitrate | 30.48 |
| Nitro-limestone | 162.57 |
| Nitrophosphate | 40.64 |
| Urea | 284.49 |
| Ammonium Phosphate | 243.85 |
| Ammonium Cloride | 20.32 |
| Total | 1,016.05 |

Source: *Third Five Year Plan*, Planning Commission.

A significant portion of the additional output of nitrogen was planned in the form of compound and/or complex fertilisers so that a part of the phosphate requirements were met simultaneously. The ammonium phosphate was planned for production on the basis of wet process making use of sulphuric acid from imported sulphur and indigenous pyrites. The tight situation relating to availability and cost of power in the country during the Third Plan and the comparatively easy supply position of sulphur were factors which weighed against the adoption of the electrothermal process for phosphoric acid phosphatic

fertilisers and for the swing in favour of the wet process.

The position in regard to nitrogen in the Third Plan was expected to be as follows (Table 17).

TABLE 17. NITROGENOUS FERTILISERS, IN THE THIRD PLAN: 1961-66

('000 tonnes of nitrogen)

| Year | Requirements | Installed Capacity | Indigeneous Production |
|---|---|---|---|
| 1961-62 | 406.42 | 245.88 | 142.25 |
| 1962-63 | 533.43 | 304.82 | 203.21 |
| 1963-64 | 660.43 | 406.42 | 304.82 |
| 1964-65 | 812.84 | 609.63 | 508.03 |
| 1965-66 | 1,016.05 | 1,016.05 | 812.84 |

Source: *Third Five Year Plan*, Planning Commission.

Since the offtake of nitrogenous fertilisers was visualised at about 1 million tonnes of nitrogen in 1965-66 and the N:$P_2O_5$ ratio was proposed at approximately 2:1, the capacity and production targets for phosphatic fertilisers was kept at about 400 - 500 thousand tonnes of $P_2O_5$. Among the end-products of $P_2O_5$ proposed for manufacture during the Third Plan were single superphosphate, ammonium phosphate, nitrophosphate and dicalcium phosphate.

The total capacity of phosphatic fertilisers licensed amounted to about 350,000 tonnes of $P_2O_5$. This included the nitrophosphate schemes of Trombay, the ammonium phosphate schemes of FACT and Vizagapatnam and the schemes for dicalcium phosphates in addition to the existing and licensed units for single superphosphate. Adding to this 30,000 tonnes of $P_2O_5$ on account of bone meal and ground rock phosphate, the total comes to 380,000 tonnes of $P_2O_5$. The balance of the target capacity was expected to be achieved by complex fertilisers, e.g., nitrophosphate and ammonium phosphate in the new nitrogenous fertiliser factories whose details were to be finalised. A scheme had been licensed for a capacity of 5,000 tonnes of triple super-phosphate based on hydrochloric acid to be established near Bombay as an integral part of a caustic soda-cum-organic chemicals plant [Planning Commission, 1962(a), Pp. 349-352].

The requirements of potassic fertilisers during the Third Plan, (203,200 tonnes) were likely to be met mainly by imports. In the absence of major expansion of indigenous production the value of imports was expected to reach about Rs 10 crore towards the end of the Third Plan.

### *Report of the Petro-Chemical Committee, December 1961*

A Committee for the preparation of a plan for the development of the petro-chemical industries during the Third and Fourth Five Year Plans was appointed by the Government in October/November 1960 (a) to assess the types and quantities of materials whose production may have to be organised in petro-chemical industries; (b) to evolve a suitable pattern for development in India in the context of the integrated pattern of production of petro-chemicals in advanced countries; (c) to assess the extent to which the aromatic as well as aliphatic raw materials may have to be produced as petro-chemicals during the period 1961 to 1971; and (d) to recommend the pattern of development of petro-chemical industries in the country. The Committee submitted its Report in December 1961.

There was no Petro-Chemical Industry of significance in the country at that time. However, a beginning had been made in that direction with the decision to utilize the associated gases at Nahorkatiya for the manufacture of nitrogenous fertilisers, Cis-Polybutadiene (a new type of synthetic rubber), polyethylene and Furnace type Carbon Black. Approval had also been given to a number of schemes for the manufacture of nitrogenous fertilisers based on naphtha. The Committee referred to the estimated demand for nitrogenous fertilisers at 1.02 million tonnes (in terms of nitrogen) by 1965-66 and at 2.03 million tonnes by 1970-71. As was well known, the production of nitrogenous fertilisers could be based on the utilization of naphtha (surplus motor-spirit). For some time naphtha, refinery gases, natural gas (associated gas) and gases from naphtha crackers and coke-oven gas had been considered as a source of synthesis gas for the production of nitrogenous fertilisers in the country. If the production of fertilisers was to reach 1.02 million tonnes by 1965-66, fertilisers corresponding to about 406,000 tonnes of nitrogen would have to be based on petroleum products. The production of the balance quantity of

nitrogenous fertilisers could be based on coke, lignite, gassification of coal, coke-oven gases and electrolytic hydrogen. Out of the estimated availability of surplus naphtha, nearly 50 per cent would be needed for the production of nitrogenous fertilisers during the Third Plan period [Kane, 1961, Pp. 42-46].

The surplus naphtha likely to be available each year would increase from 212.35 thousand tonnes in 561.88 thousand tonnes in 1964 and 913.43 thousand tonnes in 1960 to 1966 from the existing oil refineries in the country.

The greatest surplus of naphtha would occur in 1965 and that it would go down gradually in subsequent years. Additional refining capacity would have to be brought into existence during the Third and Fourth Plans and this would naturally release additional quantities of naphtha. It was therefore, evident that the disposal of naphtha would be a problem, since the imbalance in the demands and production of motor spirit was likely to continue.

The most profitable uses of surplus naphtha would be for production of materials that would save maximum foreign exchange, such as nitrogenous fertilisers, petro-chemicals and town gas for substitution of kerosene as a domestic fuel. Since a tonne of naphtha costing about Rs 71.85 per tonne at the refinery (exclusive of excise duty) could produce a tonne of nitrogen as fertiliser and the c.i.f. value of imported fertiliser was approximately Rs 984.20 per tonne of nitrogen, use of naphtha for fertiliser production would save foreign exchange equivalent to about ten times its value. The likely requirement of naphtha for production of nitrogenous fertilisers in factories already licensed/approved as well as under consideration would be about 402 thousand tonnes by 1965-66.

The approved project for the supply of 20 million cu.ft. per day of domestic gas to the city of Bombay by the Trombay Fertiliser unit was expected to consume naphtha to the extent of 96,500 tonnes per year. Thus for production of nitrogenous fertilisers and town gas nearly 499,000 tonnes of naphtha had already been ear-marked. This was expected to leave a quantity of about 406,000 tonnes for the manufacture of organic chemicals.

The price at which naphtha was made available for the manufacture of fertilisers, organic chemicals and related products would have a bearing not only on the utilization of the surplus naphtha but also on the cost of the manufactured article. The Committee recommended that the raw naphtha used for the production of fertilisers should be exempted from the payment of excise duty to ensure economic production of fertilisers. Public sector refineries should sell naphtha for the production of fertilisers at prices comparable with those for Trombay (Rs 71.85 per tonne) and FACT (Rs 88.60 per tonne). In case adequate quantities of surplus naphtha from the indigenous sources were not available for the manufacture of nitrogenous fertilisers, etc., the shortfall should be made good by imports of naphtha, as it would cost less foreign exchange than the imports of the finished products [Kane, 1961, Pp. 64-75].

It was reckoned in the Mid-term Appraisal that the total internal production at the end of the Plan would be of the order of 508,025 tonnes compared to 812,840 tonnes initially approved. Despite some quantity of imports, the supplies of nitrogenous fertilisers at the end of the plan period would fall short of the original targets. Production and capacity of nitrogenous fertiliser factories were also expected to fall short of the targets. By 1965-66, capacity was expected to rise to 650 thousand tonnes as against a target of 1,016 thousand tonnes and production to 508 thousand tonnes as against the target of 812 thousand tonnes. Though schemes with a total capacity of the order of 1.410 million tonnes had been approved, the production target of 812,840 tonnes of nitrogenous fertilisers was not likely to be achieved mainly on account of the slow progress in the implementation of private sector schemes. Shortfalls in the phosphatic fertilisers targets of capacity and production were also expected. Supplies of potassic fertilisers depended wholly on imports.

Actual achievements in 1965-66 were much below the revised targets laid down at the time of the mid-term appraisal of the Third Plan. The installed capacity in the fertiliser industry was expected to increase to 640,000 tonnes for nitrogen and 270,000 tonnes for phosphoric acid in 1965-66. One factory for the manufacture of murate of potash from salt bitterns was also under consideration of the Government to be set up at

Tuticorin in Kerala by the end of 1965-66. Actual installed capacity by the end of the Third Plan stood around 450,000 tonnes for nitrogen and 184,000 tonnes of $P_2O_5$. The production of these two fertilisers was much lower than capacity due to power cuts imposed at FCI-Nangal and FACT-Alwaye, non-availability of better-grade gypsum and other raw materials at FCI- Sindri, restricted supply of coke-oven gas for the production of calcium ammonium nitrate at Rourkela, shortage of sulphur and rock-phosphates which affected production in the by-product factories in the eastern region, etc. The entire requirements of potassic fertilisers were imported.

The production, imports and distribution of fertilisers during the Third Plan period was as follows (Table 18).

TABLE 18. FERTILISER: PRODUCTION, IMPORTS AND DISTRIBUTION 1961-66

(tonnes)

| Year | NITROGEN (N) | | | PHOSPHORIC ACID ($P_2O_5$) | | | POTASH ($K_2O$) | |
|---|---|---|---|---|---|---|---|---|
| | Production | Imports | Distribution | Production | Imports | Distribution | Imports | Distribution |
| 1960-61 | 111,987 | 171,926 | 211,685 | 53,722 | 128 | 53,134 | 24,845 | 29,052 |
| 1961-62 | 154,326 | 142,920 | 291,536 | 65,360 | 645 | 63,932 | 30,381 | 27,982 |
| 1962-63 | 194,194 | 229,462 | 360,033 | 88,300 | 7,959 | 81,385 | 44,276 | 36,503 |
| 1963-64 | 219,072 | 197,691 | 406,976 | 107,836 | 12,267 | 116,674 | 64,060 | 50,570 |
| 1964-65 | 243,230 | 256,517 | 434,473 | 130,434 | 12,293 | 147,652 | 57,176 | 70,440 |
| 1965-66 | 233,443 | 376,270 | 547,363 | 118,779 | 21,766 | 132,178 | 93,641 | 77,746 |

Source: *Fertiliser Statistics, 1965-66.*

Shortfalls in production of nitrogenous fertilisers were primarily due to lower production at Sindri, FACT, Trombay and Neyveli. To attract private investment in the fertiliser industry, new units were freed from distribution and price control for an initial period of seven years, Government reserving the right to procure 30 per cent of output on a negotiated basis. A number of new projects in the private sector were approved. These included Goa, Kanpur, and Kotah projects. In addition, expansion programmes of Gujarat and Ennore projects were also approved. Mixed fertilisers were exempted from licensing procedures under the Industries (Development and Regulation) Act, 1951.

Considerable efforts were made for import substitution wherever possible. Regarding sulphur substitution, sulphuric acid production from Amjor pyrites was established. Sulphuric acid projects based on copper pyrites at Khetri and Ghatsila had made good progress and production was expected by the beginning of the Fourth Plan. Sulphuric acid based on indigenous zinc ores at Udaipur and imported zinc ores at Alwaye had also commenced production. The availability of rock phosphate at Udaipur mines was expected to reduce the pressure on imports of rock phosphates. Sodium nitrate and sodium nitrite which were hitherto being imported were also proposed to be produced in the country [DGTD, 1970, p. 58].

### *Annual Plans, 1966-67 to 1968-69*

The Fourth Plan which was to commence in 1966-67 was postponed due to the severe drought in 1965-66 and the dislocation caused by the Indo-Pakistan conflict in that year. In its place, there were three annual plans. The drought in 1965-66 was followed by a second year of poor monsoons in 1966-67. As a result the levels of fertiliser consumption, as targeted, were not achieved. Table 19 gives the consumption during the three years of the Annual Plans.

TABLE 19. CONSUMPTION OF FERTILISER 1966-69

(000 tonnes)

| Year | | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|
| 1966-67 | Target | 1,008 | 300 | 140 |
| | Achievement | 840 | 250 | 115 |
| 1967-68 | Target | 1,350 | 500 | 300 |
| | Achievement | 1,035 | 335 | 170 |
| 1968-69 | Target | 1,700 | 650 | 450 |
| | Achievement | 1,210 | 380 | 170 |

Source: *Annual Plan Progress Report*, Planning Commission.

*Fourth Five Year Plan 1969-74*

Consumption of fertilisers for the Fourth Five Year Plan, were fixed at 3.2 m tonnes of N, 1.4 m tonnes of $P_2O_5$ and 0.9 m tonnes of $K_2O$ by 1973-74. These quantities implied more than trebling the 1968-69 level of fertiliser consumption. The targets for the fertiliser industry were (a) to establish a capacity of about 4 million tonnes of nitrogen and 1.9 million tonnes of $P_2O_5$ by 1973-74; (b) to distribute the additional capacity throughout the country; (c) to determine the capacity of each unit with due regard to economies of scale, the imperatives of modern technology and the economies of transport to the likely markets; and (d) to fix for each unit such product mix as will maximise its cost efficiencies as well as lower the cost per nutrient of its products to the farmer [Ramakrishnayya, 1969, p. 28].

The Fourth Plan document pointed out that the schemes under implementation for nitrogenous fertilisers were expected to give a capacity of approximately 2.54 million tonnes. In addition, eight projects involving a capacity of 1.31 million tonnes were approved in the private sector. In the public sector, six projects involving a capacity of 0.95 million tonnes were in an advance stage of preparation for being taken up for implementation. A provision of Rs 262 crore was made in the public sector for new fertiliser plants. In regard to phosphatic fertilisers, the firm capacity added up to one million tonnes. In addition, another 0.4 million tonnes was expected to be taken up for implementation. Some of these projects were for the production of complex fertilisers forming part of nitrogenous plants. The possibilities of diversifying the raw material base for nitrogenous fertiliser were being continued. As a first step, it was decided to take up three coal-based fertiliser projects in the public sector and in addition a number of projects based on fuel oil and other heavy petroleum feed-stocks were under investigation. The Plan provided for the development of pyrites deposits near Amjore in Bihar. Provision was made for the exploration of the pyrrhotite, pyrite deposits near Saladipura in Rajasthan. In addition, development of rock-phosphate deposits, which were discovered in the Udaipur district, were contemplated in the Central and in the State sectors. Minimum production targets of one million tonnes of rock- phosphate and 0.25 million tonnes of pyrites were envisaged for 1973-74 [Planning Commission, 1970, Pp. 319-320].

The estimates of capacity and production as finally envisaged in the Fourth Plan are shown in Table 20.

TABLE 20. TARGETS FOR THE FOURTH PLAN

| | Unit | 1960-61 Production | 1965-66 Production | 1968-69 | | 1973-74 | |
|---|---|---|---|---|---|---|---|
| | | | | Capacity | Production | Capacity | Production |
| 1. Nitrogenous Fertilisers (in terms of N) | '000 tonnes | 101 | 232 | 1,024 | 541 | 3,000 | 2,500 |
| 2. Phosphatic Fertilisers (in terms of $P_2O_5$) | '000 tonnes | 53 | 123 | 421 | 210 | 1,200 | 900 |
| 3. Rock Phosphates and Pyrites | million tonnes | - | - | - | - | - | 1.25 |

Source: *Fourth Five Plan*, Planning Commission.

*Committee to Suggest Measures for Curbing the Consumption of Petroleum Products, March 1971*

With the increase in the prices of imported petroleum products, Government of India appointed a Committee in early 1971 to suggest ways and means of reducing the consumption of oil products by 12 per cent, or at least by 6 per cent. The Committee was also given the task of suggesting measures for curbing the medium and the long range growth in demand. The Committee submitted its Report on March 22, 1971. With regard to the consumption of petroleum products

by the fertiliser industry, the Committee worked out, on the basis of past trends of sales of naphtha until 1970, the anticipated future sales up to 1980 and observed that, as the use of naphtha was almost entirely limited for fertiliser and petrochemical projects, both of which were high priority industries, it was not desirable to curb its consumption, unless suitable substitutes could be developed [Kashyap, 1971, Pp. 41-50].

*Planning Commission Study on Fertiliser Consumption, May 1971*

In May 1971, the Planning Commission made a study of fertiliser consumption and noted that fertiliser consumption after showing phenomenal growth in 1966-67 and 1967-68 had been deteriorating and maintaining a level far below the Plan expectations. The compound annual growth rates in the consumption of fertilisers required to achieve the level of fertiliser application envisaged for 1973-74 worked out to 22.8 per cent for N, 29.2 per cent for $P_2O_5$ and 41.3 per cent for $K_2O$. The annual compound growth rates achieved during 1969-71 were only 11.1 per cent for N, 8.4 per cent for $P_2O_5$ and 18.6 per cent for $K_2O$. The fertiliser application in areas under high yielding varieties were only slightly more than half the recommended dosages in the case of nitrogen, about 1/5th in the case of $P_2O_5$ and about 1/4th in the case of $K_2O$. Some of the main factors were (i) lack of extension and sale promotion activities; (ii) inadequate soil testing facilities; (iii) unsatisfactory retail distribution arrangements; (iv) insufficient quality control of fertilisers; and (v) difficulties in providing credit to farmers [NCA, 1971, Pp. 4-5].

*Techno-Economic Study Team on Cooperative Granular Fertiliser Units, 1973*

The National Cooperative Development Cooperation (NCDC), appointed in January 1971 a Team to study the progress and problems of the cooperative granular fertiliser units and of their economic viability. There were 31 granular fertiliser units in the country of which 18 were in the cooperative sector, 2 in the public sector and 11 in the private sector. All of them, except 2, were of 7.5 tonnes per hour capacity. Their total annual capacity was estimated at 1.64 million tonnes which was hardly 50 per cent of the gap between the demand for complex/mixed fertilisers and their supply from large scale indigenous factories providing complex fertilisers. There was thus scope for additional indigenous capacity of the order of 1 million tonnes for the preparation of complex/granulated mixed fertilisers. Citing the advantages of mixed granular fertilisers to mixed powdered fertilisers, the Team said that the most important advantage of granular fertilisers was the possibility of producing high analysis fertilisers which was not possible in the mixing of powdered fertilisers. The production of high analysis fertilisers led to reduction in transport handling and storage and packing costs. The granular fertiliser units should be able to obtain their supplies of raw material from the Central Fertiliser Pool or direct from the indigenous manufacturers of fertilisers on f.o.r. or ex-factory (freight paid) delivery basis at wholesale rates and not from the dealers at the sub-wholesalers' or retailers' prices. For this purpose, in view of the important role that these units could play in ensuring balanced application of fertilisers, the Government of India (Central Fertiliser Pool) could consider making direct allotments of Pool Fertilisers to these units at least at the State Government level so that they could obtain their Pool supplies on f.o.r. delivery basis at wholesale rates and not from the dealers at the sub-wholesale or retail prices. These allotments should be made on priority basis. This was possible if the Government exercised its right to secure up to 30 per cent of the indigenous fertilisers from the manufacturers at negotiated prices. This could then be allotted to the granular units [NCDC, 1973, Pp. 7-25].

*Progress in the Fourth Plan*

The targets of production and consumption laid down for the Fourth Plan did not materialise (Table 21).

TABLE 21. ACHIEVEMENTS IN FOURTH PLAN
(000 tonnes)

| | 1969-70 | | 1973-74 | |
|---|---|---|---|---|
| | Target | Achievement | Target | Achievement |
| *Nitrogen (N)* | | | | |
| Consumption | 1,700 | 1,360 | 3,200 | 1,829 |
| Production | 1,400 | 731 | 2,500 | 1,050 |
| Imports | - | 574 | - | 661 |
| *Phosphates (P2O5)* | | | | |
| Consumption | 650 | 420 | 1,400 | 650 |
| Production | 700 | 224 | 900 | 325 |
| Imports | - | 88 | - | 214 |
| *Potassic (K2O)* | | | | |
| Consumption | 450 | 209 | 900 | 360 |
| Imports | - | 100 | - | 381 |

Source: *Fertiliser Statistics*, 1973-74.

The installed capacity for nitrogenous fertilisers stood at 1.944 million tonnes by April 1, 1974 and that for phosphatic fertilisers at 0.531 million tonnes. Indigenous production of potash continued to be negligible and requirements were met through imports. As compared to capacity, actual production by the end of the Fourth Plan was less than 55 per cent for nitrogenous fertilisers and about 60 per cent for phosphatic fertilisers. Larger quantities of N, $P_2O_5$ and $K_2O$ had therefore to be imported. Shortfalls in production were due to a number of factors, including power cuts, labour unrest, shortage of raw materials and breakdowns in the fertiliser units. There were, however, certain constraints peculiar to the Indian situation which inhibited capacity build up. Some of the major constraints were (a) a large part of the plant and equipment had to be imported due to non-availability of engineering materials, and limited domestic fabrication capacity for specialised items; (b) imports required to be backed with foreign exchange; (c) Government clearance, issue of licence for projects and clearance from the DGTD for import of individual items of machinery or components caused delays in completion of projects; (d) construction delays; (e) constraints on availability of capital, particularly foreign exchange; and (f) uncertainties over the availability of feedstocks for ammonia production and imported phosphoric acid.

### *Fifth Five Year Plan, 1974-79*

Based on the programmes approved in the public and private sectors, it was expected that a capacity of 4.1 million tonnes of nitrogen and 1.2 million tonnes of $P_2O_5$ would be achieved in the early years of the Plan. In addition, the Fifth Plan programmes envisaged the establishment of five new fertiliser projects in the public sector, three of them at inland locations and two on coastal locations. These projects were estimated to contribute an additional capacity of 1.3 million tonnes of nitrogen and 0.6 million tonnes of $P_2O_5$. Provision was also made for the production of phosphoric acid at Kandla and Madras. It was expected that additional capacity of the order of 0.6 million tonnes would be set up in the private sector. Advance action would also be taken on projects, amounting to a capacity of one million tonnes of nitrogen, which were required to be completed in the initial years of the Sixth Plan period. A capacity target of 7 million tonnes of N inclusive of the capacity on advance action projects, and 1.7 million tonnes of $P_2O_5$ was envisaged in the Plan.

Attention was to be given for fuller utilisation of existing capacity and reduction in the gestation period of new projects. Necessary action was proposed in some of the old units which required substantial modernisation and renovation (Sindri) or had technological and design deficiencies (Neyveli) or where capacity utilisation was low on account of an inadequate supply of feed stocks, e.g. coke oven gas (Rourkela). Special attention was to be given to the problems of maintenance of fertiliser projects so that the loss of production due to breakdowns was minimised.

Based on the programmes envisaged, production of 4.0 million tonnes of N and 1.25 million tonnes of $P_2O_5$ was envisaged in 1978-79. The new fertiliser projects in the Fifth Plan were proposed to be based on fuel oil. The measures required to make the production of fertilisers with fuel oil as feed stock competitive with fertilisers using naphtha as feed stock were under consideration. From the long term point of view, it was necessary to explore the possibilities of producing fertilisers from domestic sources of coal. In addition to three coal based fertiliser projects already under way, studies were initiated on identifying other possible locations.

The optimum use of mineral resources in the country for fertiliser production was also envisaged in the Fifth Plan. The production of rock phosphate from the deposits at Jhamarkotra in Rajasthan was envisaged to be stepped up to 750,000 tonnes per annum during the Fifth Plan period. The sulphurous gases from non-ferrous refineries at Khetri and Zawar were also to be utilised for the production of fertilisers [Planning Commission, 1974, Vol. II, Pp. 145-146]. Research and development programmes under Science and Technology in the area of fertilisers included newer technologies for fertiliser application, better catalyst systems, effective utilisation of indigenous raw materials (coal and low grade rock phosphate), economy in the use of imported sulphur, and high pressure gasification of coal to produce methane rich gas for use in fertilisers [Planning Commission, 1974, Vol. II, p. 221].

*Revised Fifth Plan*

The Draft Fifth Five Year Plan was formulated in terms of 1972-73 prices and in the context of the economic situation obtaining in the first half of the fiscal year 1973-74. Thereafter, two major developments took place. The inflationary pressures gathered momentum till September 1974; and the balance of payment position worsened due to steep rise in the prices of imported oil and other materials. Hence, Plan targets were revised for all sectors. Consumption of fertilisers, in terms of nitrogen alone which was targeted at 5.2 million tonnes, was scaled down to 4.8 million tonnes in terms of nutrients by 1978-79. The installed capacity for nitrogenous fertilisers which had been expected to rise to 7 million tonnes was now expected to reach only 4.7 million tonnes by 1978-79. Production was expected to decline from 4 million tonnes N in the Draft Plan to 2.9 million tonnes by 1978-79 and of $P_2O_5$ from 1.25 million tonnes to 0.77 million tonnes. It was concluded that any spurt in demand would have to be met from imports [Planning Commission, 1976, p. 10].

*Progress During the Fifth Plan, 1974-79*

The progress of fertiliser production, imports, distribution and consumption during the period 1974 to 1979 is shown in Table 22.

TABLE 22. PROGRESS IN FIFTH PLAN

(000 tonnes)

| | 1974-75 | 1978-79 |
|---|---|---|
| *Nitrogenous (N)* | | |
| Production | 1,186.6 | 2,219.9 |
| Imports | 884.0 | 1,233.1 |
| Distribution | 1,845.2 | 2,986.3 |
| Consumption | 1,765.7 | 3,419.5 |
| *Phosphatic (P2O5)* | | |
| Production | 331.2 | 778.0 |
| Imports | 286.0 | 243.5 |
| Distribution | 497.4 | 950.6 |
| Consumption | 471.5 | 1,106.0 |
| *Potassic (K2O)* | | |
| Production | - | - |
| Imports | 437.0 | 517.4 |
| Distribution | 317.5 | 560.1 |
| Consumption | 336.1 | 591.5 |

Source: *Fertiliser Statistics, 1978-79.*

A Committee was set up in 1975 to evaluate the technological capabilities of the Planning & Development Division of F.C.I., the FACT Engineering and Design Organisation and Engineers India Limited in the field of fertiliser technology, project planning, design, engineering, procurement, construction and commissioning and defined their precise role in the various areas. Based on the recommendations of this Committee, Government decided in 1977-78 to convert the Planning and Development Division of F.C.I. into a separate company so that the capabilities developed by this organisation could be utilised to a greater extent within the country and also be offered abroad. This would also ensure greater attention towards developing indigenous technology in the field of fertilisers and reducing dependence on foreign technology [Ministry of Chemicals and Fertiliser, 1978, Pp. 6-7].

A wide variety of feedstock was used for fertiliser production. These included naphtha, natural gas/coke oven gas, lignite and electricity. Earlier, Government had, as a matter of policy, decided that, to the extent possible, fertiliser plants to be set up in future should move away from naphtha and use fuel oil/coal. Accordingly, six projects were planned on the basis of fuel oil

as feedstock and were under implementation. Two large-sized coal based fertiliser plants were also taken up for implementation. Following the discovery of crude and gas reserves off Bombay in 1974 and its commercial utilisation from 1978, the feedstock policy was reviewed and it was decided that (i) where gas was available, it should be the preferred feedstock, (ii) consideration should be given to the further use of coal as fertiliser feedstock as soon as it could be confirmed, on the basis of experience, that the operation of two coal-based plants with coal gasification technology was established and viable, (iii) thereafter the use of coal and gas should be arranged on techno-economic considerations, namely area of consumption, logistics of transportation, viability, availability, etc. While the use of fuel oil as fertiliser feedstock was to be excluded for the present for all new fertiliser projects, the use of naphtha as fertiliser feedstock for entirely new plants would be considered only in the case of a long term disposal problem in an inland location. Consideration would, however, be given to the use of naphtha as feedstock where existing plants at inland locations could be expanded at comparatively lower capital cost and completed in quick time. This feedstock policy was in line with India's policy to maximise the use of indigenously available feedstock [Ministry of Chemicals and Fertiliser, 1978, Pp. 6-7].

Based on regional and feedstock considerations the Fertiliser Corporation of India and National Fertilisers Limited were reorganised on 1st April 1978 into (1) The Fertiliser Corporation of India (FCI): Sindri (including Sindri Modernisation of and Sindri Rationalisation), Gorakhpur, Talcher, Ramagundam and Korba. (2) National Fertilisers Limited (NFL): Bhatinda, Panipat and Nangal. (3) Rashtriya Chemicals and Fertilisers Ltd. (RCFL): Trombay and new fertiliser plant at Thal based on Bombay High, and (4) Hindustan Fertiliser Corporation Limited (HFCL): Namrup, Haldia, Barauni and Durgapur.

The targets of production laid down in the revised Fifth Plan were nearly achieved. As against a target of 2.9 million tonnes of Nitrogen expected to be achieved by 1978-79, the actual production was 2.22 million tonnes and of $P_2O_5$ 0.78 million tonnes (target 0.77 million tonnes). By 1978-79, there were 26 large-sized plants producing nitrogenous and complex fertilisers, one plant producing triple super phosphate and 29 small units producing single super phosphate. The total installed capacity had risen to 32.59 lakh tonnes of nitrogen and 10.8 lakh tonnes of $P_2O_5$. In addition to the operating units, 11 fertiliser projects were under different stages of implementation.

*Draft Five Year Plan 1978-83*

Because of change in Government, the Fifth Plan (1974-79) was wound up in 1977-78 and a new draft Plan was presented for the period 1978-83. The main shift in emphasis in the fertiliser strategy was much greater attention to organic manures, minimising pollution and reducing costs of providing key nutrients. A substantial step-up in basic research and extension activity in the production and application of organic manures was envisaged in the Plan. Organic manures, would, however, need to be supplemented with chemical fertilisers. Expansion of capacity for production of chemical fertilisers was therefore also necessary.

The demand for nitrogenous and phosphatic fertilisers was estimated at 52.5 lakh tonnes and 16 lakh tonnes respectively for 1982-83 and at 73.3 lakh tonnes of nitrogen and 25 lakh tonnes of $P_2O_5$ by 1987-88. Considering the time-lag in establishing new capacity, the attainable levels of production were estimated at 39 lakh tonnes of N and 11.25 lakh tonnes of $P_2O_5$ by 1982-83. Substantial imports would therefore be necessary even at the end of the Plan period.

Advance action was proposed to be taken for setting up additional fertiliser capacity during the Plan period to meet the anticipated requirements during the period beyond 1982-83. In addition to the projects under implementation, construction of nine new nitrogenous fertiliser projects were contemplated. Three of the new gas based fertiliser projects in the public sector, two in Maharashtra and one in Assam were under implementation, and provision was made for a start on two more projects during the Plan period. The remaining four plants were envisaged to be taken up in the cooperative/private sector. The most recent estimates of off-shore gas suggested that there was sufficient feed-stock for several

more gas-based fertiliser plants. The capacity of phosphatic fertilisers would be based on a judicious combination of indigenous rock in Rajasthan and imported rock and phosphoric acid [Planning Commission, 1979, Pp. 349-350].

*Sixth Plan, 1980-85*

In the Sixth Plan (1980-85), greater attention was to be devoted to creation of indigenous production capacities for both nitrogenous and phosphatic fertilisers, maximising to the extent possible, the utilisation of indigenous raw material resources like gas, pyrites, rock phosphate, etc. The capacity of the fertiliser industry stood at 38.9 lakh tonnes for nitrogenous fertilisers (nutrient content) and 12.30 lakh tonnes for phosphatic fertilisers by 1979-80. The demand for nitrogenous and phosphatic fertilisers was estimated at 60 lakh tonnes and 23 lakh tonnes respectively in 1984-85 and at 86.0 lakh tonnes and 33 lakh tonnes in 1989-90. Considering the time-lag inherent in the establishment of new capacity, the attainable levels of production in 1984-85 were estimated at 42 lakh tonnes of nitrogen and 14.0 lakh tonnes of $P_2O_5$. Substantial imports would, therefore, be necessary even at the end of the Plan period [Planning Commission, 1981, Pp. 265-266].

*Progress During the Sixth Plan, 1980-85*

The progress of fertiliser production, imports and consumption during 1980-85 is shown in Table 23.

TABLE 23. PROGRESS IN SIXTH PLAN

(000 tonnes)

| | 1980-81 | 1984-85 |
|---|---|---|
| *Nitrogen (N)* | | |
| Capacity | 4,586 | 5,592 |
| Production | 2,164 | 3,917 |
| Imports | 1,510 | 2,009 |
| Consumption | 3,678 | 5,486 |
| *Phosphatic (P205)* | | |
| Capacity | 1,330 | 1,768 |
| Production | 841 | 1,318 |
| Imports | 452 | 745 |
| Consumption | 1,214 | 1,886 |
| Potassic ($K_2O$) | | |
| Imports | 797 | 624 |
| Consumption | 871 | 839 |

Source: FAI *Annual Review of Fertiliser Production and Consumption, 1980-85*, October 1986.

The Sixth Plan had provided that in addition to the four gas-based fertiliser plants (Thal Vaishet and Hazira), work would be started on eight new nitrogenous fertiliser factories. The first phase of the gas-based fertiliser complex at Thal Vaishet was completed during 1984-85 and phase II of this project as well as the entire Hazira project was to be commissioned in 1985-86. Preparatory work was taken up on six other gas-based plants which were being set up at Guna (MP), Sawai Madhopur (Rajasthan), Aoula, Jagdishpur, Shahjahanpur and Babrala (UP). Four of these plants were being set up in the joint sector and one each in the public and the cooperative ectors.

With the completion of the above gas-based plants and other projects already under implementation, the aggregate capacity of nitrogenous fertilisers by the end of the Seventh Plan was expected to be 92.53 lakh tonnes. The total production at the end of the Seventh Plan, i.e. in 1989-90 was estimated at 65.6 lakh tonnes. In view of the long gestation period involved in setting up fertiliser projects a long term perspective plan with a 15-year time horizon would have to be drawn up and preparatory work for new projects would have to be initiated.

So far as the phosphatic fertilisers were concerned, the shortfalls in capacity occurred because of the slippages in the completion schedules of the projects at Haldia, Mangalore, Goa (expansion), Pradeep I, and some new Single Super Phosphate Plants. The Sixth Plan also envisaged start of work on 11 phosphatic fertiliser plants including expansion of some of the existing units. Seven of these projects were taken up for implementation. Tuticorin (expansion) and Cochin (expansion) was completed while the remaining five were under different stages of implementation. It was expected that the capacity of phosphatic fertilisers at the end of the Seventh Plan would be 28.91 lakh tonnes with a production estimate of 21.90 lakh tonnes. A gap of about 5 lakh tonnes between demand and indigenous production would remain which would have to be met by imports.

*Progress during the Seventh Plan*, (1985-90)

The Seventh Plan had envisaged a target of consumption of fertilisers between 13.5 and 14.0 million tonnes by 1989-90. The consumption of fertilisers during the first three years of the Seventh Plan fell short of targeted levels due to unfavourable weather conditions and an unprecedented drought during 1987-88. The fourth and fifth years of the Plan were very good years and consumption of fertilisers increased both in the rabi and kharif seasons to about 12.43 million tonnes during 1989-90. The consumption of fertilisers during the Seventh Plan period is shown in Table 24.

TABLE 24. CONSUMPTION OF CHEMICAL FERTILISERS, 1985-90
(million tonnes)

| Year | Nitrogenous | Phosphatic | Potassic | Total NPK |
|---|---|---|---|---|
| 1985-86 | 5.66 | 2.00 | 0.81 | 8.47 |
| 1986-87 | 5.77 | 2.11 | 0.86 | 8.74 |
| 1987-88 | 5.72 | 2.19 | 0.88 | 8.79 |
| 1988-89 | 7.25 | 2.72 | 1.07 | 11.04 |
| 1989-90(E) | 7.90 | 3.31 | 1.22 | 12.43 |

(E) Estimated
Source: *Economic Survey, 1989-90*, p. 27.

*Progress during 1985-90*

By the end of the Seventh Plan period (1990), there were 55 manufacturing units for nitrogenous fertilisers with a capacity of 8.44 million tonnes and 87 units manufacturing phosphatic fertilisers with a capacity of 2.75 million tonnes. Eight more fertiliser projects were under implementation, of which five were for manufacture of nitrogenous, and three for phosphatic fertilisers. The physical targets laid down for production and capacity during the Seventh Five Year Plan and expected achievements are shown in Table 25.

The production of phosphates suffered during 1989-90 due to the shortage of imported phosphoric acid. Imports continued to meet the gap between production and demand. The level of imports had declined from 3.4 million tonnes in 1985-86 to 1.6 million tonnes in 1988-89.

TABLE 25. TARGETS AND ACHIEVEMENTS DURING 1985-90
(lakh tonnes)

| Fertilisers | Actual in 1984-85 | Target for 1989-90 | Actual in 1988-89 | Estimated for 1989-90 |
|---|---|---|---|---|
| *Capacity* | | | | |
| Nitrogen | 55.70 | 92.53 | 81.48 | 81.48 |
| Phosphates | 15.72 | 26.91* | 27.50 | 27.50 |
| *Production* | | | | |
| Nitrogen | 39.71 | 65.60 | 67.12 | 68.00 |
| Phosphates | 12.64 | 21.90 | 22.52 | 18.00 |

Source: *Annual Report, 1989-90*, Department of Fertilisers, Ministry of Agriculture, p. 15.

However, shortfall in the indigenous production of phosphatic fertilisers in 1989-90, resulted in increased imports to 3.44 million tonnes. All potassic fertilisers are imported. The quantum of imports during the Seventh Plan is shown in Table 26.

TABLE 26. IMPORTS OF FERTILISERS, 1985-90
(000 tonnes)

| Year | Quantum |
|---|---|
| 1985-86 | 3,399 |
| 1986-87 | 2,305 |
| 1987-88 | 984 |
| 1988-89 | 1,608 |
| 1989-90 | 3,442 |

Source: *Economic Survey, 1989-90*, p. 27.

*Working Group on Fertilisers for the Eighth Plan*

The Working Group set up by the Planning Commission for assessing the requirements of fertilisers for the Eighth Five Year Plan (1990-95), recommended that the demand-supply gap of nitrogen should be kept at the minimum and in any case not more than one million tonnes to be met by imports. In the case of phosphates, indigenous capabilities for production of finished products should be created to the extent of 85 per cent of the requirements. It was pointed out that since the country did not have significant sources of rock phosphate, and no source of sulpher, the indigenous production of phosphatic fertilisers was dependent on imported rock phosphate, sulpher and phosphoric acid. The likely demand-supply position during the Eighth Plan period as assessed is shown in Table 27.

TABLE 27. DEMAND/SUPPLY GAP DURING THE EIGHTH PLAN PERIOD

(million tonnes)

| Year | Nitrogen | | | Phosphate ($P_2O_5$) | | |
|---|---|---|---|---|---|---|
| | Demand | Production | Gap | Demand | Production | Gap |
| 1990-91 | 8.31 | 7.06 | (-) 1.25 | 3.53 | 2.55 | (-) 0.98 |
| 1991-92 | 8.18 | 7.15 | (-) 1.50 | 3.78 | 2.65 | (-) 1.13 |
| 1992-93 | 9.26 | 7.65 | (-) 1.62 | 4.03 | 3.10 | (-) 0.93 |
| 1993-94 | 9.75 | 8.60 | (-) 1.15 | 4.28 | 3.15 | (-) 1.13 |
| 1994-95 | 10.00 | 8.90 | (-) 1.40 | 4.55 | 3.20 | (-) 1.35 |

Source: *Annual Report, 1989-90*, Department of Fertilisers, Ministry of Agriculture, p. 9.

The Working Group recommended the following measures for angmenting production in the country: (i) Implementation of spill over gas-based projects of the Seventh Plan along the HBJ pipeline. (ii) Rehabilitation and revamping of those plants which were consistently operating at low level of capacity utilisation, for improved performance and productivity. Such revamping, with incorporation of modern technology to the extent feasible, would ensure significant enhancement of production levels from the group of plants whose full potential was never realised due to various constraints. (iii) Expansion of production capacity in existing fertiliser plants, particularly in new units, where significant investment made for various offsite/onsite and other infrastructural facilities could be fully utilised. These locations could sustain new expansion projects of identical capacity or medium capacity projects commensurate with infrastructure and other facilities available. (iv) Installation of new units at location where raw material resources such as natural gas has been found and exploited for utilisation. It would be necessary to plan for establishment of 3 new plants of 1,350 tonnes per day ammonia with matching urea capacity. The report of the Working Group was under examination.

Thus, between 1950 and 1990, the consumption of chemical fertilisers increased by 180 times, from around 0.07 million tonnes in 1950-51 to over 12.43 million tonnes in 1989-90. However, the bulk of the fertiliser use has been in areas with assured irrigation, the rainfed areas constituting 70 per cent of the cultivated area continuing to use only 20 per cent of the total fertiliser consumption even in the Seventh Plan period. Production increased from 0.02 million tonnes to 8.60 million tonnes, while licensed capacity of the factories increased from about 0.02 million tonnes to 8.15 million tonnes for nitrogenous fertilisers and from 0.02 million tonnes to 2.75 million tonnes for phosphatic fertilisers during the same period.

### REGULATION, PROMOTION, AND PRICES

The import and distribution of nitrogenous fertilisers were in the hands of private organisations till Government took them over during the war years. The 'Grow More Food Campaign' during 1942-43, attached great importance to manures and fertilisers and, in 1943, the Government of India established a Central Fertiliser Pool in the Ministry of Food and Agriculture to import fertilisers, to procure the entire quantity of fertilisers produced in the country, and to ensure equitable distribution of available fertilisers throughout the country at a uniform reasonable price. For instance, as against a price of Rs 344.50 per tonne charged by Sindri Fertilisers and Chemicals Ltd., and the import price of Rs 380 to 400 per tonne, the pool price of ammonium sulphate was fixed in 1951 at Rs 375 per tonne f.o.r. Sindri or ports.

In October 1948, a Central Phosphate Pool was created. The object was to import superphosphate, buy indigenous output of the fertiliser on the basis of the actual costs of production, and sell both the imported and the indigenous superphosphate to State Governments and others at a uniform 'pool price' fixed on a 'no profit, no loss' basis. In order to operate this scheme, Government had, from time to time, referred the matter, to the Tariff Board, of fixing the purchase price of superphosphate factories. In 1949, the Tariff Board had recommended the setting up of a

Superphosphate Advisory Panel; the Panel was set up by the Ministry of Agriculture, which met for the first time in February 1950. At its meeting, eight manufacturers (out of eleven) agreed to reduce their ex-factory prices by Rs 13.78 per tonne from March 14, 1950, in view of the fall in prices of the raw materials utilised. The Ministry of Commerce, therefore, referred the matter of fixation of ex-factory prices of superphosphates to the Tariff Board in April 1950. Later in December 1950, the Tariff Board were requested that the fair ex-works prices of superphosphates to be fixed by the Tariff Board may relate to the periods (i) March to December 1950, and (ii) January - December 1951 [Dey, 1951(a), P. 1].

The Tariff Board submitted its Report in January 1951. The fair ex-works prices of sulphuric acid and superphosphate (excluding transport charges on raw materials from the port to the factory and on superphosphate from the factory to the nearest railway station) for a national representative unit were recommended at Rs 140.53 per tonne for the period from 14th March to 31st December 1950, and at Rs 167.52 per tonne for 1951. For superphosphate, the recommended prices were Rs 180.25 per tonne for the period from 14th March to 31st December 1950, and Rs 196.97 per tonne for 1951. The Board recommended that the cost of rock phosphate and sulphur should be reviewed by the end of June 1951 and in case of a significant change in the cost of these materials, the prices of superphosphate should be adjusted. The Central Government should continue to link the allocation of sulphate of ammonia with those of superphosphate to the maximum possible extent, allowing sufficient discretion to the State Governments and other consuming interests to fix a suitable ratio between the two fertilisers according to local conditions [Dey, 1951(a), Pp. 34-36].

Government accepted the recommendations of the Board in March 1951 and announced pool price for phosphatic fertilisers at Rs 218.50 per tonne for the period of six months from January to June 1951. In August 1951, Government fixed provisionally the pool price of superphosphate at Rs 236.20 per tonne, but again referred the matter of revision of prices of superphosphate for the period July - December 1951 to the Tariff Board.

In a second report submitted in October 1951, the Board found that the cost of production of superphosphate during 1951 were significantly higher than those in November 1950 and hence recommended revised prices of superphosphate to range between Rs 208.65 and Rs 256.88 per tonne for the different factories for the period July - December 1951 as compared to Rs 207 and Rs 250 recommended earlier. Government announced the revised prices in January 1952 [Dey, 1951(b), p. 15].

In January 1952, the Ministry of Commerce and Industry requested the Tariff Commission (known earlier as Tariff Board) to recommend fair ex-works prices of indigenous superphosphate for the year 1952. The Commission submitted its report in September 1952. But, with the transfer of the work of procurement and distribution of all chemical fertilisers to the Central Fertiliser Pool, the Government announced the termination of the Central Phosphate Pool from August 15, 1952. The prices recommended by the Commission therefore related to the period 1st January - 15th August 1952. The Commission recommended the fair prices per ton for superphosphate for the different factories ranging from Rs 210 to Rs 257 per tonne for the period January to June 1952. The Commission also recommended that (i) as the cost of production of superphosphate was not likely to have changed to any appreciable extent, the fair prices recommended for the period January - June 1952 should be made applicable for the period 1st July to 15th August 1952 also; (ii) a recovery of Rs 4.63 per tonne should be made from DCM Chemical Works, Delhi for deliveries made by them to the 'Phosphatic Pool' during 1951 in view of the concession enjoyed by them since 15th August 1950 on the transportation charges on rock phosphate from Bombay to Delhi; and (iii) the prices recommended should be subject to rebate to State Governments equal to the difference between the freight from the nearest factory to the consuming centre and from the supplying factory to the consuming centre, as agreed to by the manufacturers at their conference with the Government of India, held on 5th/6th May, 1952 [Bhat, 1952, Pp. 1-11]. The Government of India

accepted these recommendations.

The Central Government, through a Division in the Department of Agriculture, continued to administer the 'Central Fertiliser Pool'. It collected the estimated demands of fertilisers from the State Governments and also from corporate bodies of plantations (Tea, Coffee and Rubber Boards) and industrial users. The estimated indigenous production was ascertained from the producers. The ex-factory works price (or retention price) for domestic producers was fixed by the Cost Accounting Division of the Ministry of Finance based on average actual cost of production, but including a fair return on investments to manufacturers. Imports were also arranged by the Pool. The indigenous production as well as the imported stocks were pooled together and allotted to the State Governments, etc., once a quarter in accordance with the estimated availability of supplies and the demand from the States during the period [Patel, 1960, Pp. 16-19]. The fertilisers from the Central Pool were distributed throughout the country at a uniform selling price, on the basis of f.o.r. despatching station plus freight prepaid up to nearest rail-head destination. The pool issue price was fixed by the Ministry of Food and Agriculture taking account of, (i) purchase price of (a) indigenous products from various units and (b) of imported material including ocean freight; (ii) inland transport from sources of supply in the case of indigenous product and port of landing in the case of imported product, up to rail-head destinations and an element of equated freight charge being included in the pool issue price; (iii) handling, storing and clearing charges at ports of imported fertilisers; (iv) departmental charges of purchasing organisations overseas; (v) sales tax on indigenous sulphate of ammonia; (vi) interest on capital at the prevailing government rates for six months on the imported material; and (vii) incidentals including expenditure for the staff employed, shortages and rebagging, etc. [Aiyangar, 1959, p. 8]. In Table 28 are shown the quantity and value of fertilisers handled by the Central Fertiliser Pool during the First Plan period.

TABLE 28. FERTILISERS HANDLED BY CENTRAL FERTILISER POOL 1951-56

| Year | Quantity (tonnes) | Value (Rs Crore) | Profit(+)/Loss(-) (Rs Lakh) |
|---|---|---|---|
| 1951-52 | 188,513 | 5.09 | (+) 4.45 |
| 1952-53 | 332,460 | 12.88 | (+) 3.40 |
| 1953-54 | 369,166 | 8.77 | (+) 68.71 |
| 1954-55 | 463,133 | 10.40 | (-) 45.47 |
| 1955-56 | 568,969 | 16.73 | (+) 8.76 |

Source: *Report of the Fertiliser Distribution Enquiry Committee*, 1960.

*Fertiliser Control Order, 1957*

The Central Government promulgated in May, 1957 the Fertiliser (Control) Order, 1957 under clause 3 of the Essential Commodities Act, 1955. The Order provided for (i) control of prices of fertilisers, (ii) licencing of dealers in fertilisers, (iii) registration of fertiliser mixtures, (iv) restrictions on manufacture, sale and distribution of fertilisers, and (v) prescription of specifications of fertilisers in relation to the maxima and minima of the various important constituents. The District Agricultural Officers, Agricultural Extension Officers and Agricultural Inspectors were vested with the powers of inspection and enforcement under the Order. Powers for fixing prices of fertilisers vested with the Government of India. The State Governments had however been concurrently authorised to fix prices at which fertiliser mixtures may be sold by a manufacturer or a dealer. The Order also provided for the sampling of fertilisers and mixtures and analysing them to ensure the standard of quality.

*Second Five Year Plan, 1956-61*

The procurement and distribution of chemical fertilisers was expected on a greatly expanded scale in the Second Plan. This raised the question of strengthening the administrative arrangements

of the operations of the Central Fertiliser Pool as well as of the States. Distribution was undertaken by State Governments through Government sale depots, private distributing agencies and cooperative organisations, the detailed arrangements varying considerably in different States. As new chemical fertilisers were being brought into use and manurial trials were being carried out in the country, the Second Plan stressed the importance of disseminating information regarding the use of fertilisers on the widest possible scale and using cooperative societies as the main agency for distribution of fertilisers at the village level [Planning Commission, 1956, p. 270].

*Report of the Tariff Commission on the Fair Retention Price of Ammonium Sulphate produced by Sindri Fertilisers, December 1959*

In March 1959, the Ministry of Commerce and Industry requested the Tariff Commission to undertake an enquiry into the production costs at the Sindri Fertiliser Factory under Section 12(d) of the Tariff Commission Act, 1951 and furnish a report to Government to include specific recommendation in regard to a reasonable retention price to be allowed to the Company for its ammonium sulphate by the Central Fertiliser Pool. The Commission submitted its report in December 1959. The Commission examined the working costs of the Factory, particularly for the year 1958-59. Among the raw materials used for the manufacture of ammonium sulphate, the Commission found that the Coal Controller had diverted the good quality, non- metallurgical coking coals with high ash fusion and low iron content which the factory had obtained from the nearby Lodna and Loyabad collieries to the Steel Plants, Railways and other consumers. Instead coal of inferior coking grade with low ash fusion from distant collieries involving longer leads had been allotted to the Sindri Fertiliser Factory. This had reduced plant efficiency and increased the percentage of breeze. There had therefore been a significant drop in the production of ammonia with consequent reduction in the output of ammonium sulphate during 1959-60. The Commission recommended that Government should ask the Coal Controller to take immediate steps to make available to Sindri such grades of coal as would enable it to obtain the right blend for its coke regularly and in adequate quantities from nearby collieries.

With regard to gypsum too, the fertiliser industry required superior grades of gypsum (86 per cent and above of calcium sulphate) and deterioration in quality affected plant efficiency and output. In order to conserve gypsum resources, the Commission recommended that the industries consuming gypsum should be classified according to the grades normally required by them. Measures should be devised to ensure that high grade gypsum was not used where a slightly lower grade could be used without any appreciable loss of efficiency. Freight on gypsum despatched to Sindri as a raw material for production of fertilisers should be reduced; this matter should be pursued by Sindri with the Ministry of Railways [Aiyangar, 1959,, Pp. 15-17].

The Tariff Commission also recommended that (a) standards or norms should be set for proper process costing at each stage, and Sindri should adopt a suitable system of management accounting; (b) a proper plant register should be compiled and maintained regularly; (c) a proper time study should be made to determine the fair strength of staff for continuous operation of the plant; (d) the retention price payable to Sindri from the Fertiliser Pool should be Rs 277.55 per tonne, exclusive of local taxes, for the period 1st April 1959 to 31st March 1962; and (e) the Ministry of Food and Agriculture should in concert with State Governments, enforce economy right through the stages of intermediaries for handling, procurement, and distribution of fertilisers, so that the ultimate price to the consumer would be as low as possible [Aiyangar, 1959,, Pp. 37-38].

The retention price of ammonium sulphate produced at Sindri at the beginning of the Second Plan was Rs 265.73 per tonne while the pool price was Rs 310 per tonne f.o.r. railhead destination. In 1957, the retention price was raised to Rs 275.58 while the pool price was raised to Rs 344.47 per tonne. In 1958, the retention price was further raised to Rs 285.42 per tonne while the pool price remained at Rs 344.47 per tonne. In

1959, the Tariff Commission recommended a retention price for Sindri at Rs 295.25 per tonne upto 31st March 1962.

*Sub-Committee for Superphosphate Prices, 1960*

The Sub-Committee appointed by the Development Council for Acids and Fertilisers in 1960, consisting of the representatives of the Ministry of Food and Agriculture, Ministry of Commerce and Industry, and the manufacturers of superphosphate, to evolve a formula for fixation of prices of superphosphate after taking into account the factors that contributed towards reduction of the manufacturing cost, recommended that the ex-works price of superphosphate, in the case of factories situated near ports, should not be more than Rs 177.16 per tonne when rock phosphate and sulphur were available at Rs 108.26 and Rs 177.16 per tonne respectively at site. The Committee also suggested an additional allowance for those units situated beyond 100 miles from a port [Ministry of Commerce and Industry, 1961, p. 25].

*Report of the Fertiliser Distribution Enquiry Committee, 1960*

In November 1959, Government of India set up the Fertiliser Distribution Enquiry Committee to (i) study the system followed for assessing the demand of nitrogenous fertilisers, the mode of distribution in vogue and to recommend steps for improvements, wherever necessary; (ii) study the role of the distribution agencies employed and their share in the distribution margin allowed and to recommend such adjustment as may be necessary in the distribution margin; (iii) recommend steps that should be taken to ensure that the cultivators get the fertilisers of the required quality and at the notified price; and (iv) study the system in vogue for the distribution of superphosphate and the cost of distribution and to suggest such improvements as may be considered necessary [Patel, 1960, Pp. 8-9].

The Committee submitted its Report in August 1960. It found that, at the Centre, the Central Fertiliser Pool collected the demands of fertilisers from the State Governments and arranged for their supply/allotment to the States. In the States, the Department of Agriculture administered the distribution of fertilisers; the actual distribution, however, was done by the cooperative societies. This was, being gradually taken over by the Cooperation Department. The Apex Cooperative Societies also functioned as coordinating agencies. The indents of fertilisers were however, passed on to the Central Government by the Agriculture Departments. With the taking over of the distribution work by the Cooperative Societies there was a growing tendency to act independently of the District Agricultural Officers and for the Agricultural Officers themselves to lose interest in this important work. The Committee was of the view that there was no justification for more than one agency at the State level for the work of coordination. There was no necessity for both the Agriculture Department and the Apex Cooperative Organisation to coordinate distribution and allocate supplies. The State Agriculture Department should be closely associated with the estimation of demand, and the District Agricultural Officers should be consulted while preparing the seasonal estimate.

The Committee recommended the use of fertilisers in mixed form to promote balanced fertilization and assist in stretching the limited supplies of nitrogen over larger areas. The prices of nitrogenous and phosphatic fertilisers were very high. Nitrogenous fertilisers were susceptible to considerable reduction without in any way impairing the financial position of the Pool and its ability to subsidise the sales of mixtures and superphosphate as recommended by the Committee. Phosphatic and potassic fertilisers also required a substantial price reduction on grounds of equity and promoting their free use.

While it was recognised that sales tax was an important source of revenue, its incidence on fertilisers was very high in some States. In order to keep the cost of fertilisers down, the Committee recommended exemption of fertilisers from the sales tax. Fertilisers should also be recognised as of special importance in inter-state trade or commerce under the Central Sales Tax Act, 1956.

The Committee made a number of recommendations for the streamlining of the distribution system, the costs of distribution, control of quality, licensing and registration, training of

sales personnel, etc. It considered the organisation of the Central Fertiliser Pool inadequate. The duties being performed by Central Fertiliser Pool and the anticipated additional responsibilities may be entrusted to an organisation which may be called the Central Fertiliser Marketing Corporation. This Corporation should enjoy a liberal measure of autonomy while working under the direction and superintendence of the Department of Agriculture [Patel, 1960, Pp. 90-100].

*Report of the Working Group for the Formulation of the Fourth Five Year Plan Proposals on Price Incentives and Subsidies for Agricultural Production, 1965*

In June 1963, the Ministry of Food and Agriculture set up a Working Group on Price Incentives and Subsidies for Agricultural Production, (i) to make a critical review of the progress of the programmes and schemes in the Third Five Year Plan; (ii) to assess in the light of current trends and other available data, the position likely to be reached at the end of the Third Plan period; and (iii) to formulate proposals for the Fourth Five Year Plan in the perspective, wherever possible, of development over a ten year period. The Group submitted its Report in early 1965.

The Working Group referred to the pattern of subsidies being provided for different agricultural inputs during 1963-64. For fertilisers, a subsidy of 25 per cent was available in the case of superphosphates provided the subsidy was shared equally between the Central and State Governments. In addition, in Bihar, calcium ammonium nitrate was subsidised to the extent of 11 per cent. In Madhya Pradesh and Mysore, the respective State Governments gave subsidy to the Cooperative Marketing Organisations over and above the prescribed margins allowed by the Central Fertilisers Pool for the distribution of nitrogenous fertilisers. In the case of Jammu and Kashmir, a subsidy amounting to Rs 245 per tonne in Kashmir Province and of Rs 145 per tonne in Jammu Province was given for super-phosphate. On nitrogenous fertilisers a subsidy of Rs 130 per tonne was available in Kashmir Province and Rs 35 per tonne in Jammu Province. Fertilisers were imported and distributed by the Cooperative Department. The subsidy represented the difference between the sale price and the landed cost of fertilisers. In Punjab subsidies were given for nitrogenous fertilisers in the hilly areas. Subsidies were also given for transport of fertilisers in the hilly areas [Kamat, 1965, Pp. 3-11].

*Progress During the Third Plan*

A major assumption in formulating the Third Plan programmes for agricultural production was that consumption of nitrogenous fertilisers would increase from 234 thousand tonnes (nitrogen) in 1960-61 to 1.02 million tonnes in 1965-66, with corresponding increases for phosphatic and potassic fertilisers. But, mainly because of limited supplies, the actual consumption was much less. During the first two years of the Plan, consumption of phosphatic fertilisers had shown only a small increase from 71,123 tonnes to 81,284 tonnes ($P_2O_5$). This was ascribed to two main reasons namely (a) in many areas cooperative agencies were not yet undertaking the distribution of phosphatic fertilisers and of mixtures of any scale, and (b) often cooperative credit did not become available to farmers for purchase of phosphatic fertilisers from private agencies. It was suggested that steps should be taken to (i) reduce the pool price of calcium ammonium nitrate, (ii) reimburse transport charges for remote areas, (iii) arrange for intermediate bulk storage, (iv) grant off-season rebates, (v) intensify programme for fertiliser demonstrations on cultivators' fields, and (vi) arrange for supply of fertiliser mixtures of approved standards [Planning Commission, 1963, Pp. 75-76].

A number of measures were taken during the Third Plan to encourage the use of chemical fertilisers. The Inorganic Fertiliser (Movement) Control Order, 1960 was passed banning w.e.f. 1.1.1961 the inter-State movement by trade of ammonium sulphate, ammonium sulphate nitrate, urea, calcium ammonium nitrate and ammonium nitrate. Under the Fertiliser (Control) Order, 1957, maximum selling prices for fertilisers were fixed in October 1961; these were reduced under the Order in December 1961, October 1962 and again in April 1964 but were raised in February 1966 (Table 29).

TABLE 29. POOL PRICES OF FERTILISERS

(Rs per tonne)

| Fertiliser | Earlier Price | Revised Price | |
|---|---|---|---|
| | | 1-4-1964 | 1-2-1966 |
| Ammonium Sulphate | 384.60 | 374.60 | 405.00 |
| Urea | 715.00 | 615.00 | 680.00 |
| Ammonium Sulphate Nitrate | 451.50 | 435.00 | 515.00 |
| Calcium Ammonium Nitrate | 354.80 | 310.00 | 365.00 |

Source: *Fertiliser Statistics*, 1965-66.

Subsidies on fertilisers were granted by Assam, at Rs 10 per tonne on transport charges for all fertilisers to hilly areas and Rs 15 per tonne in inaccessible areas; Kerala at a 25 per cent subsidy on the sale price of all fertilisers; Madhya Pradesh between 12.5 and 25 per cent for the different fertilisers; Maharashtra at Rs 50 per tonne for fertiliser mixtures in the cultivation of hybrid jowar, maize and bajra, and Taichung Native I paddy; Uttar Pradesh at Rs 5 per maund on transport charges for hilly areas and Rs 25 per maund on sale price of phosphatic fertilisers; and Himachal Pradesh and the North Eastern States between 25 and 50 per cent.

Nearly all the States allowed off-season rebates for use of nitrogenous fertilisers - sulphate of ammonia, urea, calcium ammonium nitrate - supplied from the Central Fertiliser Pool. These rebates were admissible at graduated rates on despatches made by the Pool during the different months of the non-manuring period. The rebates ranged between Rs 2.50 per tonne and Rs 7.50 per tonne for the different months of the non-manuring period for sulphate of ammonia and calcium ammonium nitrate and between Rs 4.00 per tonne and Rs 12.00 per tonne for urea.

In view of the fall in demand for fertilisers during the drought years of 1965-66 and 1966-67, manufacturers were also permitted to sell up to 15 per cent of their production in the open market commencing 1965-66 season.

*Report of the Committee on Fertilisers, September 1965*

In October 1964 the Government of India set up a Committee on Fertilisers, to (i) consider short-term and long-term problems connected with distribution of fertilisers both in the States and at the Centre and to recommend measures which would lead to the establishment of an effective system of distribution of fertilisers with a view to bringing about a rapid increase in their use for increased agricultural production; (ii) study the pricing policy at different levels and to suggest modifications, if any, that would lead to a substantial increase in the consumption of fertilisers; (iii) study the role of distribution agencies employed in the States, namely departmental, cooperative and private trade, their distribution margins and to suggest measures for increased sales promotion; (iv) study the role of extension services in the promotion and popularisation of the use of fertilisers and suggest measures for increased sales promotion; and (v) study the role, if any, of the producing units, both in the public and private sectors, in marketing and promotional activities. The Committee submitted its Report in September 1965.

The Committee observed that use of chemical fertilisers was predominantly in the irrigated areas for food crops. More than 70 per cent of the fertilisers were used on food crops. Reduction in prices of certain fertilisers and rising agricultural prices contributed in some measure to the growth of fertiliser use. The Intensive Agricultural District Programme also contributed to a greater awareness of the need for fertiliser use. The growth of fertiliser consumption was, however, slow because of delayed receipts of fertilisers, inadequate credit facilities, and bottlenecks in distribution.

The fertiliser prices paid by cultivators should not be allowed to exceed Rs 18.50, Rs 17.50 and Rs 6.25 respectively per unit of N, $P_2O_5$ and $K_2O$ during 1966-71. On the assumption of the maintenance of a proper price structure for farm produce, no subsidies in fertiliser prices were needed. However, so long as disparities between import prices and in the ex-factory prices of local units

existed, the system of pool prices adopted in the Central Fertiliser Pool would have to continue. The Central Fertiliser Pool had made considerable profits amounting to Rs 43.35 crore. These profits should be made available to the Fertiliser Promotion Corporation recommended by the Committee for fertiliser promotion work. This Corporation was necessary as the existence of several agencies dealing with procurement and dispatch of fertilisers was not conducive to efficient performance. The functions of the Central Fertiliser Pool should be transferred to the Fertiliser Promotion Corporation which could handle the fertiliser distribution on business lines and also ensure that profits were used for promotional work. The Corporation may be enabled to procure 10 - 20 per cent of indigenous production. The Fertiliser Promotion Corporation should also take over the distribution of a part of the indigenous production of phosphatic fertilisers. As soon as the Fertiliser Promotion Corporation took up active promotion of balanced fertiliser use, arrangements with the Indian Potash Supply Agency should cease and the Corporation should also be entrusted with handling potash imports.

The Corporation was to ensure proper distribution of fertilisers at reasonable prices, in remote areas and in situation of shortage. Its activities could be expanded to become an Agricultural Services Corporation. It could also sponsor technical and statistical studies and promote use of new fertilisers with technological and price advantages. The Corporation would have a Board of Directors at Central level and advisory bodies at Zonal level. There would be a Chief Executive Authority assisted by divisions in administration, marketing, agronomy, soil chemistry, and plant protection. Part of the expenditure on the Corporation was to be met by a 1 per cent cess on fertilisers on the landed cost for imports and ex-factory prices for indigenous production. The Central Government was expected to contribute nearly Rs 300 million to the Corporation's activities during the Fourth Plan.

Beginning with 1967-68, consumption of chemical fertilisers, as a whole, increased though it remained below the targets fixed. The actual use in the high-yielding varieties programme, introduced in 1966-67, did not always correspond to the optimum doses recommended for the various varieties. Inadequate distribution points and credit facilities also affected consumption. One of the measures taken to facilitate increased off-take was to increase the open market quota of sales of indigenous manufacturers. This quota was raised from 30 to 50 per cent from October 1, 1967. Other measures taken included off-seasonal rebate on pool supplies of calcium ammonia nitrate and sulphate of nitrate, subsidy on transport of fertilisers by road to destinations up to 500 kms and in hilly and inaccessible area, subsidy on fertiliser use on field demonstrations, and increase in the number of departmental/private agency sales depots.

Since the success of the high yielding varieties programme was largely conditioned by the large application of fertilisers, a study was undertaken to assess the actual consumption of chemical fertilisers in the States, vis-a-vis requirements on the basis of coverage of high-yielding varieties of each State. In the course of this study, it was found that one of the main defects was the lack of balanced application of fertiliser doses. In order to improve the situation, States were asked to devise ways of increasing the consumption of phosphates and potash by the system of incentives and awards. Dealership licences were to be given to dealers who stocked all the three types of nutrients. Audio-visual media were called upon to lay greater stress on the balanced use of fertilisers.

*Report of the Fertiliser Credit Committee, 1968*

The Committee on Fertilisers (1965) had submitted its Report towards the end of 1965. The Board of Directors of the Fertiliser Association of India considered the Committee's recommendations as a whole and felt that, in regard to credit, a more detailed survey should be undertaken. Accordingly the Association set up a Committee to examine further and make specific proposals in respect of credit required at all stages

subsequent to the manufacture of fertilisers, including distribution by the wholesaler and the retailer and purchase by the cultivator in order to ensure, as far as possible, that the arrangements were adequate in regard to (i) the amount of credit available both in the aggregate and at different stages; (ii) the procedures followed, including the securities demanded by the different agencies of credit; and (iii) the operation of the system as a whole including the implementation of different parts of the programme by those to whom the responsibility was allocated. The Committee submitted its Report in February 1968.

The Committee emphasised that agricultural production should not suffer on account of shortfalls in internal production of fertilisers. Therefore, import programmes should be so drawn up that due allowance was always made for possible failure of some factories to reach expected production levels and for the emergence of unforeseen circumstances which may delay imports. At the same time, suitable measures should be taken to ensure maximum internal production. This included giving freedom and responsibility to the manufacturers themselves to make their own arrangements for the importation of raw materials and marketing of their finished products.

Arising from the Central Government's policy to allow manufacturers freedom to market their product, the future pattern of supplies to States would be very different from what it used to be till 1965-66. Assuming that the Centre would take over 15 per cent of the internal production in 1970-71, and the factories would be interested in marketing their products as near the point of production as possible, it was probable that only a few States would substantially depend on the Pool for the supplies of N by 1970-71. Many States would increasingly depend on the sales made by the factories. This would call for close coordination between those concerned with agricultural programming and those who supplied and distributed fertilisers.

The cooperative agencies had been entrusted with the distribution of nitrogenous fertilisers either on a monopoly or near-monopoly basis in many States. The 18-months credit facility for Pool fertilisers available till 1965-66, resulted in the cooperative agencies handling in 1965-66 nearly 72 per cent of the total value of supplies in the country. With the larger increases in supplies, and the Centre's decision to give increasing freedom to the manufacturers to make their own distribution arrangements for their products, the role of the cooperatives in fertiliser distribution would decline. Other factors were the decline in the relative importance of the Central Fertiliser Pool as a source of supplies, and the curtailment of credit from the Centre to the States in respect of Pool supplies.

The cooperatives had also operated under severe handicaps particularly those arising from unsold stocks transferred to them by the State Agriculture Departments, receipt of supplies late for each season, and of supplies much in excess of demand. At the same time while they were called upon to handle increasing supplies as a matter of State policy, the financial assistance from the Governments either for building up of managerial personnel or construction of storage accommodation, purchase of transport vehicles, etc., was not always forthcoming to the required extent. Prolonged delays in adjusting the amounts due to the cooperatives on account of supplies made by them against taccavi permits or on account of transportation costs, etc., had also greatly affected their efficiency of turnover.

With the reduction of supplies from the Central Fertiliser Pool, the credit facilities available to the cooperatives from the Pool got curtailed. The cooperative societies found it difficult to adjust to the requirements of institutional finance, especially in the matter of raising margin money. At the same time, if the cooperatives handled the entire Pool supplies in 1970-71 there would be a very considerable strain on the resources both of the Centre and of the States. Also, credit from the Centre would not be available to different States in proportion either to their need or their capacity to utilise it as. It was necessary to consider (a) the extent to which the cooperative agencies could be reasonably expected to undertake efficient distribution by 1970-71 taking into account their finances, organisation, etc., and (b) the extent to which the manufacturers would make their own arrangements for distribution. The Committee considered that the production credit for fertilisers estimated to be available from the cooperatives in 1970-71 also set the minimum level up to

which the cooperatives in each State should handle fertilisers. On the assumption that credit turnover would be twice during the year and the margin money had to be provided at one-tenth of the total distribution finance needs, the distribution credit and margin money needs of the cooperatives in the event of their handling (a) minimum and (b) maximum levels would amount to Rs 1,208 million and Rs 134 million, and Rs 1,753 million and Rs 195 million, respectively.

For this purpose, the financial position of the cooperative marketing/distribution agencies should be strengthened. The National Cooperative Development Corporation should examine the requirements of each State and, in particular, those of cooperative wholesalers in the programme areas for handling fertilisers for the next few years and make loans to the States on a more liberal scale than hitherto. It was also necessary to relax the existing norms followed by the cooperative banks and the State Bank of India for sanctioning clean cash credit limits to the cooperative marketing societies in order to enable them to make adequate initial purchases of fertilisers.

Unless there were liberal facilities for refinance in the context of the increasing demand for fertiliser credit, the commercial banks would be in no position, especially during the busy season, to meet the credit requirements of fertiliser distribution. These facilities should be available (a) on a priority basis; (b) in adequate measure; (c) at rates of interest applicable to priority sectors; and (d) without technically affecting the net liquidity position of the banks. These elements were already available in the Reserve Bank's Scheme, then current, and the Committee recommended its continuance, notwithstanding the substantial increase in the volume of refinance needed for the distribution of fertilisers. The distribution credit for fertilisers would become necessary at one or more of the points in the distribution chain, viz., manufacturers, distributors, wholesalers, subdistributors and retailers.

The Committee recommended the setting up, under the Companies Act, 1956, of a Fertiliser Credit Guarantee Corporation which should be notified by Government under Section 17(8A) of the Reserve Bank of India Act. The Corporation would operate a scheme known as the Fertiliser Credit Guarantee Scheme, the objects of which were to include ensuring larger bank credit for the stocking and distribution of fertilisers, pesticides, and other approved items, by extending to banks and other credit institutions a degree of protection in respect of their advances made or guarantees or acceptances given, by them, to stockists, distributors, wholesalers, sub-wholesalers and retailers [Venkatappiah, 1968, Pp. (i)-(xxv)].

The targets of consumption of fertilisers for the Fourth Five Year Plan (1969-74) were fixed at 3.2 million tonnes of N, 1.4 million tonnes of $P_2O_5$ and 0.9 million tonnes of $K_2O$ by 1973-74. This implied more than trebling the 1968-69 level of fertiliser consumption. According to the Fourth Plan, there was a large gap that existed between the recommended dosage and the actual application of fertiliser even in areas covered by HYV. Consumption of fertiliser depended on the characteristics of the soil. At the end of 1968-69, there were 65 soil-testing laboratories all over the country whose capacity was being under-utilised, the quality of soil analysis was poor and effective follow-up action by the extension agency was lacking. Measures were needed to rectify these shortcomings and also to expand the number of soil-testing laboratories, some of them mobile. There was also need for the intensification of agricultural extension and sales promotion arrangements. The manufacturers had been given the freedom to market their entire product subject to the proviso that Government had the option to acquire up to 30 per cent of their production at negotiated prices. In fact, the Central Fertiliser Pool were not exercising this option. The manufacturers, therefore, possessed both the freedom and the responsibility for sales promotion. The Government and the industry could jointly set up a Fertiliser Promotion Council as an autonomous body to strengthen and coordinate sales promotion arrangements.

One of the factors influencing fertiliser consumption was the availability of fertilisers within easy reach of the farmer. The Fertiliser Control Order was amended, so as to substitute mere registration for licensing of fertiliser dealers. While expansion in the number of retailers was likely, it was necessary to ensure that the

retail points were widely dispersed so as to include coverage of villages away from the railheads. This was particularly urgent as the number of cooperative rail depots had declined from over 48,000 to nearly 40,000 as a result of the policy of cooperatives to rationalise their distribution system in the context of competition from private trade.

Attention was also necessary to certain qualitative aspects relating to balanced use of fertilisers. From the agronomic point of view, the proportion of $P_2O_5$ and $K_2O$ in relation to N had to be much higher than what was consumed. It was necessary to accelerate the consumption of phosphatic and potassic fertilisers. These included popularisation of fertiliser mixtures and complex fertilisers and stocking of these fertilisers by the dealers. Other measures included demonstrations and a more effective soil testing programme bringing out deficiencies of phosphorous in certain areas of Kerala, Mysore, Andhra Pradesh, Maharashtra, eastern Madhya Pradesh, Orissa, Bihar and southern Gujarat and deficiencies of potash in certain pockets of Orissa, Kerala, Tamil Nadu, Gujarat, Maharashtra and western Rajasthan [Planning Commission, 1970, Pp. 130-133].

*Interim Report of the National Commission on Agriculture on Fertiliser Distribution, November 1971*

The Planning Commission requested the National Commission on Agriculture (NCA) to examine the problem of fertiliser consumption on a priority basis and advise Government, through an interim report the factors restricting their growth. The NCA therefore submitted an interim report on this subject in November 1971.

In its Report, the NCA recommended that a special Expert Team should analyse the production trends, responses to fertilisers and the actual dosages adopted in the field and make a fair estimate of the fertiliser requirements that would have to be assured. Requirements of fertilisers should also be estimated on the basis of balanced application of fertilisers taking into account soil studies and field trials. The NCA expressed concern at the shortfalls in domestic production of fertilisers, both nitrogenous and phosphatic, as compared to the targets of production laid down in the Plans, as well as their capacity. There was also serious lack of balance in the production pattern of the various fertiliser factories in the country. While a capacity for 13.44 lakh tonnes had been created for the production of nitrogenous fertilisers by 1970-71, indigenous capacity in phosphate production was only 4.21 lakh tonnes partly because nearly half of the phosphate capacity was for super-phosphate, a product which was fast losing its popularity due to damage in transit and storage and also to heavy transport cost because of the low nutrient content. A suitable programme for up-grading the nutrient content of fertilisers issued from the super-phosphate factories was necessary. The Ministries of Petroleum and Chemicals and Agriculture should closely examine the working of the factories and initiate corrective action to increase the percentage utilisation of indigenous production capacity.

It would be better for all fertiliser plants to produce complex/compound fertilisers of required grades. The unit or units for production of basic phosphate nutrient for incorporation in the production of the FCI factories which were producing only urea should be expeditiously constructed to enable the FCI units to market suitable complex granulated fertilisers. Arrangements to utilise saladipura pyrites and Rajasthan rock phosphate should be speeded up and the Rajasthan complex of phosphate ingredients should be put into operation not later than in 1975-76.

Referring to the extension and sales promotion activities proposed to be taken up by fertiliser producers in the country, the NCA recommended that the Ministry of Agriculture with the cooperation of the State Governments should fill up only the gaps in the fertiliser promotion programmes in the country.

Much more was required to be done in the provision of soil analysis service to ensure that fertiliser application was based on proper soil analysis. The Ministry of Agriculture should organise a Centrally Sponsored programme for the extension of soil analysis services in the States in the interest of promoting large scale adoption of balanced fertiliser application based on systematic programme of soil analysis.

The NCA discussed in detail the arrangements for retail distribution of fertilisers, including its storage, transport, distribution margins, etc. It referred to the difficulties of small and marginal farmers to obtain credit for the purchase of fertilisers and recommended that the norms of lending in terms of requirements per acre of credit and rate of interest should be changed in order that the small farmers may be helped to afford the increased outlay needed for intensive agriculture. Means had to be found to ensure that a substantial portion of the credit for fertilisers went to the small farmers and marginal farmers to meet their requirements [NCA, 1971, Pp. (i)-(v), 1-13].

*Committee on Fertilisers Distribution, 1972*

There were pressures on the domestic producers, directly and indirectly, to hand over an increasing proportion of domestic production to cooperatives and other Government agencies. Some State Governments started to actively support the institutional agencies in acquiring additional share of domestic production. State Governments took the stand that to control malpractices and to ensure equitable distribution of fertilisers, cooperatives should distribute a larger share of the material. The Government of India appointed a Committee in 1972 to examine the question. The Committee suggested that the share of cooperative and public agencies might not be less than 50 per cent and may range up to 75 per cent; the exact percentage above 50 to be decided by negotiations between the manufacturers and State/cooperatives. Where the percentage share of these agencies was already more than 50, it should not be reduced. These recommendations would not apply to the existing agreements between the manufacturers and their dealers and approved by the Government. The Committee recommended enhanced distribution margins for the sale of urea at the farm level. The suggestions of the Committee would enhance the margins from Rs 80.00 per tonne to Rs 95.00 per tonne. The Committee recommended that the enhanced margin would apply only if Government increased the selling price correspondingly. It also recommended the setting up of a tripartite monitoring cell to resolve differences between marketeers and institutional agencies over shareouts and margins [Qureshi, 1972, Pp. 43-45].

The targets of consumption laid down for the Fourth Plan did not materialise partly due to shortfalls in production and imports, but also due to factors like unfavourable weather conditions in certain States, lacunae in distribution of fertilisers, and non-availability of certain types of fertiliser products. Government took a number of measures to encourage the consumption of fertilisers. In 1972-73, an Emergency Agricultural Production Programme for increasing the production of Rabi/Summer crops was introduced requiring a strong support in terms of fertiliser supplies. The ICAR circulated special recommendations regarding application of fertilisers which could help to achieve best results from smaller quantities. The entire distribution system pertaining to imported and indigenously produced fertilisers was regulated to ensure that available fertilisers were distributed for priority crops and areas as specified by the State Governments. Orders were issued under the Essential Commodities Act requiring each manufacturer to deliver the specified quantities of fertilisers to specified States. To avoid long and difficult haulage and cross-movements of fertilisers, a rationalised coordinated supply plan for the distribution of imported and domestically manufactured fertilisers was enforced. Bulk import in unbagged form, even of Hygroscopic fertilisers like urea was started. Short-term loans were provided to the State Governments by the Ministry of Agriculture for the purpose of stocking and distribution of fertilisers and other inputs. Nationalised banks also provided credit for direct and indirect financing of distribution and use of fertilisers.

To popularise and encourage the balanced use of fertilisers, a Fertiliser Promotion Scheme involving an outlay of Rs 2.19 crore was sanctioned for 1972-73 and 1973-74. A beginning was made during 1972-73 in 26 districts selected in 17 States. 31 existing soil testing laboratories were selected for strengthening. 32 mobile Soil Testing Laboratories were manufactured during 1972-73 and 28 of them supplied to different States. Regional Workshops on Soil Testing,

Quality Control and Fertiliser Promotion were held at different centres [Ministry of Agriculture, 1973, Pp. 38-40].

The 1973-74 weather and rainfall conditions were favourable and demand for fertilisers increased but supply became difficult. Production was less than in the preceding year. In the world market, fertilisers became scarce and prices rose sharply. Prices of rock phosphate also increased considerably. Almost all foreign suppliers informed the Government of the possibility of reduced supplies because of cut-backs in their feed stock and energy resources. Raw materials for the indigenous fertiliser industry also became difficult to obtain. The shortages led to adulteration and over-charging. The Fertiliser (Control) Order 1957 was amended in July 1972 to control not only prices of fertilisers but also their quality and distribution. The State Governments were given powers under the Essential Commodities Act, 1955 to take necessary action to search, seizure and apprehension of offenders. In addition, since October 1972, the Fertiliser (Control) Order 1957 was declared as a Special Order under the Essential Commodities Act, thereby enabling the State Governments to undertake summary trials of the offenders.

A number of measures were taken to deal with the fertiliser shortages. Coordinated supply plans, covering both indigenous and imported fertilisers were worked out at zonal conferences attended by representatives of States and the manufacturers. Orders were promulgated under the Essential Commodities Act, 1955 making it obligatory on the domestic manufacturers to supply fertilisers to the States as committed by them in the zonal conferences. Efforts were made to make the most efficient use of available fertilisers, by concentrating on high-potential low-risk crops and areas and adopting the full package of other improved agricultural practices and elimination of waste. A massive campaign was organised for the production and utilisation of rural compost in the country. Availability of wagons for rail movement was maintained so as to avoid transport bottlenecks and to ensure quick distribution of fertilisers. The States were advised to prepare a careful inventory of the stocks available with them and to review the stock position frequently in order to ensure timely and equitable distribution of the available supplies.

Further, to secure equitable distribution of fertilisers in various States, and ensure that no unauthorised inter-State movement of fertilisers took place, the Fertiliser (Movement Control) Order, 1973 was promulgated on 25th April 1973 under Section 3 of the Essential Commodities Act, 1955. This Order banned all inter-State movement of fertilisers except when made by the manufacturers specified in the Schedule to the Order in accordance with the authorisation of the Central Government or the State Governments.

Finally, in June 1974, Government raised the retail selling prices of Urea, Ammonium Sulphate and Calcium Ammonium Nitrate by 50 to 200 per cent over those prevailing since October 1973 [Ministry of Agriculture, 1974, Pp. 32-36]. The increase was much larger than the increase in the cost of domestic production but was much less than the increase in the import prices. A Fertiliser Pool Equalisation Charge (FPEC) was therefore introduced whereby domestic manufacturers were required to pay a charge to help subsidise the high cost of imported fertilisers since 1973-74.

*Fifth Five Year Plan, 1974-79*

The Fifth Plan envisaged that by the end of 1978-79, the level of consumption would rise to 52 lakh tonnes of N, 18 lakh tonnes of $P_2O_5$ and 10 lakh tonnes of $K_2O$. This order of increase implied an annual compound growth rate of nearly 21.5 per cent in the case of N, 23.7 per cent in the case of $P_2O_5$ and about 19.5 per cent in the case of $K_2O$. The overall growth rate of NPK was to be 21.7 per cent per annum. Much greater promotional effort would have to be made by the public sector, the cooperative sector and the private sector for this purpose.

For promoting the balanced fertiliser use, substantial expansion of facilities of soil testing was envisaged. In 1973-74 there were 79 soil testing laboratories, each with a capacity of 20 to 30 thousand samples per year. There were another 40 small laboratories each with a capacity of 3 to 10 thousand samples per year. About 41 private soil testing laboratories also existed. Apart from strengthening of existing laboratories, and

improving their utilisation, another 150 soil testing laboratories were envisaged. Mobile soil testing laboratories were also proposed to be added.

To strengthen distribution it was proposed that every primary multi-purpose society, having a wholetime secretary, could operate a fertiliser retail depot. Strengthening of arrangements at the wholesale level was also proposed. In the Fifth Plan, it was estimated that transportation, port handling and coordinated allocation in respect of nearly 20 million tonnes of domestic and imported fertilisers would have to be organised by the Fertiliser Pool. Apart from development of adequate rail transport facilities, considerable expansion of port handling facilities would be essential. Increasing efforts would be made to switch over from part to bulk shipments for as many types of fertilisers as possible. Provision was made for installation of mechanised and semi-mechanised equipment for handling of bulk fertilisers at the concerned ports [Planning Commission, 1974, Vol. II, Pp. 12-13].

The consumption of fertilisers in 1974-75 (2.57 million tonnes) was below that in 1973-74 (2.84 million tonnes in 1973-74) partly because of adverse weather conditions but partly also because of increases in the retail prices of fertilisers in October 1973. The prices were increased once again on June 1, 1974 to offset to some extent the rising cost of fertilisers, both of the imported and indigenous varieties. But in order to reverse the trend in consumption, the prices were reduced on 18th July and 1st December 1975 and again on 16th March and on 20th April 1976 and once again on 8th February 1977. The Government also notified, for the first time, the maximum ex-factory prices in respect of urea, ammonium sulphate and (CAN) Calcium Ammonium Nitrate with effect from 2nd November 1976. They were per tonne Rs 625 for Ammonium Sulphate, Rs 1,245 for Urea and Rs 686 for Calcium Ammonium Nitrate (25 per cent N). The retail price of urea was reduced from Rs 1,650 per tonne to Rs 1,550 per tonne with effect from the 12th October, 1977.

A number of fiscal concessions were also given to reduce the cost of raw materials used by the domestic industry. These included reduction in the import duty on phosphoric acid from 45 per cent to 15 per cent and excise duty on single superphosphate from 15 per cent to 7-1/2 per cent, grant of subsidy on production of phosphatic fertilisers to the extent of Rs 1,250 per tonne of $P_2O_5$ and reduction in the prices of indigenous and imported rock-phosphate and imported sulphur [Ministry of Agriculture, 1976, Pp. 45-46]. The Government of India reduced the excise duty on Triple Superphosphate produced indigenously from 15 per cent to 7-1/2 per cent with a view to giving an impetus to the consumption of phosphatic fertilisers [Ministry of Agriculture, 1978, p. 58].

An Intensive Fertiliser Promotion Campaign was launched in selected districts where the level of fertiliser consumption was low though with high potential because of irrigation or assured rainfall. Other measures included: (i) allotment of urea to single superphosphate manufacturers as well as to Indian Potash Ltd., to give nitrogen support to single superphosphate and potash, (ii) authorising the State Governments to reallot the imported fertilisers to private dealers, (iii) grant of subsidy on phosphatic fertilisers to the manufacturers, (iv) maintaining buffer stocks at more than 500 centres in the country and (v) increasing the number of retail points in the country [Ministry of Agriculture, 1977, Pp. 47-48].

The Government of India provided an annual sum for grant of short-term loans to the State Governments for the purpose of stocking and distribution of fertilisers and other inputs.

*Retention Prices*

In the meanwhile, following the steep rise in the cost of feed stocks and other inputs, as well as investment in new plants, the cost of domestic fertilisers increased sharply. Therefore, in 1975, the Government set up a Committee to study the basis for pricing of fertilisers and to recommend a pricing policy that would ensure a fair return on investment on a sound basis. The Committee submitted its report in two parts, Part I in May 1977 and Part II in early 1979.

One of the term of reference of the Committee was 'to examine the cost of feed stock and other major inputs at different fertiliser factories and

suggest whether the prices of feed stocks and inputs need to be rationalised'. The two major inputs for fertilisers production were stock and utilities. The cost impact of both these inputs varies greatly from one unit to another and in some cases on account of technology used, there was a trade off between the cost of feed stocks and those of utilities. Further, as between fertiliser units using different feed stocks, and also units using the same feed stock, there were very wide variations. Thus, in the middle of 1976, the cost of raw materials and utilities for the two coal based plants ranged between Rs 355 and Rs 422 per tonne; for the fuel-oil based plants at about Rs 625 per tonne; and for the naphtha based urea plants, costs varied between Rs 449 and Rs 997 per tonne. These costs reflected the difference in technology as well as the variations in the delivered prices of feed stocks to units at different locations.

Restructuring the prices of the four feed stocks, viz. naphtha, fuel oil, gas and coal, would not make any significant contribution to the problem of evolving a more uniform cost structure for the industry as a whole on account of several reasons: (i) the differences in the total costs of production, including a reasonable margin of profit arose not only from variations in the costs of feed stock but also from other elements of costs such as utilities, depreciation, manpower costs and overheads; (ii) the relative cheapness of the feedstock in coal-based plants was more than offset by the larger initial investment and risks and uncertainties involved in using a relatively untried technology; (iii) even if the prices of gas, naphtha and fuel oil were restructured at more or less uniform levels, the problem of cost differential between units would remain because of the differences in technology used in the different plants established at different periods of time; (iv) naphtha, fuel oil and gas were used for steam generation and restructuring of their prices affecting utilities costs would vary considerably from one unit to another, depending upon the energy system in use; and (v) minimising the cost variations due to feed stock, would exclude a substantial segment of costs including depreciation, manpower costs and the return element which were subject to very wide variations. Further, adjustments in the relative pricing of fertiliser feed stock could not be considered in isolation of the overall petroleum products pricing policy. The Committee, therefore, concluded that while *inter se* adjustments in the prices of naphtha, fuel oil and gas could perhaps be possible, the extent to which such adjustments would reduce the need for differentiated retention prices was rather limited.

The determination of fair prices for fertilisers based on attainable norms of consumption of feed stocks and reasonable high level of utilisation of capacity (at about 80 per cent), together with the common norms for other major items such as capital costs per unit of output, labour and overhead costs, replacement and repairs or selling and distribution, was also not practicable as the number of variables was large. Again it was not possible to fix prices on the basis of average costs of relatively more efficient firms accounting for at least two-thirds of output, as a large number of plants would run at a loss. Altogether, the Committee felt that the application of a single ex-factory price based on weighted average of cost of lower cost producers would tend to benefit some units and work to the detriment of other units in the industry. There was, therefore, clearly a need for some arrangement for the pooling of ex-factory prices together with separate retention prices for different units or groups of units. Even otherwise, a system of pooling would be necessary so long as imports of fertilizers continued and their prices were different from the domestic prices.

The Committee was required to suggest 'with due regard to the feed stock used, vintage of plants, and other constraints to production, the retention prices for different units in operation and those likely to be commissioned during the Fifth Plan period which would give the requisite rate of return and also recommend a scheme of pooling for the operation of the retention price concept'. Accordingly, the Committee worked out, on the basis of capacity utilisation of 80 per cent and corresponding consumption norms of feed stocks and utilities, and often providing for a return of 12 per cent post-tax on net worth, the fair ex-factory works realisation (i.e., retention price) for each of the production units, including those under construction. The prices ranged between Rs 948 and Rs 2,261 per tonne of nitrogenous fertilisers for the different factories. (It may be mentioned that nitrogenous fertiliser

production constituted nearly 80 per cent of domestic production).

However, the Committee was of the opinion that the system of individual unit wise retention prices suffered from serious limitations and disadvantages: Any unit wise estimates of fair ex-factory prices involved a number of judgements and assumptions which would make the prices unrealistic and would affect the profitability and commercial viability of the units. Further, over a period of time, the system would tend to create a vested interest in 'proving' costs rather than in reducing them. From the point of view of the community, it was clearly desirable to have, as far as possible, uniform product price for all producers. In cases where, as in fertilisers, such a course was not feasible because of certain special considerations, it was necessary to explore other alternatives, such as limited number of groups instead of unitwise differentiated retention prices. The Committee therefore grouped the existing units and those under construction into (a) gas reforming, (b) naphtha reforming, pre-1974 and post-1974, (c) partial oxidisation of naphtha, (d) electrolysis-cum-fuel oil process, (e) coal gasification, and (f) fuel oil based and fixed prices for each group separately. These ranged between Rs 1,017 and Rs 2,120 per tonne for nitrogenous fertilisers. The Committee stressed that the calculations of the retention prices should not be interpreted as a plea for upward revision of retail prices of fertilisers. The prices at which fertilisers were to be made available to farmers should be based on wider considerations like price policy for agricultural products and popularising of fertiliser use [Marathe, 1977, Part I, Pp 76-98].

However, the Government preferred unit wise prices and, with effect from November 1977, introduced retention prices for nitrogenous fertilisers for each individual factory separately. The scheme was later extended to phosphatic and other fertilisers. Under the scheme, the consumer prices of fertilisers were fixed by the Department of Agriculture under the provisions of the Essential Commodities Act, 1948. The difference between the retention price and the net realisation by a manufacturing unit was paid as subsidy under the 'Retention Price and Subsidy Scheme'. The retention prices were fixed product-wise and plant-wise in respect of nitrogenous and complex fertilisers. Pre-tax return of 25.26 per cent on net worth corresponding to post-tax return of 12 per cent was given as a part of the retention price after covering all elements of cost on the basis of a combination of actuals and norms. In respect of single super-phosphate (SSP) units, the cost of production was divided into variable cost and fixed charges. Consumption norms for major raw materials, namely sulpher and rock phosphate were fixed industry-wise. Pre-tax return of 23.4 per cent on net worth corresponding to 11 per cent post-tax return was given for SSP units. In addition to retention price subsidy, freight subsidy was paid to fertiliser manufacturers to cover the cost of transportation from production points and consuming centres.

With effect from February 1, 1979, Government revised the retention prices for units in the nitrogenous fertiliser industry mentioned above and also introduced the system of retention prices for complex phosphate fertilisers and triple superphosphate, under which the manufacturers were allowed a price support equal to the difference between their ex-factory retention price and their current ex-factory price (without subsidy) and the fertilisers were brought under statutory price control. The scheme of uniform price support of Rs 1,250 per tonne of $P_2O_5$ introduced in March 1976 was confined to single superphosphate only [Ministry of Agriculture, 1979, p. 6].

A Fertiliser Industry Coordination Committee was set up under the Department of Chemicals & Fertilisers to administer and operate the system of retention prices for fertilisers. The Committee was expected to undertake cost investigation for purpose of fixing retention prices as also technical investigations of the fertilisers plants with a view to improving their operational efficiency.

*Sixth Plan 1980-85*

Again because of a change in Government, a new Sixth Plan for the period (1980-85) was drawn up. The objectives for fertiliser use were (a) to have equitable and efficient fertiliser distribution system in the country accompanied with a proper infrastructural and organisational

support; (b) to reduce regional disparities in fertiliser consumption; (c) to ensure that benefits of fertiliser use were received by all sectors of the farming community, especially the small and marginal farmers; and (d) to promote integrated nutrient supply system by better and increased mobilisation of organic and bio-fertiliser resources in order to supplement and optimise use of chemical fertilisers as also to maximise efficiency of fertiliser use.

The consumption of fertilisers was nearly 5.3 million tonnes in 1979-80. Weather conditions being favourable, consumption of fertilisers was likely to go up further during the Plan period. A large percentage of nitrogen applied to low land paddy fields got lost through denitrification, volatilisation and leaching. Losses also occurred in respect of upland crops like wheat. There was therefore need for improving the efficiency of fertiliser use.

There were differences in per hectare consumption in different States, ranging from 2.04 kg. in Assam to 108.5 kg. in Punjab with the average for the country being about 31.5 kg. (nutrient) in 1979-80. Further, fertiliser consumption continued to be concentrated in about 60 districts (out of total of 405), which account for about 50 per cent of the overall fertiliser consumption.

One of the reasons for these differences was the fact that retail outlets tended to cluster around rail-heads since fertilisers were hitherto supplied to distributors on F.O.R. rail-head destination basis. Hence, the Government introduced a scheme to meet the cost of transportation of fertilisers from all the rail heads up to all block headquarters in the country. The scheme, when implemented, would make fertilisers adequately available in all blocks.

In order to cope up with the movement of fertiliser material, port handling capacity was to be increased considerably through high speed mechanical unloading plants, port storage, portable bagging machines, etc. The irreversible trend towards rail movement in block rakes to single point destinations called for suitable infrastructural arrangements like sidings, platforms, storage space, etc., at identified nodal centres from where further distribution by road could take place. Movement of fertilisers in bulk from ports and plants for subsequent bagging near consumption centres was to receive further emphasis. Improvement of the distribution system would involve opening of additional storage depots in the states, increasing retail sale points in the interior, introducing multi-agency competitive distribution system and making arrangements for adequate supply of credit to farmers for purchasing fertilisers. A good monitoring system would also be necessary to ensure timely and adequate availability of fertilisers in all parts of the country.

Extension support for guiding the farmers in the proper use of fertilisers so as to achieve maximum benefits would be further expanded. Besides, greater attention was to be given to popularisation of fertilisers in non-conventional unirrigated areas presently under the dry farming system where fertiliser use was almost negligible.

The consumption of fertilisers was expected to go up from 5.3 million tonnes in terms of nutrients in 1979-80 to 9.6 million tonnes by the end of the Sixth Plan (later lowered to 8.4 million tonnes). This would call for necessary investment in the fertiliser sector [Planning Commission, 1981, p. 106].

### *Report of the Committee to Review the Fertiliser (Control) Order 1957, 1982*

Government had appointed a Committee in August 1978 to make an overall review of the Fertiliser (Control) Order 1957. The Committee observed that since the introduction of the Fertiliser (Control) Order, 1957, considerable developments in technical and distribution aspects of fertilisers had taken place. In order to tackle the situations as had risen, suitable amendments were issued. So far, 63 amendments had been issued to the Fertiliser (Control) Order. Inspite of these amendments, deficiencies were pointed out by various State Governments. The Committee examined in depth the various clauses of the Order and gave their recommendations for amendments wherever felt necessary. The Committee recommended amendments to the definition of fertilisers in the Order to include a mixture of fertilisers and special mixture of fertilisers. In the Schedule I, specifying the types of fertilisers, liquid fertilisers were also to be included. Further,

all the micro-nutrients should be brought within the purview of the Fertiliser Control Order, and a list of all 16 trace elements added to Schedule I. Any substance which contained micronutrients and other substance, including N, P, and K should be categorised as a mixture of fertilisers. The Committee recommended revision of the definitions of retailers and wholesalers, including their registration, stocking, port handling and distribution [Vidyarthy, 1982, Pp. 1-4].

*Reports on Quality Control Arrangements of Fertilisers in States, February 1984*

In 1983, the Government constituted two survey teams to report on the quality control arrangements of fertilisers. It was decided that each team would study five States. The States of Maharashtra, Gujarat, Uttar Pradesh, Rajasthan and Haryana were assigned to one team, while the second team was assigned the States of Andhra Pradesh, Karnataka, Tamil Nadu, Bihar and West Bengal. The terms of reference of the teams were to make an assessment of the quality control status in the States and make suggestions for improvement of the same.

The Teams found that there was no uniform system of giving authority, under the Fertiliser Control Order, to State functionaries by the State Governments. The level of authority for granting licence for mixing manufacturing units and Dealership Registration Certificate varied from State to State. There was no uniform cadre of quality control enforcement officials in the States, nor had the number of inspectors any relationship with the number of dealers. The condition of the laboratory facilities, their staff strength varied greatly from State to State. The Survey Teams found that about one-third of the samples of different fertilisers got analysed by them were non-standard in quality, the NPK mixture samples having the largest number of non-standard samples (60.71%). Cases were noticed where granulated single superphosphate was being sold as DAP (Di Ammonium Phosphate). Similarly, gypsum granules were found to be sold as high analysis NPK complex. The analysis gave an indication of the quality of fertilisers being sold to the farmers.

The Survey Teams made recommendations for the strengthening of the enforcement machinery together with further powers included in the Fertiliser Control Order (FCO), monitoring and coordination committees to be set up in the States, establishment of regional laboratories, regulation of soil analysis and reclamation of soils through the FCO, prosecution of offenders and punishment, suspension of licenses for sale of fertilisers, etc. [Department of Agriculture and Cooperation, 1984, Pp. 5-7].

During the Sixth Plan, consumption of fertilisers fluctuated from year to year. Adverse weather conditions during the first three years of the Sixth Plan (1980-81 - 1982-83) restricted the growth of fertiliser consumption despite the extension of the Fertiliser Promotion Campaign to over 100 districts in the country by 1982-83. Two successive hikes in retail prices of fertilisers announced by the Government - first by 38 per cent from 8the June, 1980 and again by another 17.5 per cent from 11th July, 1981 also inhibited consumption. Government took a number of measures to counteract the adverse effect of price increase. The Agricultural Prices Commission was asked to take the increased prices of fertilisers into consideration while working out the support/procurement prices of agricultural commodities. The question of credit was taken up with the Reserve Bank of India. As a result the cash-credit limits of pool handling agencies and institutional agencies were stepped up. RBI also instructed the cooperative banks to revise the scale of finance for purchase of fertilisers. The distribution margin for fertilisers was increased by about 22 per cent from 15th August, 1981 [Ministry of Agriculture, 1982, p. 21].

Production of fertilisers had increased by over 3 million tonnes (N + P) in 1982-83 as compared to 1981-82. Consumption had increased by only 2.69 lakh tonnes for these two fertilisers. By the end of the 1982-83 season, therefore, there was a glut of fertilisers in the country. Government took a number of steps during 1983-84. The prices of fertilisers were reduced by about 7.5 per cent with effect from 29th June 1983. In addition, a special rebate of 10 per cent was allowed on the prices of standard stocks of imported fertilisers of urea and DAP lying with the Food Corporation of India for

more than two years. For the first time, Agricultural Inputs Fortnights were organised as a part of the production campaign throughout the country in both kharif and rabi seasons. The distributive margins available to the cooperatives and other institutional agencies on the sale of fertilisers were raised. The Intensive Fertiliser Promotion Campaign taken up in the previous year in 104 selected districts was implemented vigorously. The crash programme, mounted in the Productivity Year 1982, of opening additional fertiliser sale points to ensure easy availability even in the interior areas, was further intensified. The fertiliser supply position was closely monitored with a view to ensuring timely supplies of the required quantities in various States.

With the object of supplying fertilisers at uniform prices to the cultivators throughout the country, the prices of fertilisers were controlled under the Fertiliser (Control) Order 1957. Two types of fertilisers, namely, Ammonium Sulphate (AS) and CAN, were brought out of statutory price control and the Retention Price Scheme w.e.f. 8th June, 1980. It was felt at that these fertilisers, used mainly for cash crops, were capable of sustaining prices at higher rates in the market and the manufacturers should be able to get reasonable return on their investment. However, the prices of AS and CAN started increasing and an effort was made to bring them under informal price control. The informal price control could not be maintained due to increase in the prices of inputs. At the same time, the demand for the two fertilisers declined due to higher prices particularly because, while the main nitrogenous fertilisers, namely, urea, was under statutory price control and its manufacturers were getting the retention price-subsidy benefits, the above two fertilisers were kept out of the scheme and a big gap arose between the unit price of urea and these fertilisers. It was, therefore, felt necessary to reintroduce the statutory price control and bring the above two fertilisers under the Retention Price Scheme in order to ensure that the capital invested in the plants, many of which were in the Public Sector, did not remain unutilised. A decision was taken accordingly and implemented w.e.f. 21st August, 1984. As these two fertilisers contained smaller portion of nutrient content compared to urea, the Block Delivery Scheme applicable to the latter was not made applicable to them [Ministry of Agriculture, 1985, Pp. 37-38].

Effective from 23rd May 1982, the uniform subsidy of Rs 1,250 per tonne of $P_2O_5$ paid on Single Super Phosphate was replaced by a differential level of subsidy. The new scheme of subsidy was based on a combination of norms and actuals in respect of the costs of various elements, to ensure an equitable treatment to all the manufacturers. Single Super Phosphate was also brought under statutory price control and a uniform price of Single Super Phosphate was fixed for the entire country in place of the varying prices in force before 23rd May 1982 [Ministry of Agriculture, 1983, p. 7].

As during the Fifth Plan period, short-term loans were sanctioned every year to the State Governments for purchase and distribution of inputs including fertilisers. The quantum of short-term loans stood at Rs 200 crore each in 1980-81 and 1981-82, Rs 250 crore in 1982-83, Rs 260 crore in 1983-84 and 1984-85.

The number of fertiliser units in the country increased from 87 in 1980-81 to 107 by 1984-85, comprising 41 manufacturing units for nitrogenous fertilisers and 66 units for phosphatic fertilisers. The capacity of the industry increased from 5.9 million tonnes to 7.4 million tonnes during the same period. The total production capacity of the plants in operation and those under construction were expected to be 72.2 lakh tonnes of Nitrogen and 27.3 lakh tonnes of $P_2O_5$ by 1987-88. The capacity utilisation of the industry had also improved during the Sixth Plan period from 47.19 per cent in 1980- 81 to 70.05 per cent in 1984-85 for Nitrogen and from 63.31 per cent to 74.55 per cent for Phosphatic Fertilisers. As a result, production increased from 21.64 million tonnes to 39.17 million tonnes for Nitrogen and 0.84 million tonnes to 1.32 million tonnes for $P_2O_5$ during the same period. The overall capacity utilisation of the fertiliser industry was however, still below the standard of 80 per cent because of the low performance of certain plants which continued to face inherent constraints [Ministry of Chemicals and Fertilisers, 1985, p. 9].

*Seventh Five Year Plan, 1985-90*

The target of fertiliser consumption contem-

plated for the Seventh Plan was in the range of 13.5-14.0 million tonnes of nutrients. To achieve this target, the strategy was to strengthen fertiliser distribution and handling arrangements at ports, enforcing quality control by increasing the number of samples to be tested and promoting measures necessary for the efficient use of fertilisers. One of the major goals was to increase fertiliser consumption in rainfed areas. The programmes taken up in the Sixth Plan period were also to be continued [Planning Commission, 1985, Pp. 14-15].

Fertiliser consumption had increased from 69,000 nutrients at the beginning of the First Plan to nearly 5.3 million tonnes in 1979-80. This had however led to an increase in the burden of subsidy on the one hand and higher import bill on the other. The prices of imported as well as indigenously produced fertilisers continued to be subsidised. With the growth in imports and domestic production, the quantum of fertiliser subsidy had increased from Rs 375 crore in 1981-82 to about Rs 1,800 crore in 1984-85. Though, it was necessary to provide sufficient incentives for domestic production and for the off-take of fertilisers, the strain on budgetary resources of the rapidly increasing quantum of subsidy could not be overlooked. The entire structure of fertiliser pricing and subsidy, therefore, required to be reviewed. In the long run, the farmer would be able to bear a larger portion of the real cost only if efficiency in the application of fertilisers went up and resulted in increase of output and income of the farmer. All these aspects required detailed examination and study [Planning Commission, 1985, Pp. 183-185].

The rainfed areas which constitute 70 per cent of the cultivated area consumed only about 20 per cent of the total fertilisers. Efforts were made during the Seventh Plan period to increase the consumption of fertilisers in these areas. Accordingly, the government sanctioned a National Project and Development of Fertiliser Use in Low Consumption Rainfed Areas in 60 identified districts in 16 States. The project provided for (i) opening of 200 additional retail outlets in each of the selected districts, (ii) laying out 10 field block demonstrations in each district, (iii) 10 farmers training programmes, and (iv) opening of 20 additional soil testing laboratories in Madhya Pradesh, Maharashtra and Rajasthan.

Government continued its policy of the retention price scheme for imported and indigenously produced fertilisers. It also continued the payment of subsidy for the difference between the expenditure incurred on the imported fertilisers and the net realisation at the statutorily notified prices by the Department of Agriculture. The subsidy paid by the government on imported and indigenous fertilisers during 1985-90 is shown in Table 30.

TABLE 30. SUBSIDY ON SALE OF FERTILISERS
(Rs crore)

| | Subsidy on Fertilisers | | |
|---|---|---|---|
| Year | Imported | Indigenous | Total |
| 1985-86 | 323 | 1,600 | 1,923 |
| 1986-87 | 197 | 1,700 | 1,897 |
| 1987-88 | 114 | 2,050 | 2,164 |
| 1988-89 | 200 | 3,000 | 3,200 |
| 1989-90(RE) | 830 | 3,771 | 4,601 |

Source: (i) *Economic Survey, 1989-90*, Government of India, p. 27.
(ii) *Annual Report, 1989-90*, Department of Fertilisers, Ministry of Agriculture, Government of India, p. 31.

In July 1991, at the time of Budget 1991-92, Government announced a reduction in fertiliser subsidies. Low analysis fertilisers such as calcium ammonium nitrate, ammonium chloride, ammonium sulphate and sulphate of potash were to be freed from price and movement controls. An increase of 40 per cent, on an average, was announced in the price of all other fertilisers. In addition, in respect of single super phosphate, a ceiling was imposed on the subsidy per tonne payable to producers so as to move towards deregulation in the ensuing years. Following widespread discontent against reduction in subsidies, the prices of fertilisers were increased by 30 per cent (instead of 40 per cent) in August 1991. Further, small and marginal farmers were exempted from this increase in prices. The revised prices announced were as in Table 31.

TABLE 31. MAXIMUM SELLING PRICES OF FERTILISERS*

(Rs per tonne)

| Fertiliser | Revised Price (August 1991) | Previous Price |
|---|---|---|
| Urea (46%N) | 3,060 | 2,350 |
| Muriate of potash (60%) | 1,700 | 1,300 |
| Di-ammonium phosphate (18:46:0) | 4,680 | 3,600 |
| NPK (17:17:17) | 3,380 | 2,600 |
| NPK (15:15:15) | 3,740 | 3,100 |
| NPK (19:19:19) | 3,840 | 2,950 |
| Ammonium phosphate sulphate (16:20:0) | 3.380 | 2.600 |
| Nitro-phosphate (20:20:0) | 3,120 | 2,400 |
| Nitro-phosphate (23:23:0) | 3,800 | 2,930 |
| Ammonium phosphate sulphate (16:20:0) | 300 | 2,300 |
| Urea ammonium sulphate (24:24:0) | 3,960 | 3,050 |
| Urea ammonium phosphate (28:28:0) | 4,680 | 3,600 |
| NPK (14:28:14) | 3,960 | 3,050 |
| NPK (14:35:14) | 4,420 | 3,400 |
| NPK (10:26:26) | 3,840 | 2,950 |
| Triple super phosphate (granular) | 3,380 | 2,600 |
| NPK (12:32:16) | 4,220 | 3,250 |
| Triple super phosphate (powder) | 3,120 | 2,400 |
| Single super phosphate | 1,080 | 820 |
| Single super phosphate | 1,240 | 950 |
| Single super phosphate (granular) | 1,440 | 1,100 |
| Anhydrous ammonia | 4.900 | 3,770 |

* Exclusive of sales tax and other local taxes.
Source: Business Standard, August 15, 1991 p 4.

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STATEMENT I. CONSUMPTION, PRODUCTION AND IMPORTS OF CHEMICAL FERTILISERS

(lakh tonnes)

| Year | Consumption | Production | Imports | | Year | Consumption | Production | Imports | |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1950-51 | 0.69 | 0.21 | 0.77 | | 1970-71 | 21.77 | 10.60 | 6.29 | |
| 1951-52 | 0.66 | 0.39 | 0.52 | | 1971-72 | 26.57 | 12.40 | 9.97 | |
| 1952-53 | 0.66 | 0.61 | 0.47 | | 1972-73 | 27.68 | 13.85 | 11.95 | |
| 1953-54 | 1.05 | 0.67 | 0.26 | | 1973-74 | 28.39 | 13.74 | 12.42 | |
| 1954-55 | 1.21 | 0.83 | 0.31 | | 1974-75 | 25.73 | 15.17 | 16.07 | |
| 1955-56 | 1.31 | 0.89 | 0.63 | | 1975-76 | 28.94 | 18.55 | 16.35 | |
| 1956-57 | 1.54 | 0.96 | 0.72 | | 1976-77 | 34.11 | 23.74 | 10.51 | |
| 1957-58 | 1.84 | 1.07 | 1.23 | | 1977-78 | 42.86 | 26.76 | 15.21 | |
| 1958-59 | 2.24 | 1.12 | 1.19 | | 1978-79 | 51.17 | 29.50 | 19.94 | |
| 1959-60 | 3.05 | 1.35 | 1.79 | | 1979-80 | 52.55 | 29.87 | 20.05 | |
| 1960-61 | 2.92 | 1.50 | 4.19 | | 1980-81 | 55.16 | 30.05 | 27.59 | |
| 1961-62 | 3.38 | 2.20 | 3.82 | | 1981-82 | 60.64 | 40.93 | 20.41 | |
| 1962-63 | 4.52 | 2.83 | 2.95 | | 1982-83 | 63.88 | 44.04 | 11.32 | |
| 1963-64 | 5.44 | 3.27 | 2.81 | | 1983-84 | 77.10 | 45.33 | 13.55 | |
| 1964-65 | 7.73 | 3.74 | 3.01 | | 1984-85 | 82.11 | 51.80 | 36.24 | |
| 1965-66 | 7.85 | 3.57 | 4.13 | | 1985-86 | 84.74 | 57.56 | 33.99 | |
| 1966-67 | 11.01 | 4.55 | 8.98 | | 1986-87 | 86.45 | 70.70 | 23.08 | |
| 1967-68 | 15.39 | 6.10 | 14.86 | | 1987-88 | 87.84 | 71.31 | 9.84 | |
| 1968-69 | 17.61 | 7.76 | 11.95 | | 1988-89 | 110.34 | 89.64 | 16.08 | |
| 1969-70 | 19.82 | 9.54 | 8.81 | | 1989-90 | 124.30 | 86.00 | 34.42 | |

Source: as in the detailed Statements.

STATEMENT II. CONSUMPTION OF CHEMICAL FERTILISERS

(lakh tonnes)

| Year | N | P | K | Total | Year | N | P | K | Total |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1950-51 | 0.55 | 0.08 | 0.06 | 0.69 | 1970-71 | 14.87 | 4.62 | 2.28 | 21.77 |
| 1951-52 | 0.59 | 0.07 | 0.00 | 0.66 | 1971-72 | 17.98 | 5.58 | 3.01 | 26.57 |
| 1952-53 | 0.58 | 0.05 | 0.03 | 0.66 | 1972-73 | 18.39 | 5.81 | 3.48 | 27.68 |
| 1953-54 | 0.89 | 0.08 | 0.08 | 1.05 | 1973-74 | 18.29 | 6.50 | 3.60 | 28.39 |
| 1954-55 | 0.95 | 0.15 | 0.11 | 1.21 | 1974-75 | 17.66 | 4.72 | 3.36 | 25.73 |
| 1955-56 | 1.08 | 0.13 | 0.10 | 1.31 | 1975-76 | 21.49 | 4.67 | 2.78 | 28.94 |
| 1956-57 | 1.23 | 0.16 | 0.15 | 1.54 | 1976-77 | 24.57 | 6.35 | 3.19 | 34.11 |
| 1957-58 | 1.49 | 0.22 | 0.13 | 1.84 | 1977-78 | 29.13 | 8.67 | 5.06 | 42.86 |
| 1958-59 | 1.72 | 0.30 | 0.22 | 2.24 | 1978-79 | 34.20 | 11.06 | 5.91 | 51.17 |
| 1959-60 | 2.29 | 0.54 | 0.21 | 3.05 | 1979-80 | 34.98 | 11.51 | 6.06 | 52.55 |
| 1960-61 | 2.10 | 0.53 | 0.29 | 2.92 | 1980-81 | 36.78 | 12.14 | 6.24 | 55.16 |
| 1961-62 | 2.50 | 0.61 | 0.28 | 3.38 | 1981-82 | 40.69 | 13.22 | 6.73 | 60.64 |
| 1962-63 | 3.33 | 0.83 | 0.36 | 4.52 | 1982-83 | 42.24 | 14.37 | 7.27 | 63.88 |
| 1963-64 | 3.76 | 1.17 | 0.51 | 5.44 | 1983-84 | 52.05 | 17.30 | 7.75 | 77.10 |
| 1964-65 | 5.55 | 1.49 | 0.69 | 7.73 | 1984-85 | 54.86 | 18.86 | 8.39 | 82.11 |
| 1965-66 | 5.75 | 1.33 | 0.77 | 7.85 | 1985-86 | 56.61 | 20.05 | 8.08 | 84.74 |
| 1966-67 | 7.38 | 2.49 | 1.14 | 11.01 | 1986-87 | 57.16 | 20.79 | 8.50 | 86.45 |
| 1967-68 | 10.35 | 3.35 | 1.69 | 15.39 | 1987-88 | 57.17 | 21.87 | 8.80 | 87.84 |
| 1968-69 | 12.09 | 3.82 | 1.70 | 17.61 | 1988-89 | 72.46 | 27.22 | 10.66 | 110.34 |
| 1969-70 | 13.56 | 4.16 | 2.10 | 19.82 | 1989-90(E) | 79.00 | 33.10 | 12.20 | 124.30 |

(E) Estimated

Sources: (i) *Agricultural Statistics at a Glance*, Directorate of Economics and (ii) Statistics, Ministry of Agriculture, Government of India, p. 81.

*Annual Report, 1989-90*, Department of Fertilisers, Ministry of Agriculture, Government of India, p. 53.

(iii) *Economic Survey, 1989-90*, Government of India, New Delhi.

STATEMENT III. LICENSED CAPACITY AND PRODUCTION OF CHEMICAL FERTILISERS

(lakh tonnes)

| Year | Nitrogenous | | Phosphate | | Year | Nitrogenous | | Phosphate | |
|---|---|---|---|---|---|---|---|---|---|
| | Licensed capacity | Production | Licensed capacity | Production | | Licensed capacity | Production | Licensed capacity | Production |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1950-51 | 0.17 | 0.11 | 0.21 | 0.10 | 1970-71 | 13.49 | 8.30 | 4.34 | 2.29 |
| 1951-52 | 0.89 | 0.29 | 0.28 | 0.09 | 1971-72 | 15.15 | 9.49 | 5.32 | 2.90 |
| 1952-53 | 0.89 | 0.53 | 0.32 | 0.07 | 1972-73 | 14.71 | 10.55 | 5.03 | 3.30 |
| 1953-54 | 0.89 | 0.53 | 0.32 | 0.14 | 1973-74 | 19.36 | 10.50 | 5.34 | 3.25 |
| 1954-55 | 0.89 | 0.69 | 0.35 | 0.14 | 1974-75 | 21.62 | 11.86 | 6.66 | 3.31 |
| 1955-56 | 0.89 | 0.77 | 0.43 | 0.12 | 1975-76 | 26.25 | 15.35 | 7.38 | 3.20 |
| 1956-57 | 0.89 | 0.79 | 0.50 | 0.18 | 1976-77 | 30.24 | 19.00 | 9.28 | 4.74 |
| 1957-58 | 0.89 | 0.81 | 0.50 | 0.26 | 1977-78 | 30.69 | 20.14 | 11.93 | 6.62 |
| 1958-59 | 0.89 | 0.81 | 0.54 | 0.31 | 1978-79 | 32.95 | 21.80 | 12.79 | 7.70 |
| 1959-60 | 1.49 | 0.84 | 0.81 | 0.51 | 1979-80 | 39.02 | 22.26 | 13.10 | 7.57 |
| 1960-61 | 1.62 | 0.98 | 0.96 | 0.52 | 1980-81 | 43.58 | 21.64 | 13.34 | 8.41 |
| 1961-62 | 2.46 | 1.54 | 1.07 | 0.65 | 1981-82 | 47.36 | 31.44 | 13.86 | 9.49 |
| 1962-63 | 2.46 | 1.94 | 1.07 | 0.88 | 1982-83 | 51.79 | 34.24 | 15.12 | 9.80 |
| 1963-64 | 3.27 | 2.19 | 1.47 | 1.08 | 1983-84 | 52.01 | 34.85 | 16.23 | 10.48 |
| 1964-65 | 3.24 | 2.43 | 1.76 | 1.31 | 1984-85 | 52.01 | 39.17 | 16.32 | 12.63 |
| 1965-66 | 3.24 | 2.38 | 1.88 | 1.19 | 1985-86 | 59.24 | 43.28 | 17.74 | 14.28 |
| 1966-67 | 5.25 | 3.09 | 2.64 | 1.46 | 1986-87 | 67.62 | 54.10 | 23.18 | 16.60 |
| 1967-68 | 6.32 | 4.03 | 3.16 | 2.07 | 1987-88 | 70.84 | 54.66 | 24.70 | 16.65 |
| 1968-69 | 9.05 | 5.63 | 4.31 | 2.13 | 1988-89 | 81.48 | 67.12 | 27.50 | 22.52 |
| 1969-70 | 11.36 | 7.31 | 4.31 | 2.24 | 1989-90 | 81.48 | 68.00 | 27.50 | 18.00 |

Sources: (i) *Fertiliser Statistics*, The Fertiliser Association of India, New Delhi (various issues).
(ii) *Economic Survey, 1989-90*, Government of India, New Delhi (various issues).
(iii) *Annual Report, 1989-90*, Department of Fertilisers, Ministry of Agriculture, Government of India.

STATEMENT IV. IMPORTS OF CHEMICAL FERTILISERS

(lakh tonnes)

| Year | N | P | K | Total | Year | N | P | K | Total |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1950-51 | 0.07 | 0.60 | 0.10 | 0.77 | 1970-71 | 4.77 | 0.32 | 1.20 | 6.29 |
| 1951-52 | 0.29 | 0.15 | 0.08 | 0.52 | 1971-72 | 4.82 | 2.48 | 2.68 | 9.97 |
| 1952-53 | 0.44 | - | 0.03 | 0.47 | 1972-73 | 6.65 | 2.05 | 3.25 | 11.95 |
| 1953-54 | 0.19 | - | 0.07 | 0.26 | 1973-74 | 6.59 | 2.13 | 3.70 | 12.42 |
| 1954-55 | 0.20 | - | 0.11 | 0.31 | 1974-75 | 8.84 | 2.86 | 4.37 | 16.07 |
| 1955-56 | 0.53 | - | 0.10 | 0.63 | 1975-76 | 9.96 | 3.61 | 2.78 | 16.35 |
| 1956-57 | 0.57 | - | 0.15 | 0.72 | 1976-77 | 7.50 | 0.23 | 2.78 | 10.51 |
| 1957-58 | 1.10 | - | 0.13 | 1.23 | 1977-78 | 7.58 | 1.64 | 5.99 | 15.21 |
| 1958-59 | 0.97 | - | 0.22 | 1.19 | 1978-79 | 12.28 | 2.43 | 5.17 | 19.44 |
| 1959-60 | 1.42 | 0.04 | 0.33 | 1.79 | 1979-80 | 12.95 | 2.37 | 4.73 | 20.05 |
| 1960-61 | 3.99 | - | 0.20 | 4.19 | 1980-81 | 15.10 | 4.52 | 7.97 | 27.59 |
| 1961-62 | 3.07 | - | 0.75 | 3.82 | 1981-82 | 10.54 | 3.43 | 6.44 | 20.41 |
| 1962-63 | 2.44 | 0.10 | 0.41 | 2.95 | 1982-83 | 4.25 | 0.63 | 6.44 | 11.32 |
| 1963-64 | 2.28 | 0.13 | 0.40 | 2.81 | 1983-84 | 6.56 | 1.43 | 5.56 | 13.55 |
| 1964-65 | 2.32 | 0.12 | 0.57 | 3.01 | 1984-85 | 20.08 | 7.45 | 8.71 | 36.24 |
| 1965-66 | 3.26 | 0.14 | 0.73 | 4.13 | 1985-86 | 16.80 | 8.19 | 9.00 | 33.99 |
| 1966-67 | 6.32 | 1.48 | 1.18 | 8.98 | 1986-87 | 11.04 | 2.57 | 9.47 | 23.08 |
| 1967-68 | 8.67 | 3.49 | 2.70 | 14.86 | 1987-88 | 1.75 | - | 8.09 | 9.84 |
| 1968-69 | 8.44 | 1.39 | 2.13 | 11.95 | 1988-89 | 2.19 | 4.07 | 9.82 | 16.08 |
| 1969-70 | 6.67 | 0.94 | 1.20 | 8.81 | 1989-90 | - | - | - | 34.42 |

Sources: (i) *Fertiliser Statistics*, The Fertiliser Association of India, New Delhi (various issues). (ii) *Agricultural Statistics at a Glance*, Directorate of Economics and (iii) Statistics, Ministry of Agriculture, Government of India, New Delhi, p. 82. *Economic Survey, 1989-90*, Government of India, New Delhi, p. 27.

STATEMENT V. SUBSIDY PAID ON SALE OF CHEMICAL FERTILISERS

(Rs Crore)

| Year (1) | Indigenous (2) | Imported (3) | Total (4) |
|---|---|---|---|
| 1977-78 | 24.88 | nil | 24.88 |
| 1978-79 | 83.32 | 120.08 | 203.40 |
| 1979-80 | 296.28 | 280.80 | 577.08 |
| 1980-81 | 170.00 | 335.26 | 505.26 |
| 1981-82 | 275.00 | 100.00 | 375.00 |
| 1982-83 | 550.00 | 55.36 | 605.36 |
| 1983-84 | 900.00 | 141.83 | 1,041.83 |
| 1984-85 | 1,200.00 | 727.31 | 1,927.31 |
| 1985-86 | 1,600.00 | 323.71 | 1,923.71 |
| 1986-87 | 1,700.00 | 197.12 | 1,897.12 |
| 1987-88 | 2,050.00 | 114.20 | 2,164.20 |
| 1988-89 | 3,000.00 | 200.70 | 3,200.70 |
| 1989-90(RE) | 3,771.00 | 830.00 | 4,601.00 |

RE = Revised Estimate
Source: *Annual Report, 1989-90*, Department of Fertilisers, Ministry of agriculture, Government of India, p. 31.

# DISTRIBUTION OF LANDHOLDINGS IN INDIA: 1961-62 TO 1982

Ashok Rudra and Uttara Chakraborty

*The paper examines the changes in the distribution of ownership and operational landholdings over the period 1961-62 to 1982 making use of the data from the 17th, 26th, and 37th rounds of the National Sample Survey. The distribution of ownership holdings in three broad groups, namely, the landless, marginal, and non-marginal owners has remained remarkably stable over the two decades. The percentage of non-operating households also remained stable but the percentage of marginal operators increased while that of the non-marginal operators decreased. In spite of the increase in the total number of households, the number of large owners remained constant while the number of large operators declined only slightly. Pareto Curve fitted to the large owners and operators provides evidence of declining inequality in these classes.*

## 1. INTRODUCTION

Distribution of landholdings is a subject that has received considerable attention from students of India's agrarian structure. While there have been various regional or local studies based on data collected by individual or institutional investigators, the most important source of data has of course been the National Sample Survey (NSS), which in its 8th, 17th, 26th and 37th rounds has collected and presented data relating to the distribution of land holdings, both ownership as well as operational.

Apart from the NSS, data have also been collected and presented by the Agricultural Census; but they lack comparability with the NSS data because of definitional differences, so that it is not possible to make any study using data from both the sources. The NSS data alone allows comparison over a time span of about thirty years, the four rounds mentioned before having been carried out in the years 1953-54, 1961-62, 1971-72 and 1982. This apart, there are plenty of reasons to think that the NSS data are much more reliable, having been based on rigorous principles of statistical sampling and carried out by well-trained experienced personnel.

It is, therefore, understandable that most research workers working on the problem of landholding distribution should have based their analysis on the NSS data; we also propose to do the same in the present paper. However, most others have worked using only data of the first two or three rounds. We, however, have had access to data of all the four rounds. But, as the 8th round data lack comparability with those of the later rounds[1], we shall confine ourselves to the three rounds, 17th, 26th, and 37th, spanning the period 1961-62 to 1982.

One important matter in which we have attempted to do something different and better is to study the distributions not only in terms of the estimated frequencies in a number of arbitrarily demarcated size groups in which the NSS data are presented, but also in terms of smooth curves fitted to the data. The advantage of working with a well fitting smooth curve are many. Firstly, such a curve condenses all the information contained in the data into a few parameters of the function. This apart, a great advantage is that a smooth frequency curve permits one to read the frequency between any two points in the range of the variable concerned; with grouped data one is obliged to deal with frequencies only for the intervals demarcated in the grouping scheme. It is further to be noted that if, instead of the intervals actually selected, one chose a much larger number of intervals of much smaller width a diagrammatic representation of those frequencies would be almost indistinguishable from the fitted curve. Statistical theory would have it that such a well fitting theoretical curve would more faithfully reflect the properties of the population from which the sample of observations is drawn than a grouped frequency distribution. Thus, we shall see that the Lorenz ratios derived from the theoretical fits to the data are higher and decline over

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time more consistently than the ratios that can be calculated by using the grouped data directly; and we shall hold that the former reflects the population inequality more faithfully.

PART I. DISTRIBUTIONAL CHANGES IN FOUR BROAD GROUPS

*Distribution of Household Ownership Holdings*

We shall first consider ownership holdings and examine changes in the following four broad groups: (i) landless, i.e., owners of zero-sized holdings; (ii) marginal owners, i.e., owners of not more than 1 hectare of land; (iii) small owners, i.e., owners of between 1 hectare and 2 hectares of land; and (iv) large owners, i.e., owners of more than 2 hectares of land[2]. In the following, we shall at times take the third and the fourth groups together and refer to them as constituting a group of "non-marginal" owners.

The predominant feature of the pattern (Table 1) is that the relative frequencies in the first two categories remain practically unchanged at the two ends of the long period of twenty odd years between 1961-62 and 1982. In 1961-62, the landless households constituted 11.67 per cent of total rural households. In 1982, there was a slight reduction in the proportion of landless households - it was 11.33 per cent. In absolute numbers, the landless had increased in 1982 more or less in the same proportion as the total number of rural households; compared to 1961-62, the number of rural households had increased by 29.52 per cent while the landless had increased by 25.65 per cent. A similar stability marks the marginal owners: 54.38 per cent going up to 55.31 per cent. This is remarkable, given how much the total number of rural households increased.

The distribution in the first two groups in the intervening 26th round (1971-72) is somewhat different. The corresponding percentages are: landless 9.64 and marginal owners 52.98. The percentage of the landless declined not only in percentage terms (from 11.67 to 9.64) but even in absolute numbers (from 8.46 million to 7.56 million, that is, by 0.90 million or 10.64 per cent). This was so in spite of the fact that during this period, the total number of rural households increased from 72.47 million to 78.37 million, that is, by 8.14 per cent. The percentage of marginal owners also declined between 1961-62 and 1971-72 (from 54.38 to 52.98) though their absolute number increased (from 39.41 million to 41.52 million, that is, by 2.11 million).

The real large gain, between 1961-62 and 1971-72, both in terms of percentage and absolute number, appears to have occurred in the class of non-marginal owners. The percentage increased from 33.94 to 37.40 whereas their number increased from 24.60 million to 29.31 million, that is, by 4.71 million. Non-marginal holdings further increased to 31.30 million in 1982; but because of the increase in the number of rural households over the years, their percentage remained about the same: 33.94 in 1961-62 and 33.36 in 1982 while it was somewhat more in 1971-72 (37.40).

The stability that marks the frequency in the group of non-marginal owners over the different rounds gives place to a very different picture when the group is considered in its two component parts, namely small owners and large owners. It is seen that all the increase in non-marginal owners has occurred among small owners while the number of large owners has remained practically constant; in fact, it declined a little. The number of small holders increased sharply, in fact doubled, from 6.64 million in 1961-62 to 12.14 million in 1971-72; thereafter, the increase was small; the number increased to 13.80 million in 1982. In terms of percentage to total rural households, the number of small holders increased from 9.16 per cent in 1961-62 to 14.70 per cent in 1982; in 1971-72, the percentage was a little higher (15.49). On the other hand, the number of large holders remained practically constant; 17.96 million in 1961-62, 17.17 million in 1971-72, and 17.50 million in 1982. Naturally, their percentage to the total rural households declined; from 24.78 in 1961-62 to 21.91 in 1971-72, and to 18.66 in 1982.

*Distribution of Household Operational Holdings*

In this section we consider the changes in the distribution of household operational holdings in the four groups - non-operators, marginal operators, small operators and large operators. The

partial stability that we observed in the distribution of household ownership holdings between 1961-62 and 1982 is absent in the distribution of household operational holdings. Only the percentage of non-operating households remained remarkably stable: 26.86 in 1961-62, 27.41 in 1971-72, and 26.06 in 1982. The percentage of all the remaining three classes changed very much. In 1961-62, the percentages of marginal and non-marginal operators were 30.73 and 42.42 respectively. In 1982, these had reversed to 41.15 and 32.79 respectively. The change was in the same direction between 1961-62 and 1971-72 but was smaller; much of the change occurred between 1971-72 and 1982. Comparing 1961-62 and 1982, the number of non-marginal operators had remained almost the same: 30.74 million in 1962 and 30.78 million in 1982; this, in spite of the fact that, over the period, the number of total rural households had increased by 29.52 per cent. In 1971-72, it was only a little higher (31.13 million). In consequence, their percentage in the total rural households declined from 42.42 in 1961-62 to 39.72 in 1971-72 and to 32.79 in 1982. In 1982, for the first time, the absolute number of non-marginal operators was smaller than the number of non-marginal owners. But the change had occurred over the whole period. For instance, comparing the non-marginal owners and non-marginal operators, the latter were 24.96 per cent more than the former in 1961-62; only 6.21 per cent more in 1971-72 and actually 1.66 per cent fewer in 1982.

Looking now at the two sub-classes small and big operators, we notice that the number of small operators increased from 11.72 million in 1961-62 to 12.88 million in 1971-72, and 13.56 million in 1982, though the increase was not so much as to cause an increase in their percentage to total rural households; it was 16.17 in 1961-62, 16.43 in 1971-72, and 14.45 in 1982. This is compensated by a decline in the number of large operators; their number declined from 19.02 million in 1961-62 to 18.25 million in 1971-72, and to 17.22 million in 1982. Naturally, their proportion to total rural households also declined; it was 26.25 in 1961-62, 23.29 in 1971-72, and 18.35 in 1982. The number of large operators declined and, of course, also their percentage to total rural households.

*Distributions of Ownership and Operational Holdings Compared*

We shall now compare the distributions in four broad classes of household ownership holdings and household operational holdings, the difference being due to lease transactions. As may be seen in Table 2, in 1961-62, there were 17.14 million fewer marginal operators than marginal owners. On the other hand, there were 11.00 million more non-operators than the landless and 6.14 million more non-marginal operators than non-marginal owners. This means that, in 1961-62, 27.91 per cent of the marginal owners had wholly leased out their land to become non-operators and 15.58 per cent had leased in enough land to become non-marginal operators; only the balance of 56.51 per cent non-marginal owners stayed as non-marginal operators.

A similar comparison in 1971-72 shows that 33.54 per cent had wholly leased out their land to become non-operators; only 4.41 per cent had leased in enough land to become non-marginal operators; and 62.04 per cent of the marginal owners had stayed as marginal operators. Thus compared to 1961-62, a larger proportion of marginal owners had become non-operators; a larger proportion had stayed marginal operators and a smaller proportion had moved up to become non-marginal operators. In 1982, the movement continued in the same direction: none of the marginal owners moved up to become non-marginal operators; in fact, as already noted, a small number, 0.53 million, of non-marginal owners had moved down to become marginal operators. 74.40 per cent of the marginal owners continued to stay as marginal operators and 26.63 per cent wholly leased out their land to become non-operators. Thus, compared to 1971-72, a larger proportion stayed as marginal operators; no one moved to become a non-marginal operator; but a smaller proportion became non-operators.

TABLE 1. DISTRIBUTION IN FOUR BROAD GROUPS: GROWTH OVER ROUNDS

| Category | Size class (hectare) | Household Ownership holding | | | | | | Household Operational holding | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 17th round | | 26th round | | 37th round | | 17th round | | 26th round | | 37th round | |
| | | Number (mill) | Growth(%) Share (%) | Number (mill) | Growth(%) Share (%) | Number (mill) | Growth(%) Share (%) | Number (mill) | Growth(%) Share (%) | Number (mill) | Growth(%) Share (%) | Number (mill) | Growth(%) Share (%) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Landless/non-operators | 0.00 | 8.46 | 100.00<br>11.67 | 7.56 | 89.36<br>9.64 | 10.63 | 125.65<br>11.33 | 19.46 | 100.00<br>26.86 | 21.48 | 110.38<br>27.41 | 24.46 | 125.69<br>26.06 |
| Marginal holders | 0.00 - 1.00 | 39.41 | 100.00<br>54.38 | 41.52 | 105.35<br>52.98 | 51.91 | 131.72<br>55.31 | 22.27 | 100.00<br>30.73 | 25.76 | 115.67<br>32.87 | 38.62 | 173.42<br>41.15 |
| Small holders | 1.00 - 2.00 | 6.64 | 100.00<br>9.16 | 12.14 | 182.83<br>15.49 | 13.80 | 207.83<br>14.70 | 11.72 | 100.00<br>16.17 | 12.88 | 109.90<br>16.43 | 13.56 | 115.70<br>14.45 |
| Large holders | Above 2.00 | 17.96 | 100.00<br>24.78 | 17.17 | 95.60<br>21.91 | 17.50 | 97.44<br>18.66 | 19.02 | 100.00<br>26.25 | 18.25 | 95.95<br>23.29 | 17.22 | 90.54<br>18.35 |
| All | | 72.47 | 100.00<br>100.00 | 78.37 | 108.14<br>100.00 | 93.86 | 129.52<br>100.00 | 72.47 | 100.00<br>100.00 | 78.37 | 108.14<br>100.00 | 93.86 | 129.52<br>100.00 |

TABLE 2. DISTRIBUTION IN FOUR BROAD GROUPS: CHANGES DUE TO LEASE TRANSACTION (INCREASE/DECREASE OF NUMBER OF OPERATORS OVER OWNERS)

| Category | Size class (hectare) | 17th round | | | | 26th round | | | | 37th round | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Increase/Decrease | | | | Increase/Decrease | | | | Increase/Decrease | | | |
| | | | Percentage of | | Percentage of | | Percentage of | | Percentage of | | Percentage of | | Percentage of |
| | | Number (mill) | Marginal owners | All owners | operators to owners | Number (mill) | Marginal owners | All owners | operators to owners | Number (mill) | Marginal owners | All owners | operators to owners |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Landless/non-operators | 0.00 | 11.00 | 27.91 | 15.18 | 230.00 | 13.93 | 33.54 | 17.77 | 284.34 | 13.82 | 26.63 | 14.73 | 230.01 |
| Marginal holders | 0.00 - 1.00 | -17.14 | -43.49 | -23.65 | 56.51 | -15.76 | -37.96 | -20.11 | 62.04 | -13.29 | -25.60 | -14.16 | 74.40 |
| Small holders | 1.00 - 2.00 | 5.08 | 12.89 | 7.01 | 176.51 | 0.74 | 1.79 | 0.95 | 106.13 | -0.23 | -0.45 | -0.25 | 98.30 |
| Large holders | Above 2.00 | 1.06 | 2.69 | 1.46 | 76.76 | 1.09 | 2.62 | 1.39 | 106.35 | -0.30 | -0.58 | -0.32 | 98.29 |

## PART II. DISTRIBUTIONAL CHANGES WITHIN THE GROUP OF LARGE HOLDERS

### *The Pareto Curve*

In Part I, we have discussed changes in the distribution of ownership holdings and operational holdings in terms of four broad groups. However, the fourth class, i.e., the one standing for 2 hectares and above is a very extensive one and changes within it are of much interest. It is to study these changes that we have taken resort to the statistical procedure of fitting a continuous curve to represent a theoretical distribution lying behind the observed group frequencies.

A visual examination of the data relating to distribution of ownership and operational holdings suggests that the theoretical distribution that is most likely to give a good fit is the Pareto distribution of which the formula is

$$N(x) = \frac{A}{x^{\alpha}} \qquad (1)$$

where N(x) is the frequency beyond the point x and A and $\alpha$ are parameters of the distribution. As is well known, it is a distinctive property of the Pareto distribution that it describes certain frequency distributions not over the entire range of the relevant variable but only for a part of it in which the distribution is J-shaped. Thus, one of the most important fields of application of the Pareto curve is the distribution of income in its upper tail.

In its logarithmic form, the distribution becomes linear as follows:

$$\text{Log}N(x) = \text{Log}A - \alpha \text{Log}x \qquad (2)$$

The statistical procedure for fitting the Pareto curve to a body of data requires initially a choice of a value of x such that beyond that x the data might be amenable to a Pareto fit. Judgement in this matter is helped by an examination of a graphical representation on double logarithmic paper of the two variables x and N(x). The range of the values of x over which the Pareto distribution might be expected to hold is one over which the scatter of points lies along a straight line. Applying this method we find that the Pareto distribution might be expected to hold for the distributions of holdings beyond the size 1 hectare. After this, the standard procedure is to obtain the best-fitting straight line. The goodness of fit of the Pareto distribution to a body of data is the same as the goodness of the straight line fit to the transformed variables.

The results of the statistical exercise are presented in Tables 3A and 3B[3]. The parameters of the fitted Pareto curves are presented below the Tables. In cols. 2, 6 and 10 are given the NSS estimates of number of owners/operators in each class. In cols. 5, 9, 13 are given the number of holdings in each class estimated by fitting the Pareto curve. The procedure by which these are estimated may be briefly stated. The number of holdings of given size and above obtained by cumulating from the bottom the number of holdings in each class (cols. 2, 6, 10) are given in cols. 3, 7 and 11 called the 'cumulative frequency'. Pareto Curve, in its logarithmic form, is the linear regression of logarithms of cumulative frequencies (cols. 3, 7, 11) on logarithms of the lower limit of the size of holding class (col. 1). What we get are the logarithms of Pareto Curve estimates of cumulative frequencies, the inverse logarithms of which give the Pareto Curve estimates of cumulative frequencies, that is, number of holdings of given size and above; these are given in cols. 4, 8 and 12. If we take successive differences of these from the top, we get Pareto curve estimates of number of holdings in each class given in cols. 5, 9 and 13.

It is seen that the number of holdings in each class estimated by fitting the Pareto curve (cols. 5, 9, 13) are in reasonable agreement with those given by the NSS (cols. 2, 6 and 10) for all classes beyond 2 hectares but not for the class 1-2 hectares (small owners/operators). Thus, our initial expectation that the Pareto curve might hold over the entire range from 1 hectare onwards is not borne out by the data. We therefore propose to treat in terms of the Pareto curve only the holdings of 2 hectares and above; in other words, only the large owners/operators.

TABLE 3A. NSS AND PARETO CURVE ESTIMATES OF NON-MARGINAL HOUSEHOLDS OWNERSHIP HOLDINGS

(in millions)

| | 17th Round (1961-62) | | | | 26th Round (1971-72) | | | | 37th Round (1982) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NSS Estimates | | Pareto Curve Estimates | | NSS Estimates | | Pareto Curve Estimates | | NSS Estimates | | Pareto Curve Estimates | |
| Size Class (hectare) | Class Frequency | Cumulative Frequency | Cumulative Frequency | Class Frequency | Class Frequency | Cumulative Frequency | Cumulative Frequency | Class Frequency | Class Frequency | Cumulative Frequency | Cumulative Frequency | Class Frequency |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1.005 - | 6.64 | 24.60 | 41.89 | 25.44 | 12.14 | 29.31 | 46.80 | 30.22 | 13.80 | 31.30 | 51.88 | 35.12 |
| 2.025 - | 6.01 | 17.96 | 16.45 | 6.86 | 6.18 | 17.17 | 16.58 | 7.48 | 6.82 | 17.50 | 16.76 | 8.03 |
| 3.035 - | 3.31 | 11.95 | 9.59 | 3.05 | 3.18 | 10.99 | 9.11 | 3.16 | 3.29 | 10.68 | 8.73 | 3.24 |
| 4.045 - | 3.69 | 8.64 | 6.54 | 2.74 | 3.62 | 7.81 | 5.95 | 2.69 | 3.66 | 7.39 | 5.49 | 2.64 |
| 6.075 - | 1.79 | 4.95 | 3.80 | 1.21 | 1.60 | 4.19 | 3.26 | 1.13 | 1.54 | 3.73 | 2.85 | 1.06 |
| 8.095 - | 1.09 | 3.16 | 2.59 | 0.67 | 0.92 | 2.59 | 2.13 | 0.60 | 0.85 | 2.19 | 1.79 | 0.54 |
| 10.125 - | 0.62 | 2.07 | 1.92 | 0.41 | 0.53 | 1.67 | 1.53 | 0.36 | 0.41 | 1.34 | 1.25 | 0.32 |
| 12.145 - | 1.01 | 1.45 | 1.51 | 0.75 | 0.82 | 1.14 | 1.17 | 0.62 | 0.70 | 0.93 | 0.93 | 0.52 |
| 20.245 - | 0.44 | 0.44 | 0.76 | 0.76 | 0.32 | 0.32 | 0.55 | 0.55 | 0.23 | 0.23 | 0.41 | 0.41 |
| Log A | 3.74171 | | | | | Log A | 3.85336 | | | Log A | 3.95697 | |
| $\alpha$ | 1.33386 | | | | | $\alpha$ | 1.48110 | | | $\alpha$ | 1.61299 | |
| $R^2$ | 0.93851 | | | | | $R^2$ | 0.95575 | | | $R^2$ | 0.95720 | |

TABLE 3B. NSS AND PARETO CURVE ESTIMATES OF NON-MARGINAL HOUSHOLD OPERATIONAL HOLDINGS

(in millions)

| | 17th Round (1961-62) | | | | 26th Round (1971-72) | | | | 37th Round (1982) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NSS Estimates | | Pareto Curve Estimates | | NSS Estimates | | Pareto Curve Estimates | | NSS Estimates | | Pareato Curve Estimates | |
| Size Class (hectare) | Class Frequency | Cumulative Frequency | Cumulative Frequency | Class Frequency | Class Frequency | Cumulative Frequency | Cumulative Frequency | Class Frequency | Class Frequency | Cumulative Frequency | Cumulative Frequency | Class Frequency |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1.005 - | 11.72 | 30.74 | 47.70 | 29.51 | 12.88 | 31.13 | 49.92 | 32.38 | 13.56 | 30.78 | 51.74 | 35.21 |
| 2.025 - | 6.54 | 19.02 | 18.20 | 7.77 | 6.79 | 18.25 | 17.54 | 7.95 | 6.75 | 17.22 | 16.53 | 7.98 |
| 3.035 - | 3.49 | 12.48 | 10.43 | 3.40 | 3.35 | 11.46 | 9.59 | 3.34 | 3.19 | 10.47 | 8.55 | 3.20 |
| 4.045 - | 3.93 | 8.99 | 7.02 | 3.01 | 3.70 | 8.11 | 6.24 | 2.84 | 3.66 | 7.28 | 5.36 | 2.59 |
| 6.075 - | 1.83 | 5.06 | 4.01 | 1.31 | 1.69 | 4.41 | 3.40 | 1.19 | 1.51 | 3.62 | 2.76 | 1.03 |
| 8.095 - | 1.09 | 3.23 | 2.70 | 0.72 | 0.96 | 2.72 | 2.22 | 0.63 | 0.77 | 2.11 | 1.73 | 0.53 |
| 10.125 - | 0.63 | 2.14 | 1.99 | 0.44 | 0.56 | 1.76 | 1.59 | 0.38 | 0.44 | 1.34 | 1.20 | 0.31 |
| 12.145 - | 1.04 | 1.51 | 1.55 | 0.78 | 0.88 | 1.20 | 1.21 | 0.65 | 0.69 | 0.90 | 0.89 | 0.50 |
| 20.245 - | 0.47 | 0.47 | 0.77 | 0.77 | 0.32 | 0.32 | 0.56 | 0.56 | 0.21 | 0.21 | 0.39 | 0.39 |
| Log A | 3.87189 | | | | | Log A | 3.91793 | | | Log A | 3.95428 | |
| $\alpha$ | 1.37570 | | | | | $\alpha$ | 1.49291 | | | $\alpha$ | 1.62869 | |
| $R^2$ | 0.95644 | | | | | $R^2$ | 0.95428 | | | $R^2$ | 0.95434 | |

Sources: 1. NSSO Report on Land Holdings 37th Round, Jan-Dec. 1982, March 1987. 2. Sarvekshana Vol XI. No. 2, Oct. 1987.

In the next two sections we shall use the Pareto fits to examine the changes within the class of large owners/operators. There are three aspects we wish to examine: (a) changes in the large ownership holdings over the years; (b) changes in the large operational holdings over the years; and (c) comparing large ownership and operational holdings in each year. To facilitate the comparison, we have presented the fitted curves graphically in Graphs 1 to 5 as well as Graphs 1A to 5A. Graph 1 shows the fitted curves for the ownership holdings in the three NSS rounds so that we may see the changes in them over the period. Graph 2 shows the same for the operational holdings. Graph 3 gives the fitted curves for the ownership and operational holdings in the NSS 17th round so that we may compare the two distributions in a given year. Graphs 4 and 5 do the same for the NSS 26th and 37th rounds.

In graphs 1A to 5A we present the same data drawn on a double logarithmic paper, that is, with logarithm of the size of the holding on the horizontal axis and logarithm of the number of holdings of given size and above on the vertical axis.

*Reading the Curves in Arithmetic Scale*

Comparison of the curves indicate that over the three rounds the distribution within the group of large ownership holdings (Graph 1) has become increasingly skew. This is seen in detail as follows. The total number of large ownership holdings having gone up, the curve for the 26th round must be above the curve for the 17th round at least over a range and the same is true about the curve for the 37th round with respect to that for the 26th round. If the additional holdings between two rounds were distributed proportionately over the entire range from 2 hectares onwards the curves would be at every point equidistant from each other in proportionate terms. But that is not what has happened. The proportionate gaps become smaller and smaller as the size increases. As a matter of fact, the three curves intersect each other at points approximately between 4.20 and 4.35 hectres. This means that the additional holdings as between the successive rounds were distributed unequally so as to create a greater concentration towards the smaller size groups. Not only that, even the absolute number of large holdings became over the three rounds less and less frequent. Thus, the relative frequencies in all the sizes above 2 hectares are lower in the 26th round than in the 17th round and the relative frequencies in all the sizes above 3 hectares are less in the 37th round than in the 26th round. These reductions are compensated by more than proportionate rises in the frequency in the group 2 - 3 hectares. All in all, therefore, the change in the distribution consists in an increased concentration of absolute numbers in the range 2 to 5 hectares and an increased concentration of relative frequencies in the range 2 to 3 hectares.

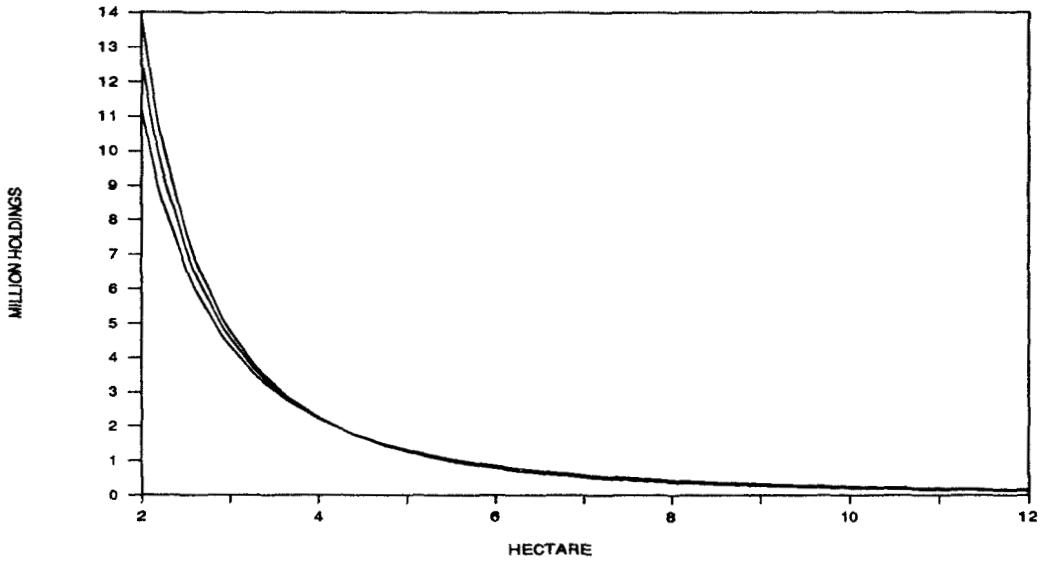
A very similar pattern is revealed by the curves for household operational holdings (Graph 2). The three curves intersect each other approximately between 2.5 and 3.0 hectares. Neglecting the minutia, the significant point to note is that large operational holdings gradually but steadily declined over the three rounds.

An important difference between the patterns of change of household ownership holdings and household operational holdings is that the increased concentration among the small size groups is much less marked in the latter case. This indicates a certain pattern of lease transactions between the landless, the marginal owners, and the different sizes of non-marginal owners.

The Graphs 3, 4 and 5 show the differences in the distribution patterns of ownership holdings and operational holdings brought about by lease transactions. For the 17th round almost all over the range the curve for operational holdings lies above that for ownership holdings. But the proportional gap between the two curves becomes smaller and smaller as size of holding increases. At 2 hectares the curve for operational holdings is 1.14 times higher than that for ownership holdings; the curves intersect far out in the tail area at 57 hectares. For the 26th round the relation between the curves for ownership holdings and operational holding is exactly the same. That is, the curve for the operational holdings lies above that for ownership holdings with the proportionate difference diminishing with increase in size and finally vanishing at the intersection point of

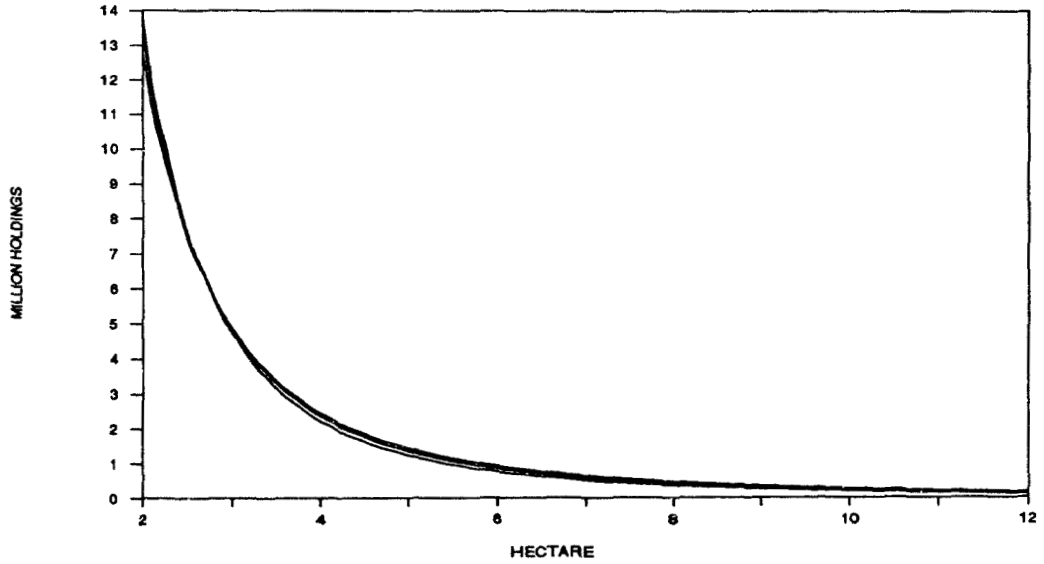
Graph 1. Frequency Distributions of Household Ownership Holdings for Different Rounds

Points of Intersection: 26/17 - 4.35; 37/26 - 4.19; 37/17 - 4.27



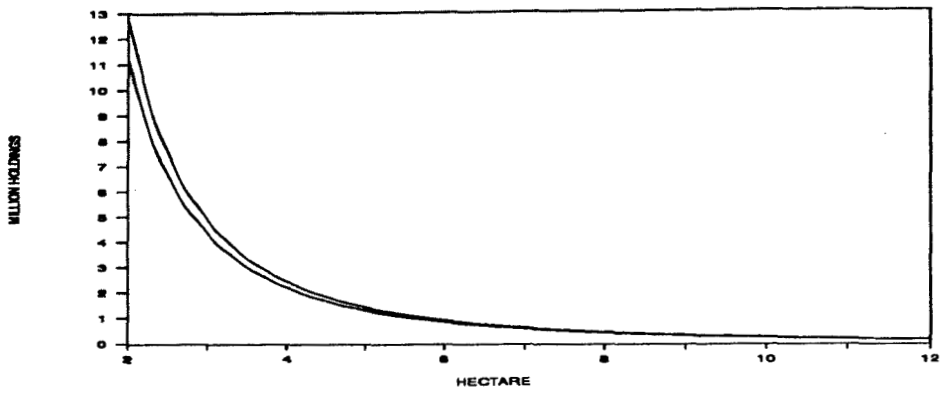

Graph 2. Frequency Distributions of Household Operational Holdings for Different Rounds

Points of Intersection: 26/17 - 2.98; 37/26 - 2.48; 37/17 - 2.70

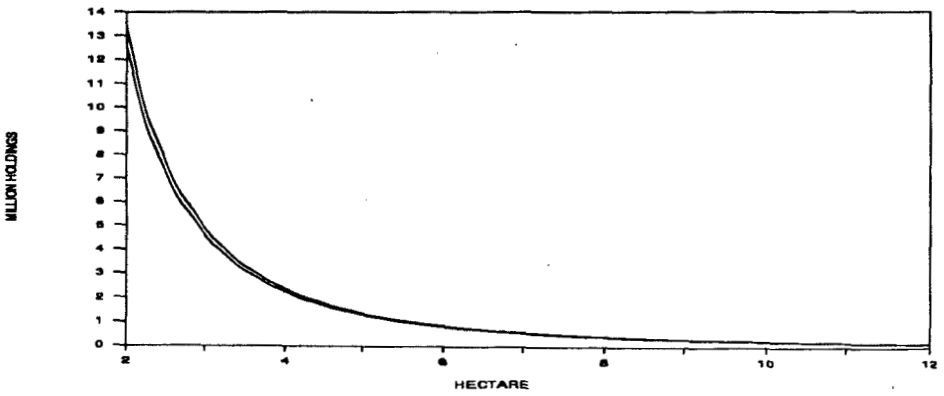



At the Start 17th round at the Top, 26th in the Middle, and 37th at the Bottom

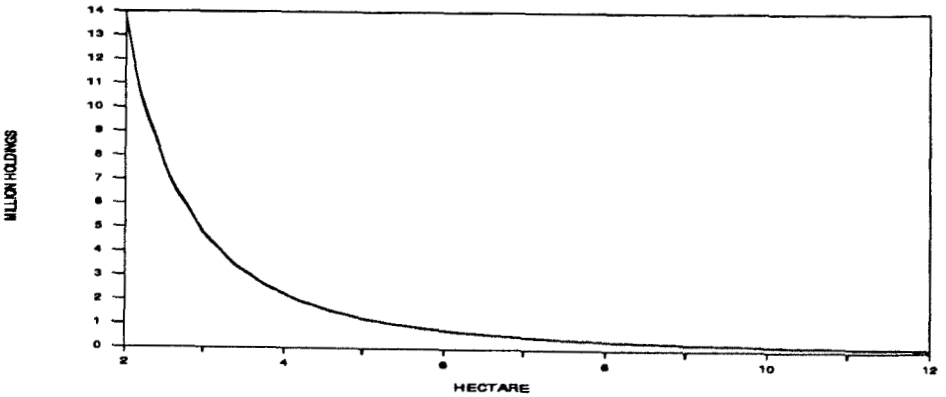
Graph 3. Frequency Distribution of Household Ownership and Operational Holdings - 17th Round




Graph 4. Frequency Distribution of Household Ownership and Operational Holdings - 26th Round




Graph 5. Frequency Distribution of Household Ownership and Operational Holdings - 37th Round




Curves of Operational Holdings lie above those for Ownership Holdings except in the 37th Round

136 hectares. However, the two curves are much closer together than in the case of the 17th round. At 2 hectares the curve for operational holdings is only 7 per cent higher than the curve for ownership holdings. This is so, because in the 17th round the non-marginal operational holdings were 25 per cent more numerous than the non-marginal ownership holdings but in the 26th round the non-marginal operational holdings were only 6 per cent more numerous than non-marginal ownership holdings.

The relation between the distributions of operational holdings and ownership holdings (as represented by the fitted smooth curves) gets reversed in the 37th round. In this round, the number of large operational holdings is actually less than the number of ownership holdings. Also, the proportionate gap between the two curves becomes larger with increase in the size of holdings. All through these three rounds, the net leases within the group of big owners were concentrated towards the lower end of the range of their holding size (3 hectares) so that, in all the rounds, within-group distribution of large operational holdings is more skew than the within-group distribution of large ownership holdings.

*Reading the Curves in Logarithmic Scale*

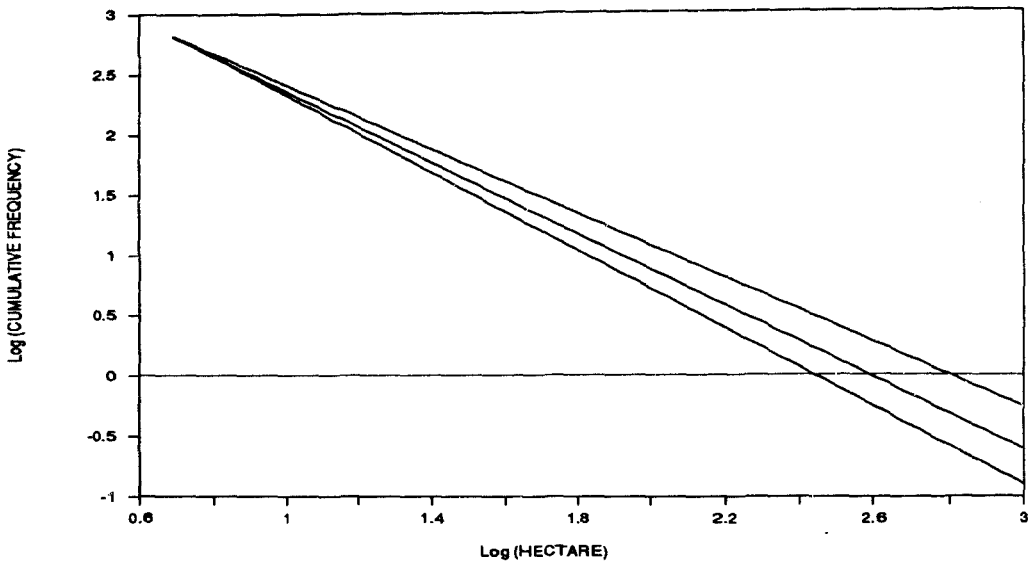
In the previous section we have looked at the Pareto curves over the size range 2 hectares and above and drawn various conclusions from their shapes. Some further insight may be obtained from a graphical representation of the same data in double logarithmic scale which we present in the Graphs 1A to 5A.

Consider first Graph 1A. The three straight lines correspond to the distributions in the NSS 17th, 26th and 37th rounds. The intercepts on the vertical axis, in terms of number of ownership holdings in million with holdings of 2 hectares and above are: 16.45 in 17th round, 16.58 in 26th round, and 17.76 in 37th round. There is a small increase over the years but too small to be seen on the graph. On the other hand, their slopes are quite different: -1.33386 for 17th round, -1.48110 for 26th round, and -1.61299 for 37th round. Therefore, though the line for 26th round starts at a slightly higher point on the vertical axis than the line for 17th round, because it has a steeper slope, it soon intersects the line for 17th round; in fact at 2.13 hectares. It means that the number of ownership holdings of 2.13 and above is the same in 26th round as in 17th round. Similarly, though the line for 37th round starts at a point higher than the lines for 17th and 26th rounds, because it has the steepest slope, it intersects the line for 17th round at 2.16 hectares and the line for 26th round at 2.19 hectares. It will be noticed that all the points of intersection are close together and one may say that the number of ownership holdings with holdings of 2.15 hectares and above were about the same in all the three rounds, in spite of the fact that the total number of rural households had increased in the meanwhile.

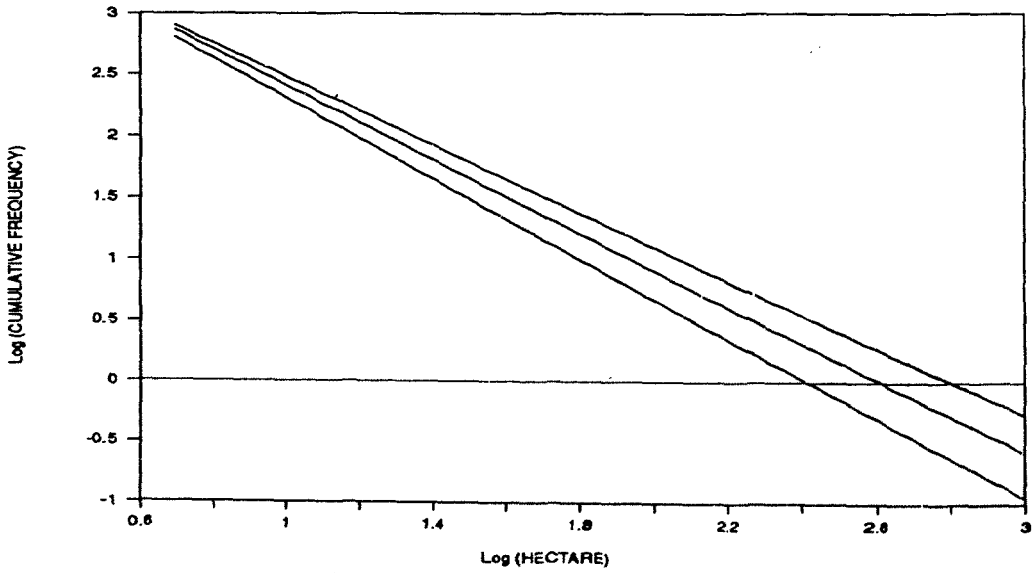
More important than where the lines start at the vertical axis and where they intersect, are their slopes. As already mentioned, the slope is steeper for 26th round and steeper still for 37th round. This means that, as we move from one size of holdings to the next higher, the number of ownership holdings with given or larger holding declines faster in 26th round than in 17th round and faster still in 37th round. In other words, of the ownership holdings having holdings 2 hectares and above, the percentage of ownership holdings of a given size and above declines as we move from 17th to 26th and from 26th to 37th round. For instance, in 17th round, 11.67 per cent of the large owners had holdings of 10.125 ha and above. This percentage declined to 9.23 in 26th round, and further to 7.46 in 37th round.

The trends in the distribution of operational holdings (Graph 2A) are similar because the slopes of the three lines are much the same as they are for the ownership holdings: -1.37570 for 17th round, -1.49291 for 26th round, and -1.62869 for 37th round. The intercepts on the vertical axis, in terms of number of operational holdings in million with holdings of 2 hectares and above are: 18.20 in 17th round, 17.54 in 26th round, and 16.53 in 37th round. Thus, here there is a decline over the years noticeable even in the graph 17th round line is at the top, 26th round line in the middle, and 37th round line at the bottom. This is in contrast to what we saw in Graph 1A for the ownership holdings. The reason is that the

Graph 1A. Household Ownership Holdings for Different Rounds
Pareto Fits to Transformed Variables

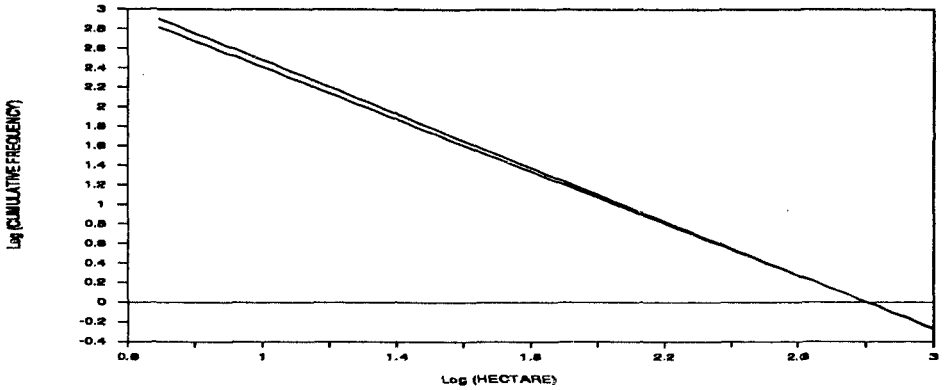



Graph 2A. Household Operational Holdings for Different Rounds
Pareto Fits to Transformed Variables

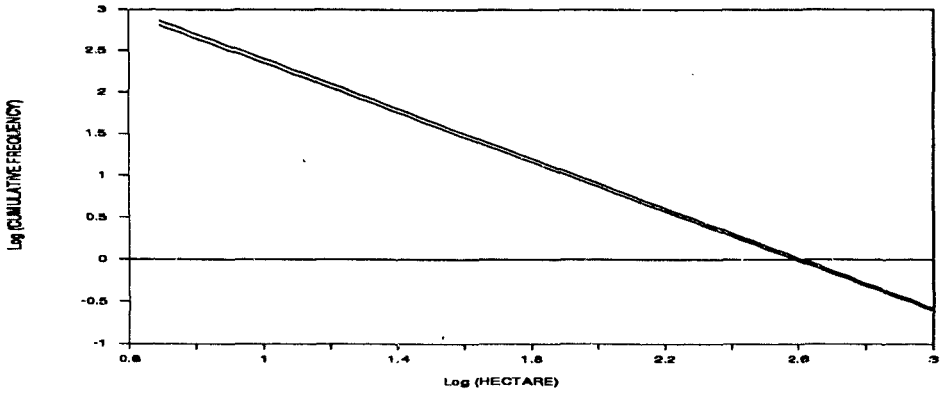



17th round at the Top, 26th in the Middle, and 37th at the Bottom

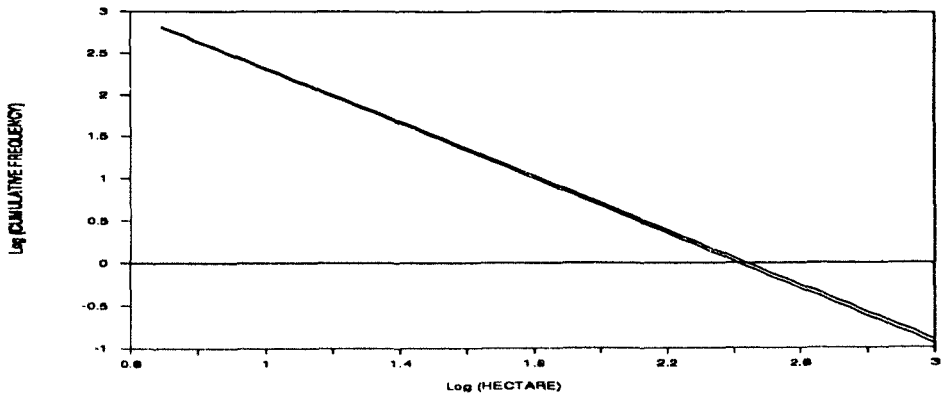
Graph 3A. Household Ownership and Operational Holdings:
Pareto Fits to Transformed Variables Compared: 17th Round




Graph 4A. Household Ownership and Operational Holdings:
Pareto Fits to Transformed Variables Compared: 26th Round




Graph 5A. Household Ownership and Operational Holdings:
Pareto Fits to Transformed Variables Compared: 37th Round




Lines for Operational Holdings lie above those for Ownership Holdings except in the 37th Round

intersections of these lines is not seen on the graph; they are below 2 hectares. In fact, line for 26th round intersects with line for 17th round at 1.48 hectares; line for 37th round intersects with line for 17th round at 1.39 hectares and with line for 26th round at 1.31 hectares. Thus, between 1.30 and 1.50 hectares, the number of operational holdings with given and larger holding is about the same in all rounds. Because of the differential slopes in them, by the time they appear on the graph, namely, at 2.025 hectares, the line for 17th round, as we have noticed, is at the top, line for 26th round in the middle and the line for 37th round at the bottom. As we move up to higher size holdings, that is, to the right on the horizontal axis, the distance between the three lines widens. This means that, as we move from one size of holding to the next higher, the number of operational holdings with given or larger holding declines faster in 26th round than in 17th round and faster still in 37th round. In other words, of the operational holdings having holdings 2.025 hectares and above, the percentage of operational holdings of a given size and above declines as we move from 17th to 26th and from 26th to 37th round. For instance, in 17th round, 10.93 per cent of the large operators had holdings of 10.125 hectares and above. This percentage declined to 9.06 in 26th round, and further to 7.26 in 37th round.

Graphs 3A, 4A, and 5A compare the distributions of ownership and operational holdings in 17th, 26th, and 37th round respectively. In all cases, the slopes of the lines for operational holdings are steeper than those for the ownership holdings. The difference is small but noticeable on the graphs. As a result, if the number of operational holdings with holdings of 2 hectares are more than the corresponding ownership holdings, the difference narrows down as we move to higher size holdings. For instance, in 17th round, number of operational holdings of 2.025 hectares or more was 18.20 million compared to 16.45 million ownership holdings of that size; that is operational holdings were 10.64 per cent more. But, the operational holdings of 10.125 hectares or more were only 1.99 million compared to 1.92 million ownership holdings of that size; that is, only 3.65 per cent more. In 26th round, the operational holdings of 2.025 hectares or more were 5.79 per cent more than the ownership holdings of that size; but operational holdings of 10.125 hectares or more were only 3.92 per cent more than the ownership holdings of that size. In 37th round, operational holdings of 2.025 hectares or more were already fewer (98.63 per cent) compared to ownership holdings of that size; operational holdings of 10.125 hectares and above were still fewer (96.0 per cent) compared to ownership holdings of that size.

The above results may be interpreted in terms of inequality in the distributions of ownership and operational land holdings. There are two principal results: First, the inequality in the distribution of large holdings, that is, above 2 hectares has decreased over the years and that this is true of both ownership and operational holdings. Second, the inequality in the distribution of operational holdings in any year is smaller than in ownership holdings.

*Changes in Inequality*

Most others who have studied changes in the distribution of landholdings have done so in terms of the Gini Coefficient. In this section we too shall present some results of our own pertaining to that particular coefficient. In doing that we shall find a justification of the trouble that we have taken of fitting a theoretical curve to the large holdings. The figures presented in columns 3 and 6 of Table 4 unmistakably show two aspects of inequality of landholding distributions which do not get revealed if one works with grouped data as presented by the NSS. With grouped data the Gini Coefficient G is defined as follows:

$$G = \frac{D}{2m}$$

Where m is the arithmetic mean

D the Mean Difference defined as

$$D = \frac{1}{N^2} \sum_{i=1}^{K} \sum_{j=1}^{K} | m_i - m_j | f_i f_j$$

where $m_i$ is the midpoint of the ith group,
$f_i$ is the frequency of the ith group, $i = 1, 2, \ldots, k$;
N the total frequency;
K the number of groups,

i.e., $N = \sum_{i}^{k} f_i$

On the other hand, for a Pareto curve with symbols defined before, the Gini Coefficient is given by

$$G' = \frac{1}{2\alpha - 1}$$

The formula holds for any part of the distribution for which the Pareto Distribution holds. Hence for the part of the distribution above 2 hectares the Gini Coefficient in the theoretical distribution is G′ as given above. It is seen that for large holdings for which both G and G′ can both be calculated the following interesting observations can be made.

TABLE 4. GINI COEFFICIENTS

| NSS | Household ownership holdings | | | Household operational holdings | | |
|---|---|---|---|---|---|---|
| | Large holders (2 hectares & above) | | All holders (above 0 ha.) Based on NSS estimates | Large holders (2 hectares & above) | | All holders (above 0 ha.) Based on NSS estimates |
| | Based on NSS estimates | Based on the Pareto fit | | Based on NSS estimates | Based on the Pareto fit | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 17 | 0.3939 | 0.5961 | 0.6843 | 0.3930 | 0.8683 | 0.6104 |
| 26 | 0.3710 | 0.5093 | 0.6862 | 0.3705 | 0.5009 | 0.5931 |
| 37 | 0.3518 | 0.4467 | 0.6859 | 0.3435 | 0.4400 | 0.6247 |

(a) Inequality (as measured by G′) of both large operational and large ownership holdings decreases systematically over the three rounds 17, 26 and 37. Of course, the decline in inequality is also evident when measured by G based on grouped data; but G′ brings it out much more sharply.

(b) Inequality of large ownership holdings is almost the same as the inequality of large operational holdings, excepting in the 17th round. In that round inequality is less in the operational holdings than in the ownership holdings when measured by the formula for G′ above but the relation is the opposite when calculated from grouped data by using the formula for G above.

(c) Inequality is very much underestimated when calculated from grouped data by using the formula for G. In each case the value for G′ is much higher than that for G.

Most others calculating Gini Coefficients for land distribution data have of course done so for all non-zero holdings without any division between marginal and non-marginal ones. We have also done the same and our results are presented in columns 4 and 7 of Table 4. We see that the inequality is much larger for the entire non-zero holdings than for only large holdings and that the inequality of ownership holdings is higher than that for operational holdings. It is further seen that there is no decreasing tendency in the inequality over the different rounds, whether for operational holdings or for ownership holdings. It is not possible to verify these results by comparable G′ because, in this case, G′, of course, cannot be calculated

NOTES

1. We have thought it best to work with the concepts of "household ownership holdings" and "household operational holdings" as used by the NSS, which concepts we take are known to the reader. The 8th round, however, did not present data relating to "household operational holdings" : it dealt with the concept of "operational holdings" only. As such, we have been obliged to exclude the 8th round from our study.

2. The last size group in all the Tables relating to distribution of holdings is 25 hectares and above. The interval being open, it has no mid point. In our own calculations we have used the average value of x of that group and assumed all the frequency of that last group to be concentrated there. Other researchers who have calculated Gini Coefficients for NSS landholdings data may not have done the same. This may be one reason

why our coefficient figures differ slightly from the figures arrived at by others.

3. The NSS defines the class intervals as 0.00-1.00, 1.01-2.02, 2.03-3.03,.... 20.25+ hectares. For a continuous frequency distribution, the upper limit of one class should coincide with the lower limit of the next class. We have, therefore, redefined the class intervals of the non-marginal owner/operators as 1.005-2.025, 2.025-3.035,... 20.255 hectares and above. This is how we have written the class intervals in Tables 3A and 3B.

As mentioned above the NSS presents landholding statistics with the following grouping scheme : 0.00, 0.00-1.00, 1.01-2.02, etc. upto 20.25 hectares and above. Our four broad groups correspond to the first three above groups and the group defined as 2.03 and above. But in the text, for the sake of simplicity, we refer to the third and the fourth groups as if demarcated as 1-2 hectares and 2 hectares and above.

## DOCUMENTATION

The purpose of this section is to make available to the readers official documents such as reports of committees, commissions, working groups, task forces, etc., appointed by various ministries, departments, and agencies of central and state governments which are not readily accessible either because they are old, or because of the usual problems of acquiring governmental publications, or because they were printed but not published, or because they were not printed and remained in mimeographed form. It will be difficult and probably not worthwhile to publish the documents entirely. We shall publish only such parts of them as we think will interest our readers. The readers are requested to send their recommendations of official documents or parts thereof for inclusion in this section.

In Vol. III No. 3 (July-September 1991 issue), we published Part I of the Planning Commission Report on Perspective Planning for Transport Development, 1988. In this issue we are publishing Chapters XIII and XIV of Part II of the Report. We expect to publish the remaining chapters of Part II in a subsequent issue.

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AI | - Air India |
| ATC | - Air Traffic Control |
| ATKms | - Available Tonne Kilometres |
| BG | - Broad Gauge |
| BL | - Block Load |
| BPK | - Billion Passenger Kilometres |
| BRPL | - Bongaigaon Refinery & Petrochemicals Ltd. |
| BTK | - Billion Tonne Kilometres |
| CATC | - Civil Aviation Training Centre |
| CEA | - Central Electricity Authority |
| CES | - Consulting Engineering Services (India) Pvt. Ltd. |
| CFS | - Container Freight Station |
| CHP | - Centralised Handling Plant |
| CIRT | - Central Institute for Road Transport |
| CO | - Carbon monoxide |
| DGCA | - Directorate General of Civil Aviation |
| DRF | - Depreciation Reserve Fund |
| DWT | - Dead Weight Tonnes |
| EV | - Entitlement Voucher |
| FRP | - Fibre-Reinforced Plastic |
| GAIL | - Gas Authority of India Ltd. |
| GDP | - Gross Domestic Product |
| GMT | - Gross Million Tonnes |
| GNP | - Gross National Product |
| GPS | - Global Positioning System |
| grt/GRT | - Gross Registered Tonnes |
| HBJ | - Hazira-Bijapur-Jagdishpur |
| HC | - Hydrocarbon |
| HSD | - High Speed Diesel |
| IA | - Indian Airlines |
| IAAI | - International Airports Authority of India |
| IATA | - International Air Transport Association |
| ICD | - Inland Container Depot |
| IGRUA | - Indira Gandhi Rashtriya Uran Akademi |
| ILS | - Instrument Landing System |
| INMARSAT | - International Maritime Satellite |
| IWT | - Inland Water Transport |
| Kms | - Kilometres |
| Kmph | - Kilometres per hour |
| LCVs | - Light Commercial Vehicles |
| LNG | - Liquefied Natural Gas |
| LPG | - Liquefied Petroleum Gas |
| LVCDs | - Last Vehicle Counter Devices |
| MG | - Metre Gauge |
| MIS | - Management Information System |
| MLS | - Micro-wave Landing System |
| MT | - Million Tonnes |
| NAA | - National Airports Authority |
| NPA | - National Ports Authority |
| NTPC | - National Transport Policy Committee |
| OCC | - Oil Coordination Committee |
| OD | - Origin-Destination |
| ONGC | - Oil and Natural Gas Commission |
| PAX | - Passengers |
| PCUs | - Passenger Car Units |
| PDS | - Positioning Determination System |
| PGCA | - Planning Group on Civil Aviation |
| PIB | - Press Information Bureau |
| POH | - Periodical Overhaul |
| POL | - Petroleum, Oils and Lubricants |
| PPG | - Ports Planning Group |
| PGRT | - Planning Group on Road Transport |
| PGTR | - Planning Group on Technology for Railways |
| RDSO | - Railway, Designs & Standards Organisation |
| RITES | - Rail India Technical & Economic Services |
| RRC | - Railways Reforms Committee |
| RTKms | - Revenue Tonne Kilometres |
| SAARC | - South Asian Association for Regional Cooperation |
| SCI | - Shipping Corporation of India |
| SDFC | - Shipping Development Fund Committee |
| STUs | - State Transport Undertakings |
| TCPs | - Transport Control Plans |
| TEUs | - Twenty-Feet Equivalent Units |
| TKms | - Tonne Kilometres |
| TOC | - Total Operating Cost |
| TOHAS | - Trunk Highways Amenities Societies |
| UNDP | - United National Development Programme |
| Urb Pop | - Urban Population |
| UTS | - Ultimate Tensile Strength |
| VHF | - Very High Frequency |
| WL | - Wagon Load |

# PERSPECTIVE PLANNING FOR TRANSPORT DEVELOPMENT

*In 1988, Planning Commission, Government of India had set up a Steering Committee for Transport Planning. In the following is the Railways and Roads Sector of Part II of the Report entitled Transport Sector.*

XIII RAILWAYS

*Perspective Review*

The growth of rail transport in India since Independence has been impressive as shown by the upsurge of two basic indices of service performance: (i) number of originating passengers and passenger kilometres; and (ii) originating tonnage of freight and tonne kilometres of freight carried.

TABLE 13.1 GROWTH OF TRAFFIC ON INDIAN RAILWAYS

| Sl. No. | Particulars | 1950-51 | 1985-86 | Multiplier Factor |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| | | million | million | |
| 1. | Passengers originating (Suburban & non-suburban) | 1,284 | 3,434 | 2.7 |
| 2. | Passenger kms | 66,517 | 260,623 | 3.6 |
| 3. | Tonnes originating (Revenue) | 73.2 | 258.5 | 3.5 |
| 4. | Tonnes originating (Total traffic) | 93.0 | 286.4 | 3.3 |
| 5. | Tonne kms (Revenue) | 37,565 | 196,600 | 5.2 |
| 6. | Tonne kms (Total) | 44,117 | 205,904 | 4.5 |

13.2 This impressive growth has, however, not kept pace with the growing demands of national economy with the result that the growth of economy has frequently been impeded by the shortage of rail transport. If such shortages are to be avoided in future, it will be necessary for the Indian Railways to almost double their present (1985-86) lift of passenger and freight traffic by 2000 AD. To achieve this, the Railways will have to adopt new technologies of rail transport relevant to the needs of our economy as a whole.

13.3 At present, the rail transport technology is developing along two different lines in the developed world. We may broadly divide the developed world in two categories. In the small, highly developed countries like Japan, France, UK and West Germany there has been a persistent decline in the railways' share of both passenger and freight traffic. In UK, for example, "over the last twenty-five years, there has been a steady decline in the market share achieved by both rail and coach traffic, on the one hand, and a dramatic growth in the motor car traffic on the other. Total traffic has increased significantly from about 240 billion passenger kms in 1960 to 494 billion passenger kms in 1984, whereas rail traffic has remained relatively constant at approximately 50 billion passenger kms with the result that railway market share has declined in a rapidly expanding market. The decline in freight traffic is more drastic than in passenger traffic. In the last thirty years the railways' share of passenger traffic in the UK has declined from 43 to 10 per cent of the national total whereas coastal shipping share has remained relatively constant between 22 and 25 per cent. Road traffic has, however, increased from 37 to 58 per cent.[1]" The situation in other European countries like France and Germany is no different. In the circumstances, railways in these countries have been obliged to devise a recovery strategy to remain in business. They have done so by opting for super-speed passenger trains travelling at 200 to 300 kms per hour like TGV *(trains de grande vitesse)* in France, HST (High Speed Trains) both in UK and Germany. But in all other countries of continental dimensions like the USA and the USSR, the railways have remained and are likely to remain largely the beast of burden of the economy. In the USA, for example, the emphasis is on the development of technology to augment the carrying or hauling capacity and reliability of the freight-carrying rolling stock to the virtual neglect of strengthening or upgrading of track structure and even of passenger transport by rail. The pattern of the Soviet as well as Chinese Railways is no different, with still greater emphasis on freight transport. A comparison of the Indian Railways (IR) with

other major railway systems shows that while Continental Railways like those in USSR, USA and China lift respectively 14.4, 9.93, and 3.41 times the freight lifted by the Indian Railways, their lift of passengers is only 1.1, 0.7 and 0.28 times that of ours[2].

13.4 The Indian Railways are not likely to face a slump in demand either for passenger or freight traffic by the turn of the century. On the contrary, they will have to create capacity to carry double the volume of both passenger and freight traffic than they do now. It, therefore, appears that in their search for new technologies to accomplish this task the Indian Railways do not have to adopt such technologies as TGV now *a' la mode* in some developed countries to recover some of their lost passenger traffic. Nor do they need to unusually increase freight train speeds to remain in business. They have actually to opt for such technologies as are appropriate for doubling their present lift of passenger and freight traffic on their *existing* network at the lowest capital and operating costs. This means that they should endeavour to remain the "beast of burden" of national economy as hitherto and eschew all attempts to become its show piece instead since we do not have the resources to achieve both these goals.

*Passenger Traffic*

13.5 Following the aforementioned approach, we will first consider the passenger traffic carried by the Indian Railways on the existing network. The bulk of additional passengers is expected to originate on the already saturated routes i.e. six routes forming the four sides and two diagonals of the Golden Quadrilateral with its vertices at the four metropolitan cities - Delhi, Calcutta, Madras and Bombay. The most economical way of increasing the number of passenger carried by the Railways is not to raise the number of trains but to enhance the number of coaches in each train. At present, the bulk of passenger trains consist of 12/13 coaches, while the Mail/Express trains have 16 to 20 coaches. If all the Mail and Express trains (depending on traffic demand) and most of the passenger trains on crowded routes run with 22/25 coaches, this should considerably augment the passenger-carrying capacity of trains without a proportionate increase in their number. Such doubling of the number of coaches, of course, may not be necessary in each case as on a number of branch lines traffic requirements may be such as can be met with just a marginal increase in the train length or the number of trains or both. Even so, to implement this strategy it will be necessary to increase coach production by expanding the existing coach factories or by setting up new ones. Some measures will have to be taken for exploiting the full potential of running longer passenger trains like strengthening couplers of coaches and brake power and lengthening of platforms at several stations.

*Freight Traffic*

13.6 Six corridors including the four sides and two diagonals of the Golden Quadrilateral are the most critical and crowded corridors. In addition, there are a few other corridors linking up important industrial centres which are getting congested. It is precisely on these corridors, already being utilized to saturation point, that the bulk of additional freight traffic is anticipated to be generated by 2000 AD. One way of creating additional capacity on these routes is to increase the carrying capacity of freight trains. A pilot project was introduced on the Northern Railways to examine the feasibility of running long heavy haul trains of 9,000 tonnes gross weight in place of the existing box trains of 4,500 tonnes gross weight, to overcome the capacity constraint on the crowded routes. It was, however, found to be unworkable under the conditions obtaining on the Indian Railways. In the circumstances, the most economical solution to the problem is to redesign the present BOX wagon to increase its carrying capacity from 55 to 65 tonnes and at the same time reduce its length but rise its height to provide a volume of around 70 cubic metres. With redesigned wagons, it will be possible to raise the net carrying capacity of a train from the present 2,475 tonnes (55 x 65) tonnes i.e. by nearly 50 per cent[3]. Consequently, the number of trains required to carry the present tonnage could be reduced by one third.

13.7 We will consider the impact of this measure on Moghalsarai-Ghaziabad route of the

Northern Railway because it is the most modernised and crowded route on the Indian Railways. Although it is a double line electrified route with colour light signalling, it is fully saturated, carrying 47 (17 passenger and 30 freight) trains every day on its first section Moghalsarai-Allahabad and nearly the same number on the following three sections from Allahabad to Kanpur, Tundla and Ghaziabad. With the induction of newly designed BOXN wagons and other appropriate measures, the volume of traffic carried in 30 freight trains of present BOX wagons could be accommodated in 20 trains of new wagons. Hence, to double the volume of freight traffic we need to run only 40 freight trains with new BOXN wagons. For this, we have only to increase the capacity of Moghalsarai-Ghaziabad route marginally by:

(a) the provision of a number of facilities like intermediate storage loops, emergency cross-overs and cripple sidings; and
(b) debugging the nodes at Allahabad, Kanpur and Tundla by appropriate measures like providing flyover at Kanpur and a new passenger terminal at Prayag, etc.

13.8 Incidentally it may be mentioned here that by running daily 40 freight trains of 5,000 tonnes gross weight each and 17 passenger trains of 900 tonnes gross weight each, it should be possible to double both the net freight and the number of passengers carried over the route. This means a volume of traffic of around 0.2 GMT per day or 70 GMT per annum, which is the throughput limit prescribed for a double-line trunk route.

13.9 However, we must caution against the temptation of increasing line capacity by raising the booked speed of freight trains from 75 kmph to 90 kmph with corresponding reduction in the differential between freight trains and passenger trains which have the booked speed of 100-130 kmph. In our opinion, such increase in the booked speed of heavy freight trains of 5000 tonnes gross weight will be counter-productive for the following reason. The advantage of higher speed depends not so much on the booked train speeds as on the average speeds realised on the run. There is already a very wide gap between the booked speed of freight trains i.e. 75 kmph and average speed which has stagnated at 22/23 kmph over the past decade despite modernisation. As already explained, increase in energy consumption by a faster train will be much more than proportionate to the increase in its speed.

13.10 It should be recognised that the average speed of a group of trains on mixed corridors depends not merely on their "booked" speeds but more importantly on the "speed differential" and "density drag" of the entire group of trains under consideration. The latter factor has a catastrophic effect if the equipment in use is not reliable and trouble-free. In the circumstances, it is essential that equipment technology is modernised to ensure quasi-zero failure. It is particularly necessary to increase the acceleration power reserve of the locomotives rather than their booked speed. This would help to increase the average train speeds which in turn would result in substantial increases in sectional capacities.

*Technological Upgradation*

13.11 The basic strategies to increase the net carrying capacity of freight trains (by 50 per cent) on the one hand, and the capacity of the routes on which they run, on the other, are: (a) redesigning of BOX wagon feet to raise its carrying capacity to 65 tonnes; (b) strengthening the track structure and bridges to raise the axle load of wagons from 20.3 tonnes to 22 tonnes; (c) upgrading of traction to carry heavier trains with 50 per cent higher net load; (d) upgrading of signalling and communications systems; and (e) modernisation of material handling technologies at terminals by the Railways' major client like coal mines, power houses, steel plants, etc. The following measures are suggested for modernisation and upgradation of material handling technology.

*Material Handling Technologies*

13.12 The most important of the bulk commodities handled by the Indian Railways is coal, which constitutes 40 per cent of the total originating railway tonnage. The present method of serving collieries by coal pilots carting empties from depot yards to collieries and bringing loaded coal wagons back to depot yards after loading is too archaic to be of much use by the end of the

century. It has led to a growth of only 2 million tonnes per annum erratically achieved in the past 24 years from 1960-61 (54.4 mt) to 1984-85 (102 mt). This rate has to be increased five-fold if the target of 250 million tonnes coal loading in 2000-2001 is to be achieved. It is a task that can never be performed by "more-of-the same" sort of approach hitherto followed. To achieve the requisite leap in coal loading, coal from existing collieries has to be collected and loaded from the Centralised Handling Plants (CHPs). No loading point should have a despatch rate of less than 1 mt. per annum with bunkerage provided for one rake plus one day's production for each type of coal separately. This rate of 1 mt. per annum for a loading point is a lower limit for amalgamating the production of existing collieries. But no new mine should be planned for less than 2 mt. per annum with loading rate of 4,000 tonnes per hour. As the aforementioned proposal will be very costly, we consider that the high cost of the proposed new system should be equitably shared between Coal India and the Indian Railways. We also recommend the provision of dedicated stock for the bulk movement of cement, fertilizers and foodgrains. Preferably, the users should bear the cost of providing the dedicated rolling stock as well as soils while the railways could institute special concessional rates based on incremental costs of haulage.

13.13 Finally, the Railways have to deal with fairly large quantities of other commodities like sugar, soda ash, edible oils, cotton raw, paper, oil seeds, tea, timber waste, jute, (about 25 million tonnes at present and likely to grow to 50 million tonnes by the turn of the century) some of which are carried in bags and are loaded as often at the Railways' goods sheds as in the client's premises. Since in all such cases the commodities will have to be loaded in block rakes, steps should be taken to replace the existing manual loading/unloading operations by palletization and lifting the palletized packages by fork lifts at all large goods sheds as well as break-of-gauge transhipment points. Railways should provide such equipment for their own as well as their clients' use. The clients may be charged for the equipment service provided by the Railways at the goods sheds.

*Wagon Fleet*

13.14 The most important step in modernizing rolling stock is the enhancement of the axle loads of wagons. Our present axle loads for BG are 20.3 tonnes for BOXN freight wagons and 20 tonnes for ordinary BOX wagons and only 18 tonnes for four-wheelers. We recommend the adoption of 22.5 tonnes as the upper limit of axle load for locomotives and 22 tonnes for freight wagons on existing routes after due upgradation of track structure. This step will greatly improve the productivity of the present wagons fleet as measured by the two commonly used indices of productivity, namely, payload to tare weight ratio and the trailing load behind a loco per unit length of the train. The payload to tare ratio will improve from 2.20 for BOX and 2.50 for BOXN to 2.93 against 3.3 on many railways in the world with even narrower gauge than our broad gauge. The trailing load will improve to 8.05 t/m from the present 5.85 t/m for BOX and 7.67/m for BOXN. But much more important is the contemplated improvement in wagon reliability by: (a) conversion of plain bearings to roller bearings, of vacuum brake to air brake, of laminated springs to parabolic springs; (b) modification of existing UIC bogie using high tensile steel in place of mild steel with redesigned suspension brackets, positive locking at bridle bars and pressed headstock; and (c) modernisation of the present system of maintenance of wagons in railway workshops for POH as well as for online repairs in sick lines and depots. This is proposed to be achieved by installation of modular system, whereby the "distressed" or defective components are not repaired *in situ* as at present, but replaced and the wagon released to traffic. The removed components are later repaired for subsequent use.

13.15 In addition, it will be necessary to modify the geometry of BOXN wagon by raising its height and marginally increasing its length to secure a volume of around 70 cubic metres and the required payload of 65 tonnes for coal. The scope for increasing its length is limited by the

consideration that existing loop lengths must accommodate a train of 55 wagons of the new design against 45 BOXs and 58 BOXN at present. We emphasise that in designing the new wagons we must also simultaneously ensure that: (i) a versatile tippler capable of handling all the three BOX, BOXN and the newly designed wagon BOXN is feasible; and (ii) the existing tipplers can be modified into such versatile ones.

*Track and Bridges*

13.16 The total track on BG, which carries over 80 per cent of rail traffic, is about 69,000 kms of which only 47,500 kms is running track. The important routes of A, B and C categories and heavy mineral sections of category D collectively called "core routes" total about 27,000 kms. Of this, 7,400 kms were due for renewal as on 1.4.1985 and another 12,060 kms will be due for renewal in the next 15 years i.e. 1985-2000. Thus, about 73 per cent of the total core route kms will be due for renewal by 2000 A.D. due to piling up of arrears of track renewals in the past decade or so.

13.17 In planning future track renewals, steps must be taken to switch over to proposed higher axle loads on core routes. It is time that the Indian Railways should change to 60 kg rail section with 90 UTS fully killed steel for core routes. Indeed, according to one view, it might be desirable to adopt rails with a longer life. Rails released form core routes after relaying can be used on other less important non-core routes. We also recommend mechanisation of track relaying for the simple reason that we cannot afford to have traffic blocks on core routes long enough to complete the task under the existing Passenger Quick Relaying System (PQRS). It will be necessary to utilize a high performance track relaying system to yield an output of at least 1 km per day. The additional advantages are higher output, more uniform quality of relaying and full speed running of trains on completion of day's work.

13.18 The situation with regard to railway bridges also needs urgent attention as most of these bridges were built about 80 to 120 years ago. Quite a number of them are distressed requiring rebuilding or strengthening. The pace of bridge rehabilitation has been greatly accelerated in the last five years with the result that as on 1 April, 1987, there were only 1,046 distressed bridges on the entire railway network. At the pace of rehabilitating around 400 bridges per annum, no distressed bridge should remain unrehabilitated by 1990-91.

*Traction*

13.19 Indian Railways are planning to double the existing BG electrified network from 7,275 kms in 1986-87 to about 15,000 kms by the turn of the century. Most of the newly electrified routes will be the sides and diagonals of the Golden Quadrilateral with its vertices at Delhi, Calcutta, Madras and Bombay. Since the existing electric locomotives and electric multiple units indigenously manufactured are of two/three decades old vintage, it is necessary to upgrade their technology to reduce their power consumption and maintenance/operating costs as well as increase the reliability, availability and acceleration reserve of the traction units. Major design changes in regard to traction motors and bogies are needed to improve the availability of locos. It is also necessary to devise new ways of eliminating the present abnormal incidence of failure of ancillary motors to improve reliability of locos. The PGTR evaluated three major technologies introduced abroad, namely, (i) thyristor-controlled DC traction motor; (ii) asynchronous traction motor; and (iii) synchronous traction motor. It recommended the trial of asynchronous technology for suburban routes to begin with, in order to gain experience under Indian conditions. As regards AC freight locos, the Indian Railways have already planned to import 18 locos of 6,000 HP with thyristor-controlled DC motors. These locos will be tried out under Indian service conditions for about a year to evaluate the most suitable design for indigenous manufacture after technology transfer. The electrification programmes of the Railways should help minimise the consumption of diesel. Besides energy conservation, electric traction also avoids atmospheric pollution. In this context, our attention has been drawn to the high electricity tariff charged to the railways by some

of the State Electricity Boards. We recommend that the Central Government should use its good offices to persuade the State Electricity Boards to charge reasonable tariff for the supply of electric power for traction purposes. The rate charged should be related to actual cost of generation and transmission of power.

13.20 As regards diesel traction, it is important to stress the need for the design of a new generation of 4,000 HP locos in lieu of the existing 2,000 HP, ones manufactured at Diesel Loco Works, Varanasi, to move heavier freight trains of 5,000 tonnes gross weight. The PGTR's evaluation shows that one 4,000 HP loco is far superior to the two coupled 2,000 HP locos for identical freight operations.

*Signalling*

13.21 On a double line electrified section like Moghalsarai-Allahabad, a traffic density of 47 trains each way is the limiting threshold of the present system of "absolute block" working. To accommodate more trains, even a marginal increase of 10 per cent, two types of signalling reforms seem to be necessary - one at terminal nodes and the other at roadside stations. The problem at nodal points is their frequent holdups to train "for line" as the jargon goes. The line problem in such nodes is due to tremendous increase in the number of internal movements within the large yard of nodal points like Moghalsarai, Allahabad, Kanpur, etc. They are now being performed by a large number of scattered cabins. While growth of traffic has given rise to inevitable new movements, no attempt has yet been made to discard old obsolete movements like staff shuttles for carrying staff at every shift change in the yard. The obsolete movements like these should be discarded wherever possible. However, even if some of these obsolete movements are discarded; there seems no escape from centralising at one place all the yard movements now being executed by a large number of widely dispersed cabins by recourse to centralised traffic control in the nodal yards.

13.22 The need for other type of signalling reform at roadside stations arises from the fact that "absolute block working" now in vogue at these stations has reached its limit on crowded corridors. It is, therefore, necessary to replace the present system of manually-operated lock-block instruments with exchange of private numbers between adjacent stations by an automatic system with the provision of such modern devices as axle counters and LVCDs.

*Telecommunication*

13.23 Railways' Corporate Plan envisages the installation of an all-pervasive Operating Information System (OIS) in order to modernise its business operations. It contemplates the transformation of its existing *analoque* telecommunication network to the digital mode as a prelude to its installation at a cost currently estimated to be around Rs. 1,300 crore excluding the computer component costing around Rs. 500 crore. The proposed scheme involves heavy investments and needs careful evaluation. For example, most of the currently available analogue microwave-based system could be retained and supplemented to the desired extent by the digital system to replace the overaged analogue network for supporting the OIS network.

*Integrated Railway and Road Transport*

13.24 During the past decade or so, the Railways have been increasingly obliged to move traffic in wagon loads aggregated in full rake loads from one origin to a single destination without having to marshall mixed trains in intermediate marshalling yards. Because of this transition from piecemeal wagon load to block rake movement the Railways have increasingly tended to offload piecemeal wagon load traffic not readily amenable to the build-up of block loads to road. They have even closed several stations for acceptance of not only "smalls" or less than wagon load traffic but even wagon loads.

13.25 The outcome of this shift from wagon-load movement to block-load or train-load movement is that the bulk of railway traffic now mostly consists of seven bulk commodities viz. coal, steel materials, iron ore for export, cement, foodgrains, fertilizers, petroleum products. These seven commodities account for 80 per cent of its

total traffic. The remaining 20 per cent compendiously called "other goods" consist of commodities not readily amenable to movement in block loads. In absolute terms this traffic is still quite substantial over 25 million tonnes per annum. According to RITES' study, the traffic in "other goods" is expected to increase from 25 million tonnes to about 60 million tonnes by 2000 A.D. Any diversion of this traffic to road transport might not only entail higher cost to the economy and excessive use of high cost diesel, but also adversely affect railways' financial viability. Some of the following ways are likely to enable the Railways to carry their due share of other goods:-

(i) Revision of existing schedule to give priority to the loading of wagons destined to a single destination irrespective of their date of indent and commodity loaded. Some way of allowing the loaders on a collective basis the benefit of a train load rate instead of wagon load may also be devised.

(ii) Organising shipping or forwarding agents to offer train loads instead of wagon loads at major goods depots playing the role analogous to that of shipping agents vis-a-vis shipping in ports.

(iii) Use of truck/trailer combine provides an alternative method for integrated rail and road services. Cooperative societies and/or organised companies could possibly provide truck-trailer services which truck owners will find it difficult to organise.

(iv) Buildup of container transport on an extensive scale. This intermodal transport chain which permits movement of containers from the door- step of the shipper to that of the consignee has, in the past decade or so, expanded very fast in the developed countries. In India, however, the inter-modal concept has not yet caught on for various reasons. Although seven Inland Container Depots (ICDs) have been set up to facilitate movement of containers to inland destinations, most of the existing internal container depots are in the nature of pilot projects like the ICDs at Delhi and Bangalore. Moreover, to realise the full potential of the ICDs, it will be necessary to set up satellite Container Freight Stations (CFSs) as well. Even if there are 4 to 5 such CFSs per ICD, there will have to be roughly 100 CFSs for around 20 ICDs which is quite a modest number for a country of sub-continental size like ours. As a result, massive investments will have to be made in the next few years if the scheme is really to take off. Since such investments (of the order of Rs. 200 crore per plan period) cannot be made by any single public sector agency, it seems necessary to enlist private sector participation to bridge the resource gap. We, therefore, recommend privatisation of ICDs as well as the associated satellite CFSs.

*Investment Profile For Railway Modernisation*

13.26 PGTR Report has given an expose' of the available technologies for enabling the Railways to globally double the volume of both passenger and freight traffic by the end of the century. But it has not assessed the capital investment required to achieve this objective. As such, the Report has confined itself only to a review of the Railway's Corporate Plan for 1985-2000.

13.27 Railways' Corporate Plan envisages a total investment of Rs. 45,050 crore at 1984-85 prices. Of this Rs. 25,050 crore will be provided from internal resources (Rs. 21,900 crore from Depreciation Reserve Fund - DRF and Rs. 3,150 crore from other funds like Development Fund DF), Open Line Works Revenue (OLWR), and the balance of Rs. 20,000 crore is to be provided as fresh capital investment from the General Revenues. This investment profile assumes that it will be possible to achieve an operating ratio of 80.7 per cent after providing adequate contribution to DRF. It also provides for payment to General Revenues a dividend of Rs. 1,885 crore per annum at 6.5 per cent on the increased capital-at-charge which will be Rs. 29,000 crore in 2000 A.D. As shown in Table 13.2 below, a small deterioration in the operating ratio, say, from 82 to 85 per cent will suffice to reduce the admissible additional capital from Rs. 20,000 crore envisaged in the Corporate Plan to Rs 15,000 crore. This is merely to say that the range of phase transition of the proposed capital investment becoming

remunerative or otherwise is very narrow so that a slight fluctuation of operating ratio decides whether the proposed investment will pay or not.

TABLE 13.2 ESTIMATES OF RAILWAY RESOURCES FOR INVESTMENT

(Rs in Crore)

| Operating ratio (Per cent) | Net earnings | Total admissible capital-at- charge | Existing capital-at-charge | Additional capital-at-charge admissible for investment |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| 80 | 2,254 | 32,200 | 8,286 | 23,914 |
| 81 | 2,142 | 30,600 | 8,286 | 22,314 |
| 82 | 2,029 | 28,985 | 8,286 | 20,699 |
| 83 | 1,916 | 27,371 | 8,286 | 19,085 |
| 84 | 1,803 | 25,757 | 8,286 | 17,471 |
| 85 | 1,691 | 24,157 | 8,286 | 15,871 |
| 86 | 1,578 | 22,542 | 8,286 | 14,256 |
| 87 | 1,465 | 20,928 | 8,286 | 12,642 |
| 88 | 1,352 | 19,314 | 8,286 | 11,028 |
| 89 | 1,240 | 17,714 | 8,286 | 9,428 |
| 90 | 1,127 | 16,100 | 8,286 | 7,814 |
| 95 | 563 | 8,052 | 8,286 | Nil |

13.28 The Railways must, therefore, conserve capital fund to be utilised for capacity works like electrification and doubling of crowded routes to the exclusion of other dispensable works like OIS, high speed corridors, heavy freight speed trains at 90 kmph and the like even if they are considered otherwise desirable. It will not suffice to be merely selective in the choice of capacity-enhancing capital works. It will also be necessary to economise expenditure as well as enhance revenue. For this, the Railways should do three things. First, they should close uneconomic branch lines especially those that serve no purpose now. Second, they should relate their tariff for passenger and freight traffic to the costs of haulage. Third, they should get organised to carry "other goods" traffic particularly along long distance routes. The last mentioned aspect has already been dealt with in the previous sections. In the following paragraphs we will discuss the other two aspects.

*Pricing Policy of Indian Railways*

13.29 Pricing Policy of Indian Railways for freight traffic was reviewed for the first time after Independence by the Freight Structure Enquiry Committee (1955-57) under the Chairmanship of Justice A. Ramaswami Mudaliar. This was followed, over two decades later in 1977-80, by the Rail Traffic Enquiry Committee (RTEC) headed by Dr. H.K. Paranjape. While the Mudaliar Committee dealt with freight structure for the carriage of goods traffic only, the scope of the Paranjape Committee was much wider. It covered the entire range of railway tariffs from freight rates to passenger fares, to tariff for coaching traffic like parcels, tourist cars and the like. Pricing Policy of Indian Railways is thus obviously too complex a topic with too wide ramifications to be part of our brief. We have, therefore, confined ourselves to making the following two general observations on this important aspect of railway operations:

(i) Our first observation is that of the two broad categories of services provided by the Railways viz. coaching and goods, the former is a parasite of the latter. In the year 1984-85, for example, coaching expenses (Rs. 2,623 crore) exceeded earnings (Rs. 1,691 crore) by Rs. 932 crore. Nearly 60 per cent of this aggregate loss was contributed by 1st and 2nd Class ordinary passengers. The losing items of freight traffic are listed in Annexure 13.1 showing a total loss on this account of Rs. 173 crore in 1984-85. As such, the total loss incurred on both passenger and freight account was Rs. 1,105 crore in 1984-85. If all traffic carried below cost by the Railways were to be charged its haulage cost, this would have resulted in an additional gross revenue earnings of Rs. 1,105 crore in

1984-85. As a result, the operating ratio would have been 79.55 instead of 96.25. The main cause of the heavy losses on coaching services appears to be the extremely low charge for ordinary 2nd class as compared to 2nd class Mail/Express fare and even the bus fares. Annexure 13.2 shows the ordinary 2nd Class rail fares for various distances compared with the corresponding Mail and Express fares as well as bus fares charged in various States. It shows that ordinary 2nd Class fares are actually one half to two-thirds of the Mail and Express fares for leads up to 500 kms. The Mail and Express fares are generally close to the prevailing bus fares in most of the States. We, therefore, wish to point out that there is scope for reducing the differential between ordinary and Mail/Express fares for 2nd Class with a view to bringing them close to the actual cost of providing these services. If the rates charged are uniform for all trains, the operating ratio would be reduced by about 8 to 9 points as shown in Annexure 13.3. In view of the qualitative differences in the services provided in ordinary and mail/express trains, a total elimination of the fare differential would not perhaps be desirable, but the present differential should certainly be reduced significantly. Moreover, the recent fare structure on mail/express trains should also be reviewed to relate it more closely to the cost of services and the extent of comfort provided in various classes of travel. In regard to goods tariff, it will be observed from Annexure I that a number of commodities are carried by the Railways at a loss. The total loss on this account in 1984-85 was estimated at Rs. 173 crore. The goods tariff structure also needs a careful review to reduce losses and to bring tariff closer to costs. Only in exceptional cases, the Railways should be called upon to carry goods below cost, say for example, to optimise capacity utilisation or build up future traffic. Any subsidies involved in railway haulage in the larger public interest should be taken care of by the Government and met from the General Exchequer.

(ii) Our second observation is concerned with the issue of staff cost due to "overstaffing" on the railways. The question was considered by the Paranjape Committee and its main conclusion was that "any retrenchment in staff is not a practicable proposition. The question of staff cost has more recently been reviewed in the Railway Board's Corporate Plan for the period 1985-2000. Its main conclusion is reproduced below for ready reference:

"Staff cost constitutes about 46 per cent of the total working expenses. In recent years, staff cost, at constant price, has risen sharply due to increase in real average wages per employee. Further increase in real wages over the years would take place on account of rising standard of living and changes in composition of work force. The Railways would, therefore, have to control their staff strength in order to be able to achieve reduction in staff cost per unit of traffic. With improved technology, more efficient methods and better trained work force, it would be possible for the Railways to carry the additional traffic over the next 15 years - without any significant increase in staff strength (not more than 0.3 per cent per year). It is estimated that with this measure, it would be possible to reduce staff cost per unit of traffic by about 20 per cent in real terms, over the next 15 years".

This conclusion of the Railway Board has been reached by viewing staff productivity as mandays per unit of traffic, that is, passenger/tonne kilometre. But, in the context of technological modernisation there is a more valid way of measuring staff productivity as mandays per train kilometre. Annexure IV shows the staff productivity in terms of train kms per manday on a number of railways. We must, however, acknowledge that such comparisons between different railways of the world are valid *ceteris paribus*, even though other conditions assumed to be alike are seldom so. For example, in many countries the railways do not take into account the labour employed in production units and, in some cases, even track maintenance and other

jobs are done through contractual arrangements rather than departmental. Nevertheless, one can always make allowance for different conditions and arrive at sone indicative though imprecise conclusions.

*Labour Productivity*

13.30 A glance at Annexure 13.4 will show, staff-wise, the Indian Railways' productivity is the lowest in the world. It is barely one fourth of the railways in the developed countries like the USA and Canada. Even if the Indian Railways succeed in achieving the goal set in its Corporate Plan 1985-2000, (increase of 0.3 per cent per annum during the next 15 years or aggregate increase of 4.5 per cent) the expected staff productivity would improve from 0.92 to only 1.7 train km per manday, which will still be much lower as compared to many other countries. The main point at issue here is that technological modernisation of Indian Railways and staff conservation, let alone a marginal increase therein as envisaged in the Corporate Plan, are two incompatible goals. Let us consider, for instance, track maintenance technology on a busy corridor like Mughalsarai-Delhi. It has to be technology intensive for the simple reason that traffic flow does not allow the traffic blocks required for the current labour intensive technology to work at all. The same applies to the phasing out of steam traction by introduction of diesel/electric traction. The changeover from steam to diesel/electric traction should have reduced significantly the manpower requirements. But there is no evidence that this has happened so far. On the contrary, the system appears to be overmanned. A single instance will illustrate the extent of overmanning in this sphere. Currently, the Indian Railways employ about 50,000 staff to service 3100 diesel locomotives in 30 major/minor maintenance facilities. The Conrail system in the USA by contrast, employs a staff of about 2,600 to look after 2,600 locomotives with only one workshop. Such overmanning in varying magnitude occurs also in other areas, such as diverse computerisations now under way like passenger train reservations, inventory control, compilation of operating information and the like. These new technologies cannot yield their optimum benefits without phasing out the large unskilled and semi-skilled labour that is presently employed. In most cases it is not possible to retrain the old staff to work the new machines as, for example, the permanent way gangman to work the *hi tech* machine for track relaying. Besides, even if that could be done, those requiring retraining would be a tiny fraction of the numbers rendered surplus. If the Railways are to be modernized as contemplated, they will have to retrench the enormous manpower made redundant by the switchover from earlier obsolete labour-intensive technologies to their modern *hi tech* capital-intensive substitutes. Otherwise, there is a serious hazard of the unpruned dead wood smothering, or at any rate greatly attenuating the modernisation process under way.

Even if we managed to double our train kms by 2000 A.D. without any increase in manpower, staff productivity would only be 2 x 0.92 = 1.84 train km per manday, which is below that of the developed countries like the USA and Canada. Hence if we aim at even a modest productivity target of 2 train kms per manday, we will have to shed at least 100(1 - 92) = 8 per cent of the surplus staff, instead of increasing it by 4.5 per cent as envisaged in the Corporate Plan. The total annual saving in staff cost by this modest reduction of 8 per cent will amount to Rs (0.08)(1,536,000)(25,000) = Rs. 307 crore.

13.31 We are, of course, aware that retrenchment of surplus staff even to the extent of 8 per cent "is not a practicable proposition" as stated by the Paranjape Committee. But this is not to suggest that the Railways should not make even a long-term plan to contain their staff strength within reasonable limits, say, by the turn of the century. As mentioned above it is necessary to achieve a modest reduction of staff by about 8 per cent. This requires the formulation of an appropriate personnel policy based on:

a) a careful review of staff recruitment in diverse categories particularly in obsolete categories or likely to be obsoleted by technological upgradation; and
b) offer of attractive incentives like "golden hand-shakes" to induce staff of obsolete categories to seek premature retirement voluntarily.

*Gauge Conversion*

13.32 As mentioned earlier, it will be necessary for the Railways to economise on expenditure incurred, among other things, on gauge conversion and uneconomic lines. Both issues have been considered by a number of expert committees from time to time. As regards gauge conversion, a policy decision was announced in the Parliament in 1971 that every new line in future would be built as broad gauge and the existing metre gauge network would be progressively converted to broad gauge so that ultimately the entire railway network becomes of one gauge. But the implementation of the unigauge policy has since encountered serious difficulties. In view of the prevailing resource constraint, a welcome shift has now taken place in gauge conversion policy. It is felt that it is far cheaper to increase throughput on a high density metre gauge route by its technological upgradation than by its conversion to broad gauge. It can be shown that the reckoned optimum capacity potential of a single line MG section is around 10 million GMT per annum in the loaded direction. Judged by this acid test, none of the high density MG routes is yet eligible for gauge conversion by a long way. The highest density is still only 5.3 GMT per annum on the 22 km long double line Kishangarh- Mander Section on the Western Railway. The next highest density is 4.9 GMT per annum on the Western Railway. We, therefore, recommend that having regard to our permanent resource constraint the policy of conserving the existing MG network and increasing its capacity, where required, by technological upgradation, should stay.

*Uneconomic Lines*

13.33 Let us now examine the question of curtailing the existing losses incurred on operating uneconomic lines by closing them. This question has been examined *ad nauseam* by no less than seven high-level committees beginning with the Committee on Transport Policy and Coordination in 1959 and more recently by the Railways' Reform Committee in 1983. All of them, with the sole exception of the Uneconomic Branch Lines Committee of 1969 have recommended their closure in some cases with the caveat that if any State Government objects to their closure it should bear the operational loss. Unfortunately, the debate whether to close them or not continues till today without any decision. We consider the time for deciding the issue has come now, and these decisions could be taken along the lines recommended by the Railways' Reform Committee (RRC).

13.34 RRC classified 136 uneconomic lines into four categories as follows:

(i) Category I consisting of 40 lines to be closed forthwith in view of the availability of adequate road services to meet full requirements of the areas concerned.

(ii) Category II consisting of 17 lines all in Gujarat; considered eminently eligible for closure especially as they are served by parallel roads some of which may need to be strengthened because they are "Kutcha" roads temporarily unserviceable during the monsoons.

(iii) Category III consisting of five lines since surveyed for conversion to BG. Since only three of them have been selected for conversion to BG, the remaining two, namely, Raipur-Dhamtari (89 km NG) and Madurai-Bodinayakkanpur (90 km MG) should be closed.

(iv) Category IV consisting of 74 lines not recommended for closure for strategic and other valid reasons.

13.35 The Railway Board have already accepted the recommendation of RCC not to close the 74 lines in Category IV. It is time that the Board consider RCC's detailed recommendations to close the lines in Categories I to III. In case any State Government persists in its objection to the closure of any of these lines, the line may continue operating by deducting in full the loss incurred in running it from the grant payable to the State in lieu of passenger fare tax fixed by the Finance Commission. According to a statement of grant payable to each State (See Annexure 13.5) vis-a-vis the loss on 40 uneconomic lines listed in Category I, the total annual grant-in-aid to the State in lieu of passenger fare tax fixed by the Finance Commission was Rs. 23.12 crore as

against the total annual loss of only Rs. 4.96 crore on category I uneconomic branch lines in 1981-82. The losses on the remaining 19 lines amounted to Rs. 2.67 crore per annum. Thus, the total losses in 1981-82 on the 59 lines recommended for closure were Rs. 7.63 crore whereas the grant-in-aid for the affected States exceeded the amount of losses by a factor of three.

13.36 In conclusion, we would like to suggest that while uneconomic lines should be closed, new lines must not be constructed or even surveyed except on the basis of a long-term overall perspective plan for the expansion of the railway network as a whole. The practice of surveying or constructing new railway lines merely as additional spurs to existing lines on an *ad hoc* basis and on local/parochial considerations must be eschewed. For, as was pointed out in the Seventh Five Year Plan 1985-90 Volume II, the traditional practice of laying additional trackage on existing trunk routes to create extra capacity has now reached a transition point of diminishing returns. It must give way to the development of alternative routes. Such an approach would enable the provision of "missing links" which could serve the following three purposes at one stroke, : (a) reduce transport effort and its cost; (b) open new areas; and (c) relieve congestion on crowded routes. A concrete example will clarify the position. A new line connecting Talcher to Sambalpur is a better alternative to the creation of more capacity on the existing highly saturated route Talcher to Sambalpur via Talcher-Khurda Raod-Kharagpur-Jharagudha-Sambalpur. We consider that the time has now come to draw detailed concrete plans to operationalise the abstract idea mooted in the Seventh Five Year Plan referred to above. It will ensure that the extension of the railway network in future proceeds on the basis of a well conceived overall plan instead of the present *ad hoc* style of adding short spurs, disconnected from the mainstream, which do not add to system capability and result in operational losses.

### XIV ROADS AND ROAD TRANSPORT

The first major attempt on the part of the Government in planning for road development was the so-called Nagpur Plan (1943) which presented a twenty-year plan for the period 1941-61 assigning a functional classification to the road system consisting of national highways, state highways, major district roads, other district roads and village roads. Subsequently, due to the rapid agricultural and industrial development of the country, the need for a second twenty-year road development plan was realised. The Bombay Plan for the period 1961-81 was thus introduced with the basic objective of raising the density of road mileage from 26 to 52 miles per 100 square miles of the area.

*Present Status*

14.2 Since the beginning of the First Five Year Plan in 1950-51, there has been a steady and significant expansion of road development with the result that the total road length in the country at the end of the Sixth Plan was about 18 lakh kilometres (including 47 per cent surfaced) as against 4 lakh kilometres in 1950-51 (including 39 per cent surfaced). The growth of road network over the period 1950-51 to 1984-85 is indicated in Table 14.1:

TABLE 14.1 LENGTH OF ROADS 1950-51 TO 1984-85

(in thousand kms)

| Year (1) | Total (2) | Surfaced (3) | Unsurfaced (4) |
|---|---|---|---|
| 1950-51 | 397.6 | 156.1 (39.3) | 241.5 (60.7) |
| 1960-61 | 705.0 | 234.4 (33.3) | 470.6 (66.7) |
| 1970-71 | 917.0 | 397.0 (43.3) | 520.0 (56.7) |
| 1980-81 | 1,534.3 | 658.1 (42.9) | 876.2 (57.1) |
| 1984-85 | 1,772.2 | 833.0 (47.0) | 939.2 (53.0) |

Note: Figures in brackets indicate percentage of total

*Deficiencies in the Road System*

14.3 Although there has been a sizeable expansion in the road length, nearly 36 per cent of the villages in the country are still without road connection and two-thirds of the villages are without all-weather roads. Only about 47 per cent of the road length is provided with a proper surface. The road density is only 0.46 km per sq. km. National Highways constitute only 2 per cent of the total network although carrying nearly 40 per cent of the total road traffic. Nearly 30 per cent of the length of national highways has a single-lane road pavement. At least one km out of every 3 kms of national highways is in need of urgent attention due to cumulative neglect of the past two decades. In the case of state highways which are mostly of single lane width (91 per cent), it is estimated that 3 kms out of every 5 kms have poor riding quality and below standard geometrics.

14.4 The steep rise in traffic during the last decade, overloading of commercial vehicles and gradual use of multi-axled vehicles, have exposed the major weaknesses of the road system. As per the assessment made by the Roads Wing of the Ministry of Surface Transport, there are still 129 kms of missing links on national highways, 5,487 kms need widening from single lane to two lanes and 1,794 kms require widening from 2 to 4 lanes, 16,046 kms need pavement strengthening, 191 towns require by-passes, 379 railway crossings need overbridges and 1,724 bridges require reconstruction.

14.5 The inadequate capacity, insufficient pavement thickness and poor riding quality have led to increased cost of operation of vehicles, reduced travel speeds, wastage of fuel resources, a large number of road accidents and degradation in environment. According to 'Road Users' Cost Study' (1982), fuel wastage alone costs Rs. 500 crore a year apart from losses in the form of tyre consumption, extra wear and tear of vehicles and their operating costs which total up to Rs. 2,000 crore per annum. The economic loss due to accidents has been estimated at around Rs. 400 crore per year and is mainly attributed to bad roads.

*Future Road Network*

14.6 The Ministry of Surface Transport (Roads Wing), at the request of the Steering Committee, has identified heavy density traffic corridors for the base year 1985 and for the horizon year 2000. The list prepared by the Ministry is based on the traffic census data collected on national highways in 1985-86 and future projections of traffic assuming an annual growth of 7.5 per cent for cars, buses and trucks (there is already evidence of traffic growing at the rate of 15 per cent in certain corridors) and 10 per cent for motor cycles and scooters. Table 14.2 summarises the emerging position.

TABLE 14.2: TRAFFIC VOLUMES IN THE YEARS 1985, 1995 AND 2000 - ALL INDIA

| Traffic Density (in PCUS) | Length of heavy density Road Corridors (in kms) as in the year | | |
|---|---|---|---|
| | 1985 | 1995 | 2000 |
| 10,000-15,000 | 5,278 | 5,807 | 4,472 |
| 15,001-20,000 | 1,861 | 4,942 | 3,835 |
| 20,001-25,000 | 935 | 3,195 | 3,815 |
| Above 25,000 | 497 | 4,788 | 10,278 |
| Total | 8,571 | 18,732 | 22,400 |

14.7 In the year 2000, the total length of roads having daily traffic within the range of 10,000 - 25,000 passenger car units (pcus) and beyond 25,000 pcus will come to 22,400 kms. The capacity of a two-lane section is assumed to be in the range of 10,000 - 15,000 pcus. Thus, nearly 18,000 kms of the present network will need to be widened to four lanes by the year 2000. For such corridors where traffic volume is likely to exceed 25,000 pcus, it will be desirable to plan for limited access highways.

14.8 The critical sections in fourteen corridors

where density of traffic is expected to increase to 25,000 pcus and above are the following: (i) Delhi - Ambala - Jalandhar - Pathankot - Jammu; (ii) Delhi - Ghaziabad - Meerut; (iii) Delhi - Jaipur - Ahmedabad - Bombay; (iv) Delhi - Kanpur - Varanasi - Durgapur - Calcutta; (v) Bombay - Pune - Bangalore - Madras; (vi) Madras - Dindigul - Madurai; (vii) Bangalore - Coimbatore - Cochin - Trivandrum; (viii) Madras - Vishakhapatnam - Bhubaneswar - Calcutta; (ix) Agra - Indore - Nashik - Bombay; (x) Delhi - Hissar; (xi) Lucknow - Kanpur; (xii) Bangalore - Mysore; (xiii) Dhule - Nagpur - Raipur and (xiv) Hyderabad - Vijayawada (see Annuxure 6.7). According to the Ministry of Surface Transport, nearly 5,000 kms of Expressways would be needed in these corridors by 2000 A.D. Expressways besides facilitating speedy traffic will be conducive to introduction of multi-axled vehicles which should save fuel consumption and increase productivity of road transport. Detailed techno-economic studies should be undertaken in order to prepare a phased programme for the development of the system.

14.9 The expressways could be developed in stages i.e. a two-lane carriageway with proper traffic restrictions in the first phase (as is the practice in vogue in some countries like Korea and Philippines) with a second carriageway added in due course. However, expressways must have full access control and even four-lane routes would need to have partial access control. This is necessary to avoid ribbon development which has already reached alarming proportions along most national highways.

*State Highways and Major District Roads*

14.10 State highways and major district roads with an existing road length of 2.49 lakh kms play a vital role in providing linkage with the national highways, important towns of adjacent States and within the State. The major district roads not only traverse each district but also serve areas of production and markets. The development of these roads in the past has been rather slow (3.5 per cent per annum) whereas the traffic has been growing much faster at about 10 to 12 per cent per annum. By the year 2000, at least 25 per cent of the existing state highways should have two-lane pavement and about 50 per cent an intermediate (5.5 metres) pavement width. As regards the major district, roads, 25 per cent of their length should have an intermediate pavement width by 2000 A.D. Besides, a substantial expansion is needed of the existing network of state highways and major district roads, the former from 95,500 to 1,45,000 kms and the latter from 1,53,000 to 3,00,000 kms.

*Other District Roads and Village Roads*

14.11 There are 5.8 lakh villages of various sizes in the country, and only 35 per cent of them are connected by all-weather roads. The development of rural economy depends a great deal on the availability of proper road system. Besides, it provides gainful employment to millions of unemployed and under-employed rural population. Government has given special attention to the development of rural roads by including them under the Minimum Needs Programme (MNP). As a consequence, outlays are earmarked and funds cannot be diverted to other sectors. Rural roads are also constructed under the various programmes for alleviation of poverty initiated by the Government, such as the Rural Landless Employment Guarantee Programme (RLEGP), National Rural Employment Programme (NREP), Command Area Development (CAD), Tribal Development Plan, etc. It is, therefore, necessary that by the turn of the century, all villages with a population of 500 and above should be connected by all-weather roads. The road network should be so planned that an all-weather road is available at a distance of less than 3 kms in plain areas and 5 kms in hilly terrain. Road links in the hilly areas should be provided on the basis of groups of villages in view of low density of population in villages. Emphasis should be on the construction of at least bridle paths and foot-bridges in stretches with scattered population.

14.12 This is, no doubt, a stupendous task as it will involve doubling of rural road network from 10.99 lakh kms to 21.89 lakh kms. Plans for rural roads may be prepared on Statewide basis which should aim at optimisation of the network length

and integration of the rural road system with the secondary and primary road systems. Some of the roads for connecting small villages are likely to be low-volume roads and may remain so for the next 15 years. There is no need to commit large expenditure in acquiring a wide right-of-way and designing geometric elements for high speeds, etc. Many of these roads could have gravel layers on top, dispensing with costly materials.

*Maintenance of Roads*

14.13 The existing primary and secondary road systems which constitute the main road network of about 2.8 lakh kms carry maximum traffic, in terms of both volume and intensity of the axle loads. According to the Axle-load Survey conducted on the national highways under the auspices of the Roads Wing of the Ministry of Surface Transport, 25 to 30 per cent of vehicles plying on these roads had axle loads exceeding the permissible limit of 10.2 tonnes. Their damaging effect was estimated to be almost four to five times that of the permissible axle loads. Even the periodical surface renewals are not carried out to the desired extent. Proper maintenance of roads merits urgent attention of the Government in the interest of prolonging the life of the roads. The preventive maintenance will not only reduce the cost of operation of vehicles but will also prove to be a very cost effective option.

14.14 The maintenance situation of national highways and secondary roads is far from satisfactory. The maintenance needs are, at present, assessed on an *ad hoc* basis; there is no scientific assessment of these needs. The net effect is that even the meagre funds are not distributed according to priorities based on traffic intensities. So far as urban roads are concerned, inadequate storm water drainage facilities, indiscriminate and unplanned cutting of roads, etc. have affected smooth traffic flows.

14.15 The rural roads of about 9.13 lakh kms of length, constructed during the last decade under the Minimum Needs Programme and other Plan schemes, require to be maintained on a priority basis to avoid their disintegration. Besides, a change in the mix of vehicles is expected with more of mechanised vehicles like LCVs and tractor-trailers. Such vehicles, for fuel efficiency and reduced operating costs, will certainly require better maintained roads. It will, thus, be necessary to give high priority to proper maintenance and improvement of the roads already constructed.

14.16 Maintenance planning needs to be modernised by establishing a highway condition survey system as a routine exercise. There is, thus, an urgent need to introduce an efficient maintenance management system so that information is available, on a regular basis, relating to condition of the road network, maintenance requirements, and availability of tools and equipment. Efforts should be made to modernise maintenance techniques, besides effecting manpower planning, training and development. The maintenance management system involving collection, storage and analysis of a large volume of data should be gradually computer-based. It is suggested that a separate Maintenance Cell should be created under the Roads Wing headed by a chief engineer for attending to the tasks envisaged above on a full-time basis.

*Future Road System and Technology Upgradation*

14.17 The magnitude of traffic volume projected along the major road corridors and the introduction of inter-urban sections of expressways and highways by the turn of the century, call for adequate technological inputs in certain crucial areas viz., road design, pavement design, construction management, effective road maintenance, bridge engineering, highway safety, research and development (R & D), human resource development, etc. These measures are essential to reduce energy consumption, bring down vehicle operating costs, enable faster and safer travel, and ensure preservation of environment. Road designs must incorporate in-built safety measures in view of the mounting rate of road accidents. So far as existing roads are concerned, accident spots/sections should be identified and action plans drawn up for correcting the situation.

14.18 Lately, the global developments have brought into sharp focus significant effect of pavement conditions on the road user cost and the

desirability of optimising pavement investments in the overall interest of minimising total transportation costs. The pavements must be so designed as to withstand the projected heavy traffic and have a life of 15-20 years so that its maintenance is easy. In this regard, adequate quality control and proper time scheduling are essential. It should be made obligatory for the prospective contracting agencies to use modern equipment and employ qualified engineers for quality control. New specifications, improvised materials and revised methods of construction should be evolved.

14.19 The huge investment on modernisation of road system will prove futile unless effective traffic management measures are enforced. State Public Works Departments (PWDs) should have traffic management cells with requisite infrastructure, equipment and trained personnel for regular monitoring of traffic flow conditions, accident investigation and correction of bottlenecks to traffic flows, etc.

14.20 A large number of bridges have been built in the country since Independence. It is suggested that with the development of a computerised data bank, a system of regular monitoring of road bridges and cross drainage works should be introduced to enable timely detection of impending problems and carrying out rectification/preventive measures. Annual condition survey of the bridge structures should be taken up for identifying those needing strengthening, repair or replacement in order of priority. In case of new bridges, the thrust should be towards: (i) adoption of longer spans by using in-situ cantilever construction; (ii) introduction of computer-aided designs; (iii) changes in design practices to cater to heavier loads; and (iv) use of modern equipment.

14.21 So far as rural roads are concerned, material surveys and preparation of pavement designs and specifications appropriate to serviceability levels required and use of local low-cost materials for minimisation of cost, are necessary. Emphasis should be laid on developing appropriate technologies relevant to hilly terrains and plains, with due regard to the limited availability of construction equipment and related facilities and skills. It is recommended that a very effective system of review and getting feed-back information should be so developed that the specifications, standards and design procedures evolved are more realistic and based on actual field requirements.

14.22 There are a number of Highways Research and Traffic Research Stations under the State PWDs. Also there are numerous road laboratories engaged in day to day investigations, design problems and quality control. The role of these Research Stations becomes crucial in view of the increased highway construction activities especially under the Rural Roads Programme. The capabilities of the Research Stations will, accordingly, have to be augmented.

*Financing of Road Construction and Maintenance*

14.23 The investment on roads in the various Five Year Plans shows that the share of road sector has come down from 6.7 per cent in the First Plan (1951-56) to 2.9 per cent in the Seventh Plan. The share of National Highways in the Five Year Plans has declined progressively from 1.4 per cent in the First Plan to 0.7 per cent in the Seventh Plan in spite of the fact that they carry nearly 40 per cent of the total road traffic. The periodic maintenance of the system has been adversely affected due to paucity of resources. A stage has reached where the system has almost become obsolete, impeding the productivity in the road transport sector just at the time when the motor vehicle industry is on the threshold of technology upgradation.

14.24 A rough cost estimate by the Ministry of Surface Transport for the development of various categories of roads to meet the requirements of projected traffic over the period 1990-2000 A.D., comes to Rs. 67,000 crore (1987 price level). These estimates, prepared by the Ministry indicate the order of mangnitude if the road development requirements are to be met satisfactorily. The actual programme will, of course, be determined on the basis of a careful assessment of priorities and the extent of resources that can possibly be mobilised.

14.25 As regards the maintenance of roads, it has been observed that the allocation of funds has

not been commensurate with the norms worked out by the Technical Group set up at the instance of the Ministry of Surface Transport. The magnitude of gap varied from 17 to 31 per cent during 1980-85 in case of national highways and nearly 37 to 93 per cent in respect of State highways. The situation is still worse as regards the lower category of roads. According to a study made by the Transport Division of the Planning Commission, a sum of Rs. 2,500 crore (at 1986-87 price level) would be required to maintain the diverse categories of roads in a reasonably satisfactory condition.

*Need for Augmentation of Resource*

14.26 It is obvious that investment on roads would need to be considerably augmented. In view of the difficult resource position, it is extremely necessary to explore innovative avenues for mobilisation of resource apart from the usual plan resources. The Ministry of Surface Transport has come up with certain proposals which merit serious review and consideration. These are given below:

(i) Levy of an additional cess on petrol and diesel earmarked to be spent exclusively in road development.

There already exists a system of earmarking a small portion of the tax on fuel to the Road Sector, which came into operation in 1929, following the recommendations of the Jayakar Committee. The fund so created is called Central Road Fund which is non-lapsing and derives its revenue from customs and excise duty on taxed motor spirit. The fund is governed by a resolution of the Parliament. The rate of accrual to the Fund was initially 2 annas per gallon which was subsequently raised to 2-1/2 annas per gallon (3.5 paise per litre). Although the price of petrol has gone up to nearly Rs. 8.50 per litre, the cess continued to be 3.5 paise per litre till recently. Thus, in percentage terms, the cess has come down from 25 in 1931 to 0.4 in 1988. Keeping in view the growing demand from the Road Sector, the Parliament through a resolution approved in May, 1988 an enhancement of the levy to 5 per cent of the basic cost of petrol. Besides, diesel which was not used in the country in 1929, has also been brought within the purview of the Fund and a cess of 5 per cent of the basic cost of diesel has been levied. It is estimated that the hike in levy would net in nearly Rs 320 crore a year for credit to the Central Road Fund. It is for the first time that nearly 35.5 per cent of the accruals to the Central Road Fund has been set apart for the development of national highways. Even after this, nearly Rs. 200 crore are estimated to be available to the State for development of roads against the present allocation of Rs. 10 crore. While we welcome these steps to augment the resources of the Central Road Fund, we suggest that the Government should revise the constitution and functions of the Central Road Fund to be organised somewhat along the lines of the Highway Trust Fund in the USA. It is understood that the receipt from the federal motor fuel taxes (levied at the rate of 9 cents per gallon on gasoline) and the taxes on motor vehicles and automotive parts are credited to this Fund. The funds thus generated are required to be exclusively utilised for works related to highway development.

(ii) Another possible avenue for mobilisation of resources for the Road Sector could be the toll-based highway projects. The Government has already decided to invite private sector to take up construction of some of the toll-based highways projects. It is, of course, not yet clear as to how much contribution the private sector can possibly make with or without recourse to borrowing from banks and financial institutions.

(iii) Some additional resources could also be raised through the capital market by issuing bonds, etc. The Indian Roads Construction Corporation, a public sector undertaking under the Ministry of Surface Transport, could possibly be permitted to raise funds through market borrowings for taking up certain selected National Highway Projects as toll roads. Alternatively, on the lines of the Indian Railways Finance Corporation, Indian Highway Finance Corporation or some such agency could be set up for generating resources for the Road Sector. The Corporation could raise resources by floating Highway Bonds. It could service and manage the bonds and advance loans for toll-based National Highway Projects including bridges, and recover them through toll earnings together with interest.

14.27 Government could also consider making the road sector a part of the "Infrastructure Sector" so that the issue of Highway Bonds falls into the general policy of the Government of permitting Bonds to be floated for infrastructure development activities like railways, power, telephones. It is also suggested that road construction should be treated as an "Industry" so as to facilitate loans on easy terms to private/public sector undertakings for taking up toll-based highway projects.

14.28 As regards roads in the metropolitan areas, their benefits go to property owners as well as to trade, industry, employers, etc.. State Governments might examine the possibility of making these beneficiaries pay by imposing some kind of a cess which may be diverted towards financing of repairs and maintenance, replacement and construction of roads in the metropolitan cities.

14.29 As regards rural roads, apart from the funds earmarked as part of the Minimum Needs Programme and various rural employment programmes, beneficiary participation should be utilized as a supplementary funding source (direct and indirect). 'Shramdan' should be encouraged towards developmental infrastructure meant for use by the local population. Massive effort is called for to organise communities and mobilise people's contribution to rural development. Unless mobilisation of community's contribution is done on a major scale, we see little chance of any significant step up in rural road development in the country. State Governments may also consider introducing special schemes like Market Committee Fund Schemes which are already working satisfactorily in Punjab and Haryana and the Krishi Upaj Mandi Scheme of Rajasthan. The funds so collected could supplement the plan resources for construction of rural roads.

*Institutional Arrangements for Long-term Planning*

14.30 The Roads Wing of the Ministry of Surface Transport is primarily concerned with the planning, investigation, design, construction, maintenance and monitoring of national highways, besides roads of inter-state or economic or strategic importance in the State Sector. It is also supposed to act as a repository of technical expertise and disseminate technical know-how to various State PWDs and other agencies. It has, however, been observed that it is not fully equipped in respect of : (a) corporate planning; (b) transport planning and (c) technology upgradation. The Planning Cell in the Roads Wing is mainly concerned with routine and day-to-day planning activities relating to the current Five Year Plan. It is not presently equipped to undertake long-term perspective planning.

14.31 Likewise, the existing Traffic and Transportation Cell in the Roads Wing is engaged primarily in miscellaneous traffic engineering activities pertaining to road junctions, use of traffic control devices, road safety, etc., for the whole national highway system. There is need for organising continuous studies regarding road transport growth, origin-destination characteristics of truck traffic, modal changes in the rural areas, and operating costs of new generation of vehicles. This could help in evolving appropriate solutions to the problems facing the road sector. More stress should be laid on utilisation of the results of proven research for improving highway planning, design, construction and maintenance techniques.

14.32 As regards the Research and Standards Cell in the Roads Wing, at present most of its time is devoted to standardisation, drafting of specifications, ordinary research projects, general policy matters related to National Highway Development, preparation of miscellaneous technical circulars, etc. This cell would, however, need to give more attention to upgrading the technology in highway construction keeping in view the quality, cost effectiveness, time constraints, etc. required for the implementation of the proposed road development programmes.

14.33 Considering the shortcomings in the long-term planning for road development, it is recommended that a separate Research and Development Organisation should be set up under the Roads Wing with three different units dealing with corporate planning, transportation planning and technology upgradation. This organisation could virtually be a think tank' for road development unhampered with the routine work relating to national highway network. This should

be organised broadly on the lines of the Research and Development Office attached to the Federal Highway Administration in the USA. There should also be a separate unit in the Research and Development Organisation which should not only maintain effective coordination with the State Highway Departments, but also set standards for road construction, provide guidelines for surveys and investigations and maintain computerised data in respect of the State Highways.

14.34 In the States, by and large, a similar situation exists so far as long-term road planning is concerned. Even comprehensive traffic volume counts are not being conducted barring the case of one or two States. The data for intra-regional and other urban movements is also very sketchy. Necessary traffic studies which provide essential inputs for long-term planning of road projects should be carried out on a regular basis along the State Highways under the aegis of the Planning Wing of the State PWD. Simultaneously, capability has to be created for pragmatic use of the results of the research being carried out in various State Highway Research stations and laboratories. This emphasises the need for creating adequate organisational support for planning and designing of road projects at the State level. There should be a separate cell dealing with research and development in the highway department of each State and maintaining close coordination with the Research and Development Organisation recommended to be set up at the Centre.

14.35 Finally, it is noted that the highway sector has become diffused and fragmented. A number of Ministries are now involved in highway transportation with the result that there is no cohesive direction as regards policy planning, technical standard, highway safety, research and development. There is no single agency which is responsible for long distance arterial routes as well as roads in urban areas and development of rural roads. Earlier, the Roads Wing of the Ministry of Surface Transport served as a focal point under one roof. Logically speaking, the Roads Wing should be the nodal agency for overall coordination and policy in regard to highway transportation. This should cover not only, all categories of roads but also traffic and transportation planning, road transport and safety.

*Road Transport*

14.36 During the last four decades, road transport has come to occupy a dominant position in the overall transport system of the country. Freight traffic by road has increased from mere 6 billion tonne kms (BTK) in 1950-51 to an estimated 210 BTK in 1984-85 and passenger traffic from 23 billion passenger kms (BPK) to about 800 BPK during the same period. The share of road transport in the total traffic has increased significantly with a corresponding reduction in the share of the railways over the period. This is attributed mainly to the flexibility and reliability of road transport and the door-to-door service it provides at competitive costs. It may also, in some regions, be accounted for by inability of the railways to meet traffic demands because of their capacity constraints.

*Goods Transport System*

14.37 Road freight services are provided mainly by single truck owners in the private sector who own nearly 90 per cent of the total trucking fleet in the country. During the ten-year period, 1975-76 to 1985-86, the production of medium and heavy trucks has nearly doubled while that of the Light Commercial Vehicles (LCVs) has increased more than five-fold as shown in table 14.3 below. The total number of goods vehicles in the country increased from 3.50 lakh in 1975-76 to 8.30 lakh in 1985-86, i.e., by about 9.4 per cent per annuam.

14.38 The utilisation of vehicles fleet has been low: according to one estimate, it is not much more than 60 per cent. Main factors accounting for low utilization are: (i) a high proportion of overaged vehicles; (ii) absence of assured loads owing to individual truck owners being lone operators; (iii) poor facilities for loading and unloading at terminals leading to abnormal detentions; and (iv) detentions at multi-point octroi posts. Steps were taken recently to improve the productivity of road transport industry

through liberalisation of issue of national and zonal permits and abolition of octroi by as many as 19 States/Union Territories. More recently, the Government has also introduced the scheme for truck parking complexes to be set up at convenient locations with facilities for refuelling, supply of spare parts and repairs, etc. The Ministry of Surface Transport is required to meet the cost of the land and internal roads. The scheme is being implemented as a pilot project through the Truck Highways Amenities Societies (THAS), and needs to be extended to all the States in the country.

14.39 Transport Nagars are proposed to be set up in the outskirts of major cities to provide loading and unloading facilities, transport operators' offices, parking areas, services by banks, post offices, canteens, etc. An early implementation of the scheme by the State Governments should help create an environment for the formation of cooperatives of small truck operators. The truck owners', cooperatives could link up their operations closely with large undertakings to reduce their risks and costs and avoid unhealthy competition.

TABLE 14.3. PRODUCTION OF COMMERCIAL VEHICLES
(1975-76 TO 1985-86)

| Year | Total No. of vehicles registered | Production of medium and heavy commercial vehicles | Production of light commercial vehicles |
|---|---|---|---|
| 1975-76 | 3,50,393 | 24,483 | 6,666 |
| 1980-81 | 5,26,608 | 36,262 | 20,338 |
| 1981-82 | 5,86,672 | 46,633 | 26,981 |
| 1982-83 | 6,47,633 | 46,438 | 26,989 |
| 1983-84 | 7,19,000 | 42,027 | 28,970 |
| 1984-85 | 7,83,000 | 40,761 | 33,328 |
| 1985-86 | 8,30,000 | 42,956 | 36,528 |

*Regulatory Measures*

14.40 The Motor Vehicles Act, 1939 is being amended and the Bill shortly to be introduced in the Parliament incorporates several amendments liberalising the present regulations. Meanwhile, the Central Government through an Ordinance issued in January, 1986, has removed the ceiling on the number of national permits for public carriers to be issued by the State Governments and Union Territories. Permit holders are now authorised to operate in any five States subject to payment of multiple taxes. There has been a significant increase in the number of national permits since the removal of quota restrictions. In the country, as a whole, the number of national permits increased from 25,045 to 56,620 in a single year.

14.41 The liberalisation policy and removal of quota system have led to a significant increase in traffic on the national highways and State highways. It has been observed that as against 9,174 national permits issued by the State of Maharashtra, nearly 40,000 trucks with such permits issued by other States are plying on already congested roads in Maharashtra. A similar situation has arisen in other industrially advanced States. It is to be hoped that this will not result in any unhealthy competition for long distance haulage at the cost particularly of short haul services provided by the industry.

*Taxation*

14.42 The various taxes being imposed on road transport by the Central and State Governments and the local bodies are: (a) excise duties on chassis and components; (b) customs duties; (c) motor vehicles tax generally termed as road tax; (d) passenger tax and goods tax, either amalgamated with road tax or separately charged; (e) entry tax at the State borders; (f) toll tax levied at octroi checkposts; (g) toll levied at bridges wherever applicable; (h) sales tax (Central-States).

14.43 Road transport is one of the most heavily taxed industries. According to the Indirect Taxation Enquiry Committee (1977), a multitude of

taxes imposed by the Centre and the States affect its main capital goods, namely, trucks and buses as well as products consumed in its operation. Road transport also gets taxed as a service over and above the taxes paid on the products needed for its operations. During the last decade in particular, the taxes on motor transport have become a major source of resource mobilisation for the States. Table 14.4 indicates the extent of increase in revenues of the Union Government, States/UTs from taxes and duties within their share and control between 1974-75 and 1985-86.

TABLE 14.4 REVENUE RECEIPTS OF THE UNION GOVERNMENT, STATES AND UNION TERRITORIES FROM THE TAXES/DUTIES ON MOTOR TRANSPORT

| Taxes | 1974-75 (Rs in lakh) | 1985-86 | Compound Growth rate per annum (per cent) |
|---|---|---|---|
| (a) Union Duties | | | |
| (i) Motor Spirit | 83,58 | 3,28,70 | 13.3 |
| (ii) Diesel Oil | 1,76,74 | 8,41,24 | 15.2 |
| (iii) Motor Vehicles | 1,47,32 | 5,60,50 | 12.9 |
| (b) State Taxes | | | |
| (i) Motor Spirit (Sales Tax) | 3,85,00 | 7,54,62 | 6.3 |
| (ii) Tax on Vehicles | 25,00 | 22,72 | -(1.0) |
| (iii) Taxes on passengers and goods | 62,00 | 4,39,68 | 19.5 |

Source: I. Reserve Bank of India - *Currency and Finance Report* (1975-76 and 1985-86).
II. Indian Economic Statistics - *Public Finance* (December, 1987).

14.44 There are wide variations in the rates of taxes from State to State. For instance, a two-tonne goods vehicle in Delhi is required to pay Rs 310 per annum, as against Rs 3,600 in Rajasthan. No recent study has been made to determine the incidence of taxes on costs of road haulage. However, a study made in 1977 by the Indirect Taxation Enquiry Committee had shown that pervasive and multi-stage taxation on manufacture and sale of trucks and buses resulted in a cumulative levy amounting to 58.9 per cent of tax exclusive-price. Taxes on motor transport need to be rationalised both on social and economic considerations not only to reduce the cost of operation but also to ensure the development of an efficient and technology progressive road transport industry. The tax structure should support cost-effective modes of transport best suited for specific applications such as the higher pay load, multi-axled vehicles and truck-trailer combinations.

*Octroi*

14.45 While there is general appreciation among the State Governments of inhibitory nature of the octroi levied by the local bodies and the scope for malpractices it provides, there are still a few States where octroi continues to be levied. These are Punjab, Haryana, Jammu & Kashmir, Orissa, Rajasthan, Uttar Pradesh, West Bengal, Gao and Union Territories of Delhi, Daman & Diu, Pondicherry and Andaman & Nicobar Islands. There were recently strong agitations in Maharashtra by truck operators demanding the abolition of octroi and the State Government has finally announced its abolition from May, 1988. However, its actual implementation has been stayed for the present. The Ministry of Surface Transport will have to continue its efforts to pursue the abolition of octroi in States/UTs where it is still levied. The Ministry of Urban Development has recently constituted a Working Group to go into the question of exploring alternate sources of revenue for the local bodies in place of octroi. It is to be hoped that these steps would lead to abolition of this most irksome levy on road transport.

*Passenger Transport System*

14.46 Road passenger transport services are

being provided both by the public and private sectors in the country. In three States, namely, Gujarat, Maharashtra and Haryana there is a total nationalisation of stage carriage services. However, in the rest of the country, private sector still has a substantial share of operations. The share of nationalised buses in the country, as a whole, declined from 45 per cent in 1980-81 to nearly 39 per cent in 1985-86.

14.47 There is no uniform pattern of management of passenger bus services in the public sector. Some of the States have established Corporations under the Road Transport Corporation Act, 1950 while others are operating either through Companies registered under the Indian Companies Act or departmental undertakings or local bodies. There are wide differences in the performance, efficiency and productivity of the State Transport Undertakings (STUs). Most of them face serious financial constraints as they need fresh capital contributions from Government for augmentation and replacement of their overaged buses and expansion of the fleet. In 1985-86, the percentage of overaged buses with STUs was as high as 51 in North Bengal, 42 in Kerala, 29 in UP and 26 in Rajasthan.

14.48 A scheme for the establishment of the Central Road Transport Development Finance Corporation has been under consideration of the Government of India for sometime back. The Transport Development Council has constituted a Working Group to identify possible additional channels of resources to fund the proposed Corporation. The Corporation is expected to assist the SRTUs in financing modernisation of their bus fleet.

14.49 One contributory factor for the poor financial position of the STUs is the heavy incidence of taxes levied on the various inputs for the road transport industry. Wide variations exist in the amount of taxes levied in different States. Thus, the tax burden per bus (including motor vehicle tax and passenger tax) in 1986-87 was estimated to be of the order fo Rs 47,000 in Tamil Nadu, Rs 48,000 in Andhra Pradesh, Rs 85,000 in Gujarat, Rs 91,000 in Rajasthan and Rs 1,87,000 in Haryana. The incidence of tax per bus, on an average, went up from Rs 50,900 to Rs 67,500 during the period.

14.50 As discussed earlier, appropriate measures need to be taken urgently to rationalise taxation of road transport industry. A substantial relief in tax burdens of STUs might enable them to increase their supplies and save funds for better maintenance and replacement of vehicles. The management structure of STUs also needs to be reviewed to give them greater autonomy in the pattern of services provided, fare structure and personnel management. Productivity of some of the STUs is fairly low and concerted efforts need to be made to increase their efficiency of management.

14.51 Financial constraints of the STUs are not likely to ease significantly in the coming few years. Passenger travel demands, on the other hand, are increasing with the growth of urbanisation and changes in lifestyles of people. The railways, owing to their capacity constraints and shortage of coaches and locomotives, are unable to meet the demands of passenger travel. Indeed, the railways in the interest of their financial viability, should divert short distance passenger traffic to road transport wherever possible. These considerations should point to the imperative necessity of increasing the participation of the private sector in road transport services. The State Governments should therefore, take a flexible approach and even the States with commitments for hundred per cent nationalisation should reorient their policies to permit operations of private services. Indeed, the coming decade presents an opportunity and a challenge for promotion of private sector participation both in freight and passenger transport in an organised way.

*Urban Transport*

14.52 As explained in Chapter II, urban population in the country has been increasing rapidly and if the present trends continue, one-third of the country's population will be living in urban areas by the year 2000. The increasing trend of urbanisation has led to a rise in the inter-urban and intra-urban movement of goods and passengers. It is observed that the overall journey speeds at present in large cities have declined to 20 to 25 kmph; while in central business areas, these are

as low as 5 to 12 kms per hour. The accident rate too in cities has gone up to 33 per cent of the total number of accidents in the country. The major deficiencies in the cities are: (i) narrow width of roads; (ii) inadequate right-of-way; (iii) poorly designed intersections; (iv) lack of segregation of traffic, etc.

14.53 According to a study of travel characteristics, nearly 124 (BPK) of travel was made by public transport in 1985 out of which buses accounted for 86 BPK (69 per cent). This is projected to increase to 362 BPKm in 2001 of which the share of buses is estimated to be 264 BPK (73 per cent). This represents an almost three-fold increase in passenger traffic. In order to manage such a large volume of passenger movement, it is necessary to provide efficient and adequate bus services in the cities. Such a policy alone can help dissuade people from using personalised transport and keep the fuel consumption, traffic congestion, pollution and road accident problems within manageable limits. A few metropolitan cities may have to go in for grade separated rapid transit systems. The Study Group established by the Ministry of Railways has already gone into the question of exploring alternative systems of urban transport which could be developed to meet the requirements of commuters. Meanwhile, the present road system in the cities needs to be modernised so that the existing deficiencies and bottlenecks are removed. As a first step, we would urge that in cities, especially with a projected population of 2,50,000 and above, the authorities should carry out comprehensive traffic and transportation studies through traffic cells consisting of town planners and traffic planners. Such surveys should help identify the nature and scale of the problems and prepare long-term transportation plans for the cities. Meanwhile, measures of immediate and medium-term nature involving simple traffic engineering and management solutions should be worked out and implemented.

14.54 At the Centre, there is need to create an agency to provide technical guidance to urban traffic and transportation cells proposed to be set up in different cities. An inter-disciplinary body of experts representing, amongst others, the Ministry of Urban Development, Ministry of Surface Transport and the Railway Board, should monitor traffic-cum-land use studies for various cities and also provide technical advice to the State agencies.

*Road Transport Scenario in 2000 A.D.*

14.55 Projections for the year 2000 as worked out by the Planning Group on Road Transport (PGRT) assume a growth rate of 7 per cent per annum for goods vehicles, 8 per cent for buses, 7 per cent for cars, jeeps and taxis and 17 per cent for two-wheelers and 15 per cent for three-wheelers. Based on these growth rates, PGRT has worked out the projected vehicle population as given in Table 14.5.

TABLE 14.5 ESTIMATES OF VEHICLE POPULATION

(in lakh)

| Vehicle Type | 1985 | 1990 | 1995 | 2000 |
|---|---|---|---|---|
| Commercial vehicle (goods) | 7.83 | 10.85 | 15.21 | 21.34 |
| Buses | 2.13 | 2.78 | 3.86 | 5.46 |
| Cars, jeeps and taxis | 15.40 | 19.11 | 25.14 | 33.14 |
| Two-wheelers | 49.60 | 96.10 | 175.59 | 346.48 |
| Three-wheelers | 2.75 | 4.65 | 8.92 | 17.17 |

14.56 The Ministry of Surface Transport while agreeing generally with PGRT's projections of vehicles is of the view that freight services by road are likely to increase faster. Firstly, the urban population in the city is expected to increase significantly, which will lead to movement of greater quantities of agricultural and finished products between rural and urban areas. Secondly, there is likely to be a rapid change in the complexion of rural traffic due to improved system of rural roads. Better accessibility will lead to an increase in the number of mechanised vehicles.

*Upgradation of Technology and Modernisation of the Road Transport*

14.57 The upgradation of technology has assumed high priority particularly in respect of design of vehicles, both freight and passenger, suitable to the requirements of cities, rural areas and hilly terrain. Various suggestions that merit consideration for modernising the vehicle fleet are:

(i) Introduction of Multi-axled Vehicles and Tractor-Trailor Combinations for Freight Operations

For freight operations, it is necessary to evaluate the possibilities of greater use of multi-axled and tractor-trailor combinations in view of their inherent advantages of fuel efficiency, capability of higher pay load and reduced damage to the road structure. However, considering the poor state of roads in the country, a careful study of the various options needs to be undertaken and a rational fleet mix and axle-load policy arrived at. A study of modernisation of vehicles fleet is now underway under the auspices of the Ministry of Surface Transport and the World Bank. The study should provide a basis for a thorough over-haul of the vehicle manufacturing programme in the country.

(ii) Upgradation of Technology of Two-axled Trucks

The use of conventional two-axled trucks would continue for quite some time on the secondary road system and for medium and short-haul traffic. The present design of the conventional trucks is of obsolete technology. Some signs of technology modernisation are already visible in the case of light commercial vehicles. It is in the 10 tonnes payload category that modernisation is urgently called for. Steps should be taken immediately to introduce a new state of-art engine which is fuel-efficient and creates less pollution. It is also necessary to introduce light weight materials replacing the present heavy wooden bodies.

(iii) Introduction of the State-of-Art Buses

A large scale manufacturing programme for a variety of buses will have to be developed which would meet the requirements of people in the cities, rural areas, hilly terrain, tourists, etc.. The bus technology continues to be primitive and needs improvements in various directions including design of the chassis and bodies of the buses and to make bus travel more comfortable, safe and attractive. The aim should be to produce vehicles which meet the needs of efficiency economy in fuel and endurance. In this connection, the efforts of CIRT and Automotive Research Association of India constitute an important beginning in adopting advanced technology to suit Indian conditions. Government will also have to ensure development of ancillary industry for necessary supplies to the manufacturers.

(iv) Upgradation of Two-wheeler Technology

The sudden spurt in the use of two-wheelers in recent years particularly in large cities, has created problems. In the interest of fuel economy and cleaner environment, it is necessary to lay down that two-stroke cycle engines would not be allowed for engines of the size above 100 cc. A time limit could be prescribed for phasing out the less efficient engines and incentives offered for production of fuel efficient engines.

*Safety Aspects*

14.58 The growth in vehicle population and limited road capacity has led to a large increase in the number of road accidents. Latest estimates indicate that 40,000 persons were killed and more than a lakh injured during 1986. The economic cost of the accidents is estimated to be about Rs 400 crore. The rate of growth of the number of persons killed during the last decade is more than 8 per cent annum. An international comparison of the accident rate shows that per 10,000 vehicles, the number of accidents is the highest in India, i.e. 45 compared to be below 5 in the developed countries.

14.59 There is now a growing awareness on the part of Government to tackle the problem of accidents on an urgent basis. A National Transportation safety Board has been set up for covering all modes of transport. For roads, a National Road Safety Council has been constituted and steps are being taken to set up State Road Safety Councils. Similarly, at the district level, district road safety committees are to be constituted. A highway safety code should also be evolved for

the country. The Government should introduce legislation to ensure uniformity in the country in respect of rules pertaining to manufacture of equipment and maintenance of motor vehicles. Funds for execution of the schemes for promotion of safety might be raised by earmarking fixed percentage of the revenues realised form motor vehicles taxes and central contribution for schemes like Highway Patrolling Scheme, etc.

*Conclusion*

14.60 Long-term policies for road transport must be oriented with a view to encourage expansion of well organised road transport services as an integral part of the country's transport system. It is particularly important to modernise design of vehicles, both passenger and freight.

14.61 The road transport industry currently is facing numerous problems which affect its commercial and financial viability. In particular, the obsolete technology of vehicles, unhealthy regulatory practices, heavy incidence of taxation, scarcity of institutional finance and disorganised state of the industry constitute serious difficulties in the way of expansion of road transport industry in future. In fact, already the market for vehicles manufactured in the country has shown signs of stagnation. It is imperative, therefore, that a detailed review is made of the current unhealthy trends and concerted efforts undertaken to improve the environment for a healthy growth of road transport industry to enable it to perform its appropriate role in the country's transport system.

14.62 There exist serious data gaps in regard to freight operations, particularly in respect of ownership pattern on commercial vehicles, fleet strength, fleet utilisation, cost of operation, tax structure, load carried, proportion of empty trips, age spectrum of vehicles, etc. The Ministry of Surface Transport propose to establish a National Institute of Road Haulage to cater to the requirements of trucking industry and to collect and analyse data on truck movements. The Institute should be able to develop a data base for the industry. We recommend an early implementation of the proposal.

FOOTNOTES

1. Railway Division Chairman's address presented at an ordinary meeting held in London on 22.9.86 by Mr. B.G. Sephton, C Eng, Fl Mech E, Traction Director, Brush Electrical Machines Ltd. Loughborough, Leicestershire.
2. Source: Business World June/July, 1986.
3. The rated capacity of the present BOXN wagon is 58 tonnes; but the actual capacity realised in practice is 55 tonnes. The average train length of a BOX wagon train is 45 wagons, but 56 BOX wagons can be accommodated in the standard loop.

ANNEXURE 5.1

COMPOSITION OF TRAFFIC (1986-87)

| Sl. No. | Commodity | Originating Tonnage (millions) | Tonne-Kms (billions) | Average lead (Kms) Rail | Road | Total |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1. | Foodgrains | 46 | 34 | 1,146 | 386 | 748 |
| 2. | Oil seeds | 6 | 3 | 1,311 | 362 | 311 |
| 3. | Cotton raw | 3 | 2 | 1,432 | 495 | 388 |
| 4. | Jute raw | 1 | - | 921 | 587 | 640 |
| 5. | Sugarcane | 1 | - | 133 | 207 | 183 |
| 6. | Tobacco | 1 | 1 | 1,139 | 502 | 383 |
| 7. | Fodder | 8 | 4 | 906 | 238 | 483 |
| 8. | Sugar khandsari | 10 | 6 | 1,067 | 363 | 606 |
| 9. | Fruits & vegetables | 14 | 8 | 1,480 | 484 | 547 |
| 10. | Livestock | 2 | 1 | 1,218 | 342 | 536 |
| 11. | Hides & skins | - | - | - | 1,507 | 287 |
| 12. | Milk & milk product | 1 | - | 1,814 | 353 | 359 |
| 13. | Coal | 120 | 82 | 717 | 469 | 482 |
| 14. | Iron ore | 22 | 7 | 325 | 373 | 327 |
| 15. | Manganese ore | 1 | - | 403 | 242 | 355 |
| 16. | Limestone & dolomite | 9 | 4 | 544 | 303 | 478 |
| 17. | Gypsum | 2 | 2 | 1,072 | 435 | 383 |
| 18. | Other stones | 14 | 4 | 418 | 242 | 377 |
| 19. | Other ore | 2 | 1 | 753 | 282 | 669 |
| 20. | Mineral oils | 30 | 13 | 504 | 271 | 429 |
| 21. | Edible oil | 4 | 3 | 1,379 | 517 | 732 |
| 22. | Iron & steel | 20 | 16 | 1,191 | 487 | 308 |
| 23. | Non-ferrous metals | 2 | 1 | 1,137 | 562 | 676 |
| 24. | Cement | 31 | 16 | 673 | 276 | 524 |
| 25. | Building material | 14 | 4 | 780 | 226 | 245 |
| 26. | Chemicals & drugs | 6 | 3 | 1,334 | 505 | 583 |
| 27. | Chemical manure | 24 | 17 | 939 | 292 | 706 |
| 28. | Paints & dyes | - | - | 920 | 627 | 652 |
| 29. | Coal-tar & bitumen | 3 | 2 | 760 | 312 | 653 |
| 30. | Bamboo, timber, other wood | 10 | 5 | 1,041 | 352 | 506 |
| 31. | Salt | 6 | 6 | 1,338 | 354 | 1,012 |
| 32. | Tea, coffee | 3 | 1 | 2,050 | 508 | 527 |
| 33. | Provision & household | 9 | 5 | 1,312 | 457 | 499 |
| 34. | Machinery & equipment | 3 | 2 | 868 | 642 | 710 |
| 35. | Elect. equipment | 2 | 1 | 1,281 | 555 | 687 |
| 36. | Tyres & tubes | 1 | - | 1,325 | 660 | 717 |
| 37. | Leather manufactured | - | - | 1,517 | 457 | 426 |
| 38. | Footwear | - | - | 1,248 | 598 | 614 |
| 39. | Automobile & parts | - | - | 1,372 | 820 | 827 |
| 40. | Cycle & cycle parts | - | - | 1,234 | 856 | 872 |
| 41. | Cotton manufactured | 3 | 2 | 1,538 | 552 | 568 |
| 42. | Jute manufactured | 1 | 1 | 1,330 | 556 | 747 |
| 43. | Paper | 3 | 2 | 1,342 | 509 | 704 |
| 44. | Other commodities | 39 | 27 | 1,027 | 545 | 679 |
| | Total | 479 | 290 | 778 | 406 | 605 |

Note:- Indicates less than 1, i.e., negligible.

ANNEXURE 5.2

COMMODITY-WISE SHARES-TOTAL TRAFFIC

| Sl. No. | Commodity | Commodity-wise Share (%) of Traffic in Terms of | | | | | |
|---|---|---|---|---|---|---|---|
| | | Tonnes | | | Tonne-Kms | | |
| | | Railways | Highways | Total | Railways | Highways | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1. | Foodgrains | 8.49 | 10.67 | 9.51 | 12.51 | 10.16 | 11.78 |
| 2. | Oilseeds | 0.34 | 2.08 | 1.16 | 0.58 | 1.85 | 0.98 |
| 3. | Cotton raw | 0.11 | 1.22 | 0.63 | 0.21 | 1.49 | 0.61 |
| 4. | Jute raw | 0.04 | 0.22 | 0.12 | 0.05 | 0.31 | 0.13 |
| 5. | Sugarcane | 0.16 | 0.38 | 0.26 | 0.03 | 0.20 | 0.08 |
| 6. | Tobacco | 0.05 | 0.48 | 0.25 | 0.08 | 0.59 | 0.24 |
| 7. | Fodder | 0.94 | 2.34 | 1.60 | 1.10 | 1.66 | 1.28 |
| 8. | Sugar & khandsari | 1.33 | 2.86 | 2.04 | 1.82 | 2.56 | 2.05 |
| 9. | Fruits & vegetables | 0.36 | 6.04 | 3.01 | 0.68 | 7.19 | 2.73 |
| 10. | Livestock | 0.15 | 0.63 | 0.37 | 0.24 | 0.54 | 0.33 |
| 11. | Hides & skins | 0.07 | 0.09 | 0.08 | 0.14 | 0.09 | 0.13 |
| 12. | Milk & milk products | 0.0005 | 0.58 | 0.27 | 0.001 | 0.51 | 0.16 |
| 13. | Coal | 40.72 | 7.36 | 25.13 | 37.58 | 8.34 | 28.39 |
| 14. | Iron ore | 8.24 | 0.41 | 4.58 | 3.44 | 0.38 | 2.48 |
| 15. | Manganese ore | 0.31 | 0.15 | 0.24 | 0.16 | 0.09 | 0.14 |
| 16. | Limestone & dolomite | 2.63 | 1.13 | 1.93 | 1.84 | 0.84 | 1.53 |
| 17. | Gypsum | 0.60 | 0.28 | 0.45 | 0.83 | 0.30 | 0.66 |
| 18. | Other stones | 1.07 | 4.96 | 2.89 | 0.58 | 2.96 | 1.32 |
| 19. | Other ores | 0.61 | 0.38 | 0.50 | 0.59 | 0.27 | 0.49 |
| 20. | Mineral oils | 8.11 | 4.35 | 6.35 | 5.26 | 2.91 | 4.52 |
| 21. | Edible oils | 0.35 | 1.21 | 0.75 | 0.63 | 1.54 | 0.91 |
| 22. | Iron & steel | 3.60 | 4.90 | 4.21 | 5.51 | 5.87 | 5.63 |
| 23. | Non-ferrous metals | 0.12 | 0.54 | 0.31 | 0.17 | 0.75 | 0.35 |
| 24. | Cement | 7.55 | 5.33 | 6.51 | 6.58 | 3.62 | 5.65 |
| 25. | Building material | 0.19 | 6.16 | 2.98 | 0.20 | 3.43 | 1.21 |
| 26. | Chemicals & drugs | 0.23 | 2.35 | 1.22 | 0.40 | 2.92 | 1.19 |
| 27. | Chemical manures | 5.47 | 4.25 | 4.90 | 6.96 | 3.06 | 5.74 |
| 28. | Paints & dyes | 0.01 | 0.13 | 0.07 | 0.01 | 0.20 | 0.07 |
| 29. | Coaltar & bitumen | 0.76 | 0.27 | 0.53 | 0.74 | 0.21 | 0.58 |
| 30. | Bamboo, timber, etc. | 0.91 | 3.62 | 2.18 | 1.22 | 3.14 | 1.83 |
| 31. | Salt | 1.57 | 1.02 | 1.31 | 2.80 | 0.89 | 2.20 |
| 32. | Tea, coffee, etc. | 0.01 | 1.22 | 0.58 | 0.04 | 1.52 | 0.50 |
| 33. | Prov. & household goods | 0.18 | 4.00 | 1.97 | 0.30 | 4.51 | 1.62 |
| 34. | Machinery & equipment | 0.37 | 0.97 | 0.66 | 0.42 | 1.53 | 0.77 |
| 35. | Electrical equipment | 0.13 | 0.66 | 0.38 | 0.21 | 0.90 | 0.43 |
| 36. | Tyres & tubes | 0.02 | 0.25 | 0.13 | 0.03 | 0.41 | 0.15 |
| 37. | Leather manufactured | 0.004 | 0.12 | 0.06 | 0.01 | 0.13 | 0.05 |
| 38. | Footwear | 0.001 | 0.06 | 0.03 | 0.002 | 0.09 | 0.03 |
| 39. | Automobile & parts | 0.002 | 0.18 | 0.08 | 0.003 | 0.36 | 0.11 |
| 40. | Cycle & cycle parts | 0.004 | 0.11 | 0.05 | 0.007 | 0.23 | 0.07 |
| 41. | Cotton manufactured | 0.02 | 1.25 | 0.59 | 0.04 | 1.70 | 0.56 |
| 42. | Jute manufactured | 0.14 | 0.47 | 0.29 | 0.23 | 0.65 | 0.36 |
| 43. | Paper | 0.31 | 1.10 | 0.68 | 0.53 | 1.36 | 0.79 |
| 44. | Other commodities | 3.71 | 13.22 | 8.16 | 5.23 | 17.74 | 9.17 |
| | Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

ANNEXURE 5.3

MODAL SHARES - RAILWAYS AND HIGHWAYS

| Sl. No. | Commodity | Modal Share (%) Based on | | | |
|---|---|---|---|---|---|
| | | Tonnes | | Tonne-Kms | |
| | | Railways | Highways | Railways | Highways |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1. | Foodgrains | 47.56 | 52.44 | 72.89 | 27.11 |
| 2. | Oilseeds | 15.88 | 84.12 | 40.70 | 59.30 |
| 3. | Cotton raw | 9.33 | 90.67 | 23.60 | 76.40 |
| 4. | Jute raw | 16.60 | 83.40 | 23.96 | 76.04 |
| 5. | Sugarcane | 31.97 | 68.03 | 23.12 | 76.88 |
| 6. | Tobacco | 11.09 | 88.91 | 22.54 | 77.46 |
| 7. | Fodder | 31.51 | 68.49 | 59.10 | 40.90 |
| 8. | Sugar & khandsari | 34.58 | 65.42 | 60.84 | 39.16 |
| | Agri. products (1 to 8) | 39.22 | 60.78 | 65.51 | 34.49 |
| 9. | Fruits & vegetables | 6.36 | 93.64 | 17.20 | 82.80 |
| 10. | Livestock | 21.46 | 78.54 | 48.78 | 51.22 |
| 11. | Hides & skins | 45.69 | 54.31 | 77.82 | 22.18 |
| 12. | Milk & milk products | 0.10 | 99.90 | 0.49 | 99.51 |
| 13. | Coal | 86.31 | 13.69 | 90.78 | 9.22 |
| 14. | Iron ore | 95.79 | 4.21 | 95.20 | 4.80 |
| 15. | Manganese ore | 70.22 | 29.78 | 79.67 | 20.33 |
| 16. | Limestone & dolomite | 72.65 | 27.35 | 82.66 | 17.34 |
| 17. | Gypsum | 71.16 | 28.84 | 85.86 | 14.14 |
| 18. | Other stones | 19.78 | 80.22 | 29.88 | 70.11 |
| 19. | Other ores | 64.65 | 35.35 | 82.62 | 17.38 |
| 20. | Mineral oils | 68.01 | 31.99 | 79.79 | 20.21 |
| 21. | Edible oils | 24.90 | 75.10 | 46.90 | 53.10 |
| 22. | Iron & steel | 45.58 | 54.42 | 67.20 | 32.80 |
| 23. | Non-ferrous metals | 19.54 | 80.46 | 32.93 | 67.07 |
| 24. | Cement | 61.74 | 38.26 | 79.86 | 20.14 |
| 25. | Building material | 3.48 | 96.52 | 11.05 | 88.95 |
| 26. | Chemicals & drugs | 10.11 | 89.89 | 22.91 | 77.09 |
| 27. | Chemical manures | 59.46 | 40.54 | 83.24 | 16.76 |
| 28. | Paints & dyes | 8.42 | 91.58 | 11.87 | 88.13 |
| 29. | Coaltar & bitumen | 76.13 | 23.87 | 88.58 | 11.42 |
| 30. | Bamboo, timber, etc. | 22.34 | 77.66 | 45.92 | 54.08 |
| 31. | Salt | 63.65 | 36.35 | 87.29 | 12.71 |
| 32. | Tea, coffee, etc. | 1.24 | 98.76 | 4.84 | 95.16 |
| 33. | Prov. & household goods | 4.85 | 95.15 | 12.75 | 87.25 |
| 34. | Machinery & equipment | 30.86 | 69.14 | 37.63 | 62.37 |
| 35. | Electrical equipment | 18.24 | 81.76 | 33.98 | 66.02 |
| 36. | Tyres & tubes | 8.54 | 91.46 | 15.79 | 84.21 |
| 37. | Leather manufactured | 3.67 | 96.33 | 11.24 | 88.76 |
| 38. | Footwear | 2.49 | 97.51 | 5.05 | 94.95 |
| 39. | Automobile & parts | 1.26 | 98.74 | 2.09 | 97.91 |
| 40. | Cycle & cycle parts | 4.20 | 95.80 | 5.94 | 94.06 |
| 41. | Cotton manufactured | 1.61 | 98.39 | 4.36 | 95.64 |
| 42. | Jute manufactured | 24.65 | 75.35 | 43.90 | 56.10 |
| 43. | Paper | 24.14 | 75.86 | 46.04 | 53.96 |
| 44. | Other commodities | 24.22 | 75.78 | 39.15 | 60.85 |
| | All commodities | 53.27 | 46.73 | 68.58 | 31.42 |

ANNEXURE 5.4

STATE-WISE DISTRIBUTION OF TRAFFIC

| Sl. No. | State/UT-wise Share of Total Tonnage Handled | | Percentage Share of Tonnage and Rail Share | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Originating | | | Terminating | | |
| | Name | % share | State/UT | Tonnage | Rail | State/UT | Tonnage | Rail |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| I | U.P. | 11.65 | M.P. | 13.31 | 77.18 | U.P | 13.36 | 44.99 |
| | Maharashtra | 10.37 | Bihar | 12.62 | 81.26 | Maharashtra | 11.57 | 45.38 |
| | M.P. | 10.11 | U.P | 9.95 | 33.05 | West Bengal | 8.72 | 77.21 |
| | Bihar | 9.95 | Maharashtra | 9.18 | 37.80 | Gujarat | 8.22 | 41.98 |
| II | A.P. | 8.48 | A.P. | 8.90 | 50.39 | A.P. | 8.06 | 48.79 |
| | Gujarat | 8.32 | Gujarat | 8.42 | 40.25 | Bihar | 7.29 | 76.88 |
| | West Bengal | 7.93 | West Bengal | 7.14 | 74.20 | M.P. | 6.92 | 61.92 |
| | Tamil Nadu | 6.11 | Tamil Nadu | 5.44 | 36.52 | Tamil Nadu | 6.77 | 51.69 |
| III | Karnataka | 4.06 | Karnataka | 4.23 | 40.79 | Delhi | 4.52 | 51.16 |
| | Rajasthan | 3.90 | Rajasthan | 4.12 | 49.40 | Karnataka | 3.89 | 39.43 |
| | Orissa | 3.40 | Orissa | 3.48 | 70.43 | Rajasthan | 3.69 | 50.17 |
| | Delhi | 3.21 | Punjab | 2.76 | 65.40 | Punjab | 3.33 | 75.10 |
| IV | Punjab | 3.04 | Assam | 2.41 | 38.04 | Orissa | 3.31 | 65.35 |
| | Kerala | 2.64 | Kerala | 2.25 | 39.13 | Kerala | 3.04 | 40.86 |
| | Haryana | 2.52 | Haryana | 2.17 | 28.98 | Haryana | 2.86 | 49.02 |
| | Assam | 2.35 | Delhi | 1.89 | 12.53 | Assam | 2.29 | 40.32 |
| V | J & K | 0.58 | H.P. | 0.56 | 2.34 | J & K | 0.70 | 2.76 |
| | H.P. | 0.49 | J & K | 0.46 | 8.46 | H.P. | 0.43 | 32.30 |
| | Chandigarh | 0.19 | Meghalaya | 0.18 | 0.80 | Chandigarh | 0.28 | 50.60 |
| | Goa, Daman, & Diu | 0.16 | Goa, Daman, & Diu | 0.15 | 41.88 | Goa, Daman, & Diu | 0.18 | 52.14 |
| VI | Tripura | 0.14 | Chandigarh | 0.11 | 6.72 | Tripura | 0.18 | 26.39 |
| | Meghalaya | 0.12 | Tripura | 0.09 | 4.82 | Nagaland | 0.10 | 44.98 |
| | Nagaland | 0.09 | Nagaland | 0.08 | 15.32 | Pondicherry | 0.10 | 14.10 |
| | Pondicherry | 0.09 | Pondicherry | 0.08 | 28.91 | Mizoram | 0.07 | 0.11 |
| VII | Mizoram | 0.04 | Arunachal Pra- | 0.02 | 0.00 | Meghalaya | 0.06 | 4.39 |
| | Arunachal Pra- | 0.02 | | | | Arunachal Pra- | | |
| | desh | | Manipur | 0.01 | 0.20 | desh | 0.03 | 0.00 |
| | Manipur | 0.02 | Mizoram | 0.01 | 0.07 | Manipur | 0.03 | 3.80 |
| | Sikkim | 0.01 | Sikkim | 0.00 | 0.00 | Sikkim | 0.01 | 19.96 |
| Total Tonnage ('000) | | 958,814 | | 479,407 | 53.27 | | 479,407 | 53.27 |

ANNEXURE 5.5

DISTRIBUTION OF TRAFFIC IN STATE CAPITALS/METROPOLITAN/ IMPORTANT REGIONS IN THOUSAND TONNES

| Sl. No. | Region | Originating | per cent to total | terminating | per cent to total | total handled | per cent to total | rail share | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | origin | terminate |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1. | Srinagar | 643 | 0.13 | 902 | 0.19 | 1,545 | 0.16 | 0.00 | 0.00 |
| 2. | Shimla | 550 | 0.11 | 297 | 0.06 | 847 | 0.09 | 10.11 | 4.91 |
| 3. | Ludhiana | 2,001 | 0.42 | 3,810 | 0.79 | 5,811 | 0.61 | 52.57 | 75.15 |
| 4. | Panipat | 1,321 | 0.28 | 2,591 | 0.54 | 3,912 | 0.41 | 44.79 | 75.91 |
| 5. | Lucknow | 1,018 | 0.21 | 2,901 | 0.61 | 3,919 | 0.41 | 22.89 | 43.13 |
| 6. | Kanpur | 3,500 | 0.73 | 5,991 | 1.25 | 9,491 | 0.99 | 44.15 | 40.55 |
| 7. | Jaipur | 1,686 | 0.35 | 2,752 | 0.57 | 4,438 | 0.46 | 16.61 | 28.84 |
| 8. | Ahmedabad | 6,468 | 1.35 | 10,549 | 2.20 | 17,017 | 1.77 | 31.09 | 44.31 |
| 9. | Bhopal | 511 | 0.11 | 1,150 | 0.24 | 1,661 | 0.17 | 18.55 | 81.45 |
| 10. | Patna | 1,572 | 0.33 | 3,002 | 0.63 | 4,574 | 0.48 | 57.25 | 62.55 |
| 11. | Guwahati | 4,134 | 0.86 | 3,938 | 0.82 | 8,072 | 0.84 | 20.72 | 31.11 |
| 12. | Shillong | 744 | 0.16 | 186 | 0.04 | 930 | 0.10 | 0.94 | 6.75 |
| 13. | Agartala | 168 | 0.04 | 728 | 0.15 | 896 | 0.09 | 12.88 | 32.08 |
| 14. | Imphal | 36 | 0.01 | 163 | 0.03 | 199 | 0.02 | 0.33 | 3.91 |
| 15. | Kohima | 250 | 0.05 | 386 | 0.08 | 636 | 0.07 | 23.85 | 56.34 |
| 16. | Gangtok | 8 | 0.00 | 35 | 0.01 | 43 | 0.00 | 0.00 | 25.62 |
| 17. | Calcutta | 5,349 | 1.12 | 12,155 | 2.54 | 17,504 | 1.83 | 46.69 | 69.19 |
| 18. | Bhubaneswar | 1,807 | 0.38 | 3,726 | 0.78 | 5,533 | 0.58 | 14.68 | 42.69 |
| 19. | Bombay | 14,617 | 3.05 | 17,623 | 3.68 | 32,240 | 3.36 | 33.87 | 32.30 |
| 20. | Pune | 2,249 | 0.47 | 4,583 | 0.96 | 6,832 | 0.71 | 14.04 | 39.37 |
| 21. | Hyderabad | 3,459 | 0.72 | 5,801 | 1.21 | 9,260 | 0.97 | 3.79 | 14.41 |
| 22. | Madras | 6,011 | 1.25 | 7,071 | 1.47 | 13,082 | 1.36 | 28.15 | 35.73 |
| 23. | Bangalore | 4,167 | 0.87 | 7,063 | 1.47 | 11,230 | 1.17 | 5.72 | 33.22 |
| 24. | Trivandrum | 285 | 0.06 | 1,111 | 0.23 | 1,396 | 0.158 | 8.18 | 31.41 |
| 25. | Delhi | 9,061 | 1.89 | 21,677 | 4.52 | 30,738 | 3.21 | 12.53 | 51.16 |
| 26. | Itanagar | 28 | 0.01 | 59 | 0.01 | 87 | 0.01 | 0.00 | 0.00 |
| 27. | Aizawl | 28 | 0.01 | 333 | 0.07 | 361 | 0.04 | 0.07 | 0.11 |
| 28. | Goa | 720 | 0.15 | 860 | 0.18 | 1,580 | 0.16 | 41.88 | 52.14 |
| 29. | Pondicherry | 396 | 0.08 | 470 | 0.10 | 866 | 0.09 | 28.91 | 14.10 |
| | Total | 72,787 | 15.18 | 1,21,913 | 25.43 | 1,94,700 | 20.31 | 53.27 | 53.27 |

ANNEXURE 5.6

COMMODITY-WISE CROSS-HAULS

| Sl. No. | Commodity | Cross-hauled Tonnes per '00 Tonnes | Cross-hauled Tkms per '00 Tkms | Lead ratio |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| 1. | Rice & rice products | 3.74 | 1.10 | 0.295 |
| 2. | Wheat & wheat products | 3.03 | 0.81 | 0.266 |
| 3. | Jowar | 2.96 | 1.78 | 0.602 |
| 4. | Bajra | 1.05 | 0.37 | 0.347 |
| 5. | Grams & pulses | 5.97 | 3.61 | 0.605 |
| 6. | Other foodgrains | 5.41 | 2.74 | 0.508 |
| | All foodgrains (1 to 6) | 7.44 | 3.59 | 0.483 |
| 7. | Oilseeds | 7.25 | 4.14 | 0.570 |
| 8. | Cotton raw | 9.38 | 6.72 | 0.718 |
| 9. | Jute raw | 1.93 | 1.06 | 0.547 |
| 10. | Sugarcane | 4.97 | 3.61 | 0.723 |
| 11. | Tobacco | 7.96 | 4.45 | 0.559 |
| 12. | Fodder | 8.59 | 4.13 | 0.480 |
| 13. | Sugar & khandsari | 3.00 | 1.26 | 0.422 |
| 14. | Fruits & vegetables | 11.01 | 6.91 | 0.627 |
| 15. | Livestock | 4.84 | 2.01 | 0.416 |
| 16. | Hides & skins | 3.33 | 1.01 | 0.301 |
| 17. | Milk & milk products | 8.02 | 5.01 | 0.625 |
| 18. | Coal | 0.81 | 0.25 | 0.305 |
| 19. | Iron ore | 0.07 | 0.06 | 0.982 |
| 20. | Manganese ore | 0.34 | 0.17 | 0.507 |
| 21. | Limestone & dolomite | 1.20 | 0.53 | 0.441 |
| 22. | Gypsum | 0.33 | 0.07 | 0.198 |
| 23. | Other stones | 3.28 | 2.42 | 0.736 |
| 24. | Other ores | 1.06 | 0.56 | 0.526 |
| 25. | Crude oil | 4.39 | 4.19 | 0.954 |
| 26. | Diesel oil | 0.68 | 0.42 | 0.621 |
| 27. | Kerosene oil | 0.55 | 0.06 | 0.432 |
| 28. | Petrol & gasolene | 1.24 | 0.89 | 0.722 |
| 29. | Grease, hexane, etc | 1.40 | 1.05 | 0.750 |
| 30. | LPG | 10.95 | 7.34 | 0.670 |
| 31. | Other fuel oil | 0.63 | 0.72 | 1.137 |
| | All P.O.L. products (25 to 31) | 2.23 | 1.85 | 0.826 |
| 32. | Edible oils | 6.60 | 3.36 | 0.510 |
| 33. | Iron & steel | 10.42 | 4.74 | 0.454 |
| 34. | Non-ferrous metals | 7.01 | 4.92 | 0.702 |
| 35. | Cement | 2.02 | 0.82 | 0.408 |
| 36. | Building material | 8.93 | 6.99 | 0.780 |
| 37. | Chemicals & drugs | 13.38 | 9.38 | 0.701 |
| 38. | Chemical manures | 4.01 | 1.54 | 0.383 |
| 39. | Paints & dyes | 7.96 | 6.80 | 0.854 |
| 40. | Coaltar & bitumen | 0.47 | 0.24 | 0.507 |
| 41. | Bamboo, timber, etc | 6.36 | 3.32 | 0.524 |
| 42. | Salt | 0.59 | 0.13 | 0.224 |
| 43. | Tea, coffee, etc | 9.79 | 6.32 | 0.645 |
| 44. | Provisions and household goods | 16.70 | 13.14 | 0.788 |
| 45. | Machinery & equipment | 11.14 | 8.83 | 0.796 |
| 46. | Electrical equipment | 11.99 | 10.11 | 0.843 |
| 47. | Tyres & tubes | 10.32 | 8.48 | 0.823 |
| 48. | Leather manufactured | 8.11 | 5.57 | 0.685 |
| 49. | Footwear | 5.48 | 3.86 | 0.707 |
| 50. | Automobile & parts | 7.36 | 5.80 | 0.805 |
| 51. | Cycle & cycle parts | 3.41 | 3.09 | 0.905 |
| 52. | Cotton manufactured | 17.38 | 14.93 | 0.858 |
| 53. | Jute manufactured | 3.65 | 1.77 | 0.485 |
| 54. | Paper | 14.60 | 9.82 | 0.673 |
| 55. | Other commodities | 23.52 | 20.24 | 0.860 |
| | Total | 6.01 | 4.12 | 0.685 |

ANNEXURE 5.7

STATE-WISE DISTRIBUTION OF TOTAL (ORIGINATING + TERMINATING) BUS TRIPS, PASSENGERS CARRIED, PASSENGER-KILOMETERS AND AVERAGE LEAD - 1986-87

| State/UT | Bus trips | | Passengers-carried | | Passenger-kilometers | | Average lead (kms) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total (000) | Public %age | Total (Million) | Public %age | Total (Billion) | Public %age | Total | Public | Private |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Jammu & Kashmir | 394 | 100 | 15 | 100 | 2 | 100 | 121 | 121 | 0 |
| Himachal Pradesh | 752 | 78 | 27 | 72 | 5 | 70 | 180 | 179 | 203 |
| Punjab | 4,387 | 95 | 180 | 94 | 21 | 95 | 117 | 117 | 108 |
| Haryana | 3,614 | 96 | 148 | 97 | 15 | 98 | 99 | 100 | 59 |
| Uttar Pradesh | 12,446 | 18 | 525 | 15 | 43 | 34 | 82 | 186 | 64 |
| Rajasthan | 3,148 | 17 | 101 | 22 | 11 | 45 | 111 | 230 | 78 |
| Gujarat | 3,503 | 100 | 142 | 100 | 16 | 100 | 114 | 114 | 0 |
| Madhya Pradesh | 2,629 | 42 | 125 | 32 | 16 | 41 | 128 | 165 | 11 |
| Bihar | 1,331 | 13 | 51 | 11 | 6 | 31 | 117 | 334 | 90 |
| Assam | 659 | 30 | 24 | 31 | 2 | 45 | 96 | 139 | 77 |
| Meghalaya | 44 | 100 | 2 | 100 | - | 100 | 140 | 140 | 0 |
| Tripura | 92 | 28 | 4 | 28 | - | 28 | 78 | 125 | 68 |
| Manipur | 38 | 15 | 2 | 9 | - | 23 | 83 | 207 | 70 |
| Nagaland | 54 | 100 | 1 | 100 | - | 100 | 144 | 144 | 0 |
| Sikkim | 33 | 95 | 1 | 93 | - | 97 | 90 | 94 | 38 |
| West Bengal | 8,008 | 18 | 427 | 13 | 17 | 30 | 39 | 87 | 31 |
| Orissa | 347 | 97 | 12 | 95 | 2 | 96 | 210 | 212 | 174 |
| Maharashtra | 8,482 | 100 | 286 | 99 | 38 | 99 | 132 | 132 | 186 |
| Andhra Pradesh | 4,719 | 97 | 191 | 97 | 29 | 98 | 152 | 154 | 99 |
| Tamil Nadu | 12,484 | 44 | 503 | 44 | 51 | 57 | 101 | 130 | 78 |
| Karnataka | 1,661 | 53 | 71 | 49 | 14 | 57 | 192 | 221 | 164 |
| Kerala | 835 | 79 | 34 | 78 | 6 | 92 | 181 | 212 | 68 |
| Chandigarh | 642 | 100 | 26 | 100 | 4 | 100 | 161 | 161 | 0 |
| Delhi | 1,033 | 83 | 43 | 79 | 8 | 91 | 187 | 217 | 76 |
| Arunachal Pradesh | 62 | 20 | 2 | 20 | - | 19 | 123 | 117 | 124 |
| Mizoram | 3 | 100 | - | 100 | - | 100 | 169 | 162 | 0 |
| Goa Daman & Diu | 48 | 85 | 2 | 82 | - | 77 | 288 | 272 | 360 |
| Pondicherry | 388 | 16 | 18 | 14 | 1 | 40 | 66 | 188 | 46 |
| Dadra & Nagar Haveli | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 71,836 | 55 | 2,961 | 51 | 309 | 69 | 104 | 140 | 67 |

ANNEXURE 5.8

STATE-WISE DISTRIBUTION OF INTER-STATE (ORIGINATING - TERMINATING) BUS TRIPS, PASSENGERS CARRIED, PASSENGER-KILOMETERS AND AVERAGE LEAD - 1986-87

| State/UT | Bus trips | | Passenger-carried | | Passenger-kilometers | | Average lead (kms) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total (000) | Public %age | Total (Million) | Public %age | Total (Billion) | Public %age | Total | Public | Private |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Jammu & Kashmir | 73 | 100 | 3 | 100 | 1 | 100 | 261 | 261 | 0 |
| Himachal Pradesh | 417 | 93 | 15 | 91 | 3 | 89 | 180 | 176 | 222 |
| Punjab | 1,137 | 95 | 44 | 94 | 7 | 95 | 163 | 164 | 145 |
| Haryana | 1,123 | 89 | 45 | 89 | 6 | 95 | 133 | 143 | 59 |
| Uttar Pradesh | 710 | 67 | 29 | 59 | 5 | 79 | 157 | 210 | 79 |
| Rajasthan | 681 | 67 | 27 | 69 | 4 | 88 | 161 | 206 | 61 |
| Gujarat | 147 | 100 | 5 | 100 | 1 | 100 | 198 | 198 | 0 |
| Madhya Pradesh | 399 | 74 | 15 | 72 | 2 | 78 | 153 | 166 | 120 |
| Bihar | 50 | 51 | 2 | 48 | - | 74 | 193 | 300 | 95 |
| Assam | 93 | 66 | 3 | 71 | - | 80 | 111 | 126 | 75 |
| Meghalaya | 16 | 100 | 1 | 100 | - | 100 | 143 | 143 | 0 |
| Tripura | 3 | 76 | - | 75 | - | 80 | 113 | 121 | 91 |
| Manipur | 6 | 100 | - | 100 | - | 100 | 207 | 207 | 0 |
| Nagaland | 21 | 100 | 1 | 100 | - | 100 | 144 | 144 | 0 |
| Sikkim | 20 | 92 | 1 | 89 | - | 96 | 94 | 101 | 38 |
| West Bengal | 134 | 90 | 5 | 86 | - | 90 | 85 | 90 | 59 |
| Orissa | 57 | 86 | 2 | 79 | 86 | 86 | 204 | 220 | 140 |
| Maharashtra | 470 | 93 | 17 | 92 | 4 | 92 | 213 | 215 | 197 |
| Andhra Pradesh | 424 | 76 | 18 | 72 | 3 | 83 | 172 | 199 | 106 |
| Tamil Nadu | 931 | 53 | 41 | 49 | 4 | 75 | 109 | 166 | 54 |
| Karnataka | 461 | 86 | 18 | 84 | 4 | 93 | 216 | 238 | 98 |
| Kerala | 185 | 100 | 7 | 100 | 1 | 100 | 176 | 176 | 0 |
| Chandigarh | 642 | 100 | 26 | 100 | 4 | 100 | 161 | 161 | 0 |
| Delhi | 1,033 | 83 | 43 | 79 | 8 | 91 | 187 | 217 | 76 |
| Arunachal Pradesh | 44 | 24 | 1 | 25 | - | 34 | 86 | 115 | 76 |
| Mizoram | 3 | 100 | - | 100 | - | 100 | 169 | 169 | 0 |
| Goa Daman & Diu | 48 | 85 | 2 | 82 | 1 | 77 | 288 | 272 | 360 |
| Pondicherry | 386 | 16 | 18 | 14 | 1 | 40 | 66 | 188 | 46 |
| Dadra & Nagar Haveli | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 9,714 | 79 | 389 | 76 | 61 | 88 | 157 | 183 | 76 |

ANNEXURE 5.9

INTER-CITY COMPARISON
INTER-REGIONAL TRAFFIC - A COMPARATIVE PICTURE

| Sl. No. | Mode/Year | Tonnes | | Tonnes Kms | | Average Lead (Kms) |
|---|---|---|---|---|---|---|
| | | Total (million) | Percentage Share | Total (billion) | Percentage Share | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1. | Railways | | | | | |
| | 1978-79 | 184.7 | 65.2 | 149.6 | 79.2 | 810 |
| | 1986-87 | 255.4 | 52.7 | 198.6 | 66.5 | 778 |
| | | (38.05) | | (32.75) | | (-4.11) |
| 2. | Highways | | | | | |
| | 1978-79 | 95.6 | 33.7 | 33.7 | 17.8 | 353 |
| | 1986-87 | 224.0 | 46.2 | 91.0 | 30.5 | 406 |
| | | (133.33) | | (170.03) | (15.01) | |
| 3. | Coastal Shipping* | | | | | |
| | 1978-79** | 3.1 | 1.1 | 5.6 | 3.0 | 1,807 |
| | 1986-87 | 5.5 | 1.1 | 9.1 | 3.0 | 1,650 |
| | | (76.28) | | (62.50) | | (-8.69) |
| | Total | | | | | |
| | 1978-79 | 283.4 | 100.0 | 188.9 | 100.0 | 665 |
| | 1986-87 | 484.9 | 100.0 | 298.7 | 100.0 | 616 |
| | | (71.10) | | (58.13) | | (-7.37) |

* To ensure proper inter-study comparison, the data of the earlier study, which related only to dry cargo have been revised to take into account both dry as well as wet (POL) cargo.
** The data relate to 1977.
Note: Figures in brackets denote percentage shift during inter-study period.

ANNEXURE 5.10

INTER-CITY COMPARISON
PERCENTAGE SHARE OF ORIGINATING TONNAGE AND AVERAGE LEAD - RAILWAYS

| Sl. No. | Commodity | Percentage Share to Total | | Average Lead (Kms) | |
|---|---|---|---|---|---|
| | | Present study (1986-87) | Earlier study (1978-79) | Present study (1986-87) | Earlier study (1978-79) |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1. | Coal | 40.72 | 34.59 | 718 | 691 |
| 2. | Foodgrains | 8.49 | 8.75 | 1,146 | 1,276 |
| 3. | Iron ore | 8.24 | 9.26 | 325 | 529 |
| 4. | Limestone & dolomite | 2.63 | 3.47 | 544 | 371 |
| 5. | Mineral oils | 8.11 | 7.09 | 504 | 656 |
| 6. | Cement | 7.55 | 6.44 | 678 | 756 |
| 7. | Chemical manures | 5.47 | 4.59 | 989 | 1,035 |
| 8. | Iron & steel | 3.60 | 5.32 | 1,192 | 1,099 |
| 9. | Salt | 1.57 | 1.53 | 1,388 | 1,429 |
| 10. | Sugar & khandsari | 1.33 | 1.38 | 1,067 | 1,084 |
| 11. | Other stones | 1.07 | 1.80 | 419 | 372 |
| 12. | Bamboo, timber, etc. | 0.91 | 1.42 | 1,041 | 989 |
| 13. | Balance commodities | 10.31 | 14.36 | 1,047 | 981 |

ANNEXURE 5.11

INTER-CITY COMPARISON
PERCENTAGE SHARE OF TONNAGE AND AVERAGE LEAD - HIGHWAYS

| Sl. No. | Commodity | Percentage Share to Total Traffic (Tonnage) | | Average Lead (Kms) | |
|---|---|---|---|---|---|
| | | Present study (1986-87) | Earlier study (1978-79) | Present study (1986-87) | Earlier study (1978-79) |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1. | Foodgrains | 10.67 | 8.24 | 371 | 296 |
| 2. | Coal | 7.36 | 6.30 | 480 | 401 |
| 3. | Building material | 6.16 | 7.81 | 238 | 161 |
| 4. | Fruits & vegetabels | 6.04 | 7.75 | 517 | 445 |
| 5. | Other stones | 4.96 | 3.58 | 261 | 202 |
| 6. | Cement | 5.33 | 3.40 | 284 | 301 |
| 7. | Iron & steel | 4.90 | 5.79 | 478 | 356 |
| 8. | Chemical manures | 4.25 | 3.74 | 291 | 281 |
| 9. | Bamboo, timber, etc. | 3.62 | 4.43 | 374 | 313 |
| 10. | Mineral oils | 4.35 | 5.43 | 277 | 227 |
| 11. | Sugar & khandsari | 2.86 | 3.45 | 378 | 367 |
| 12. | Fodder | 2.34 | 2.04 | 310 | 253 |
| 13. | Chemicals & drugs | 2.35 | 2.80 | 517 | 412 |
| 14. | Oilseeds | 2.08 | 1.74 | 328 | 354 |
| 15. | Balance commodities | 32.72 | 33.50 | 507 | 432 |

ANNEXURE 5.12

INTER-STUDY COMPARISON
MODAL SHARES

(Percentage)

| Sl. No. | Commodity | Rail modal shares Orginating tonnes | | Base on tonne kms | |
|---|---|---|---|---|---|
| | | Present study (1986-87) | Earlier study (1978-79) | Present study (1986-87) | Earlier study (1978-79) |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1. | Coal | 86.31 | 91.28 | 90.78 | 94.75 |
| 2. | Foodgrains | 47.56 | 67.22 | 72.89 | 89.84 |
| 3. | Cement | 61.74 | 78.55 | 79.86 | 89.75 |
| 4. | Fertiliser | 59.46 | 70.23 | 83.24 | 89.71 |
| 5. | Iron & steel | 45.58 | 63.96 | 67.20 | 84.57 |
| 6. | Pol. products | 68.84 | 71.88 | 80.79 | 88.20 |
| 7. | Iron ore | 95.79 | 99.23 | 95.20 | 99.83 |
| 8. | Limestone & dolomite | 72.65 | 91.01 | 82.66 | 93.54 |
| 9. | Salt | 63.35 | 70.34 | 87.29 | 90.86 |
| 10. | Bulk commodities | 71.44 | 81.22 | 83.35 | 91.73 |
| 11. | Other commodities | 19.75 | 36.23 | 36.48 | 58.23 |
| | Overall | 53.27 | 65.87 | 68.58 | 81.61 |

ANNEXURE 5.13

FIXED AND VARIABLE COST - RAILWAYS TOTAL COST-PLAINS (AT 1984-85 PRICES)

| Sl. No. | Commodity | Cost Type | Broad Gauge (BG) | | | | | | Metergauge (MG) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | DSL-WL | DDL-WL | DSL-BL | DDL-BL | EDL-WL | EDL-BL | DSL-WL | DDL-WL | DSL-BL | DDL-BL |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 1. | Wheat | V | 0.1390 | 0.1013 | 0.1263 | 0.0902 | 0.0983 | 0.0868 | 0.2107 | 0.2272 | 0.1870 | 0.2090 |
| | | F | 97.45 | 97.37 | 89.56 | 89.54 | 96.97 | 89.51 | 103.94 | 103.63 | 95.3 | 95.35 |
| 2. | Cotton (raw) | V | 0.2040 | 0.1591 | 0.1807 | 0.1382 | 0.1546 | 0.1330 | 0.3718 | 0.3849 | 0.3191 | 0.3433 |
| | | F | 315.79 | 315.66 | 304.24 | 304.22 | 315.10 | 304.18 | 334.79 | 334.15 | 319.18 | 319.13 |
| 3. | Potatoes | V | 0.1792 | 0.1354 | 0.1623 | 0.1208 | 0.1310 | 0.1158 | 0.2794 | 0.2952 | 0.2464 | 0.2702 |
| | | F | 118.23 | 118.10 | 107.33 | 107.31 | 117.56 | 107.27 | 126.78 | 126.33 | 114.74 | 114.70 |
| 4. | Coal | V | 0.1818 | 0.1330 | 0.1642 | 0.1178 | 0.1283 | 0.1124 | 0.2071 | 0.2242 | 0.1850 | 0.2076 |
| | | F | 49.36 | 49.23 | 40.37 | 40.35 | 48.63 | 40.31 | 53.00 | 52.69 | 41.81 | 41.79 |
| 5. | Fertilizer | V | 0.1393 | 0.1016 | 0.1255 | 0.0895 | 0.0986 | 0.0861 | 0.2268 | 0.2428 | 0.1991 | 0.2214 |
| | | F | 170.70 | 170.63 | 162.33 | 162.31 | 170.23 | 162.29 | 181.38 | 181.03 | 170.30 | 170.28 |
| 6. | Sugar | V | 0.1426 | 0.1047 | 0.1297 | 0.0935 | 0.1016 | 0.0900 | 0.2140 | 0.2305 | 0.1903 | 0.2124 |
| | | F | 107.80 | 107.71 | 100.52 | 100.51 | 107.31 | 100.48 | 116.16 | 116.14 | 106.29 | 106.26 |
| 7. | POL | V | 0.2284 | 0.1694 | 0.2031 | 0.1474 | 0.1630 | 0.1402 | 0.3898 | 0.3432 | 0.2832 | 0.3083 |
| | | F | 52.41 | 52.23 | 41.03 | 41.01 | 51.45 | 40.95 | 60.38 | 59.77 | 45.44 | 45.39 |
| 8. | Tea | V | 0.3208 | 0.2687 | 0.2827 | 0.2338 | 0.2626 | 0.2268 | 0.4977 | 0.5099 | 0.4276 | 0.4524 |
| | | F | 1,105.55 | 1,105.39 | 1,086.74 | 1,086.72 | 1,104.64 | 1,086.66 | 1,134.47 | 1,133.75 | 1,107.21 | 1,107.16 |
| 9. | Cotton Textiles | V | 0.2965 | 0.2520 | 0.2564 | 0.2143 | 0.2474 | 0.2091 | 0.4147 | 0.4307 | 0.3552 | 0.3789 |
| | | F | 550.63 | 550.50 | 535.51 | 535.49 | 549.94 | 535.45 | 573.97 | 573.53 | 554.49 | 554.46 |
| 10. | Cement | V | 0.1349 | 0.0974 | 0.1228 | 0.0869 | 0.0945 | 0.0835 | 0.2052 | 0.2118 | 0.1825 | 0.2045 |
| | | F | 145.24 | 145.16 | 138.40 | 138.39 | 144.77 | 138.36 | 153.31 | 152.99 | 145.11 | 145.09 |
| 11. | Live stock | V | 0.3811 | 0.2934 | 0.3313 | 0.2502 | 0.2793 | 0.2344 | 0.5879 | 0.5941 | 0.4955 | 0.5241 |
| | | F | 286.07 | 285.71 | 260.31 | 260.26 | 284.10 | 260.14 | 302.28 | 310.02 | 269.77 | 269.68 |
| 12. | Iron & Steel | V | 0.1568 | 0.1153 | 0.1408 | 0.1011 | 0.1121 | 0.0975 | 0.2327 | 0.2487 | 0.2033 | 0.2256 |
| | | F | 96.69 | 96.56 | 87.35 | 87.34 | 96.17 | 87.31 | 105.98 | 105.62 | 93.52 | 93.49 |
| 13. | Small Machinery | V | 0.2117 | 0.1657 | 0.1870 | 0.1435 | 0.1608 | 0.1379 | 0.3167 | 0.3324 | 0.2748 | 0.2988 |
| | | F | 694.58 | 694.44 | 683.97 | 683.95 | 693.84 | 683.90 | 689.54 | 689.07 | 674.00 | 673.97 |

Notes:
DSL Diesel Single line
DDL Diesel Double line
EDL Electric Double line
WL Wagon load
BL Block Load
V Variable Cost
F Fixed Cost

ANNEXURE 5.14

FIXED 7 VARIABLE COST - HIGHWAYS (AT 1984-85 PRICES)

(Amount in Rs)

| Sl. No. | Commodity | Cost Type | NHSL | | NHDL | |
|---|---|---|---|---|---|---|
| | | | Operator | Total | Operator | Total |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1. | Wheat | V | 0.2524 | 0.2534 | 0.2489 | 0.249 |
| | | F | 10.1400 | 49.3100 | 10.1200 | 49.3000 |
| 2. | Cotton (raw) | V | 0.2906 | 0.3020 | 0.2865 | 0.2979 |
| | | F | 11.3200 | 237.7800 | 11.3100 | 237.7700 |
| 3. | Potatoes | V | 0.2633 | 0.2646 | 0.2596 | 0.2609 |
| | | F | 10.4800 | 65.4000 | 10.4600 | 65.3900 |
| 4. | Coal | V | 0.2289 | 0.2291 | 0.2258 | 0.2259 |
| | | F | 9.1400 | 18.7700 | 9.4000 | 18.7600 |
| 5. | Fertilizers | V | 0.2503 | 0.2521 | 0.2468 | 0.2486 |
| | | F | 10.0700 | 139.0400 | 10.0600 | 139.0300 |
| 6. | Sugar | V | 0.2393 | 0.2413 | 0.2360 | 0.2379 |
| | | F | 9.7300 | 61.7100 | 9.7200 | 61.7000 |
| 7. | POL | V | 0.5064 | 0.5081 | 0.4988 | 0.5005 |
| | | F | 21.9200 | 29.3400 | 21.9100 | 29.3200 |
| 8. | Tea | V | 0.2896 | 0.3174 | 0.2856 | 0.3134 |
| | | F | 11.2900 | 982.3500 | 11.2800 | 982.3400 |
| 9. | Cotton textiles | V | 0.2862 | 0.3262 | 0.2822 | 0.3222 |
| | | F | 11.9900 | 440.0500 | 11.1800 | 440.0300 |
| 10. | Cement | V | 0.2359 | 0.2365 | 0.2326 | 0.2332 |
| | | F | 9.6200 | 113.7100 | 9.6100 | 113.7000 |
| 11. | Livestock | V | 0.6598 | 0.6643 | 0.6507 | 0.6552 |
| | | F | 22.8100 | 151.4100 | 22.7900 | 151.3800 |
| 12. | Iron & steel | V | 0.2657 | 0.2687 | 0.2620 | 0.2650 |
| | | F | 10.5500 | 57.3900 | 10.5400 | 57.3700 |
| 13. | Small machinery, | V | 0.2874 | 0.2993 | 0.2834 | 0.2954 |
| | package, etc. | F | 19.2800 | 636.1400 | 19.2700 | 636.1200 |

Note: NHSL: National Highway Single Lane

NHDL: National Highway Double Lane

V: Variable Cost (Rs/tkm)

F: Fixed Cost (Rs/Tonne)

ANNEXURE 5.15

BREAK-EVEN POINTS FOR SIX RAILWAY AND TWO HIGHWAY SITUATIONS BASED ON UNIT TOTAL ECONOMIC COST (AT 1984-85 PRICES)

| Sl. No. (1) | Commodity/Highway Situation (2) | RAIL SITUATION (BROAD GAUGE) DSL-WL (3) | DDL-WL (4) | DSL-BL (5) | DDL-BL (6) | EDL-WL (7) | EDL-BL (8) | Average (kms) (9) |
|---|---|---|---|---|---|---|---|---|
| 1. | WHEAT | | | | | | | |
| | NHSL | 378 | 296 | 296 | 241 | 289 | 237 | 277 |
| | NHDL | 388 | 301 | 304 | 245 | 294 | 241 | 283 |
| | Average | 383 | 298 | 300 | 243 | 291 | 239 | 280 |
| 2. | COTTON | | | | | | | |
| | NHSL | 765 | 547 | 552 | 377 | 528 | 366 | 522 |
| | NHDL | 795 | 561 | 570 | 386 | 541 | 374 | 538 |
| | Average | 780 | 554 | 561 | 381 | 534 | 370 | 530 |
| 3. | POTATOES | | | | | | | |
| | NHSL | 613 | 368 | 372 | 276 | 354 | 268 | 375 |
| | NHDL | 635 | 377 | 383 | 282 | 362 | 274 | 386 |
| | Average | 624 | 372 | 377 | 279 | 358 | 271 | 380 |
| 4. | COAL | | | | | | | |
| | NHSL | 1,081 | 524 | 296 | 198 | 497 | 190 | 278 |
| | NHDL | 1,144 | 539 | 308 | 203 | 510 | 195 | 235 |
| | Average | 1,113 | 532 | 302 | 201 | 504 | 192 | 232 |
| 5. | FERTILISERS (UREA) | | | | | | | |
| | NHSL | 262 | 210 | 190 | 152 | 204 | 149 | 182 |
| | NHDL | 269 | 214 | 194 | 155 | 208 | 152 | 185 |
| | Average | 266 | 212 | 192 | 154 | 206 | 151 | 184 |
| 6. | SUGAR | | | | | | | |
| | NHSL | 481 | 312 | 322 | 253 | 303 | 248 | 320 |
| | NHDL | 497 | 318 | 331 | 258 | 310 | 253 | 328 |
| | Average | 489 | 315 | 326 | 256 | 306 | 251 | 324 |
| 7. | PETROLEUM (HSD) | | | | | | | |
| | NHSL | 108 | 92 | 68 | 59 | 89 | 58 | 66 |
| | NHDL | 110 | 94 | 69 | 60 | 91 | 59 | 68 |
| | Average | 109 | 92 | 68 | 59 | 90 | 58 | 67 |
| 8. | TEA | | | | | | | |
| | NHSL | * | 2,527 | 3,009 | 1,204 | 2,229 | 1,144 | |
| | NHDL | * | 2,755 | 3,405 | 1,241 | 2,406 | 1,178 | |
| | Average | * | 2,641 | 3,207 | 1,222 | 2,318 | 1,161 | |
| 9. | COTTON | | | | | | | |
| | NHSL | 3,725 | 1,488 | 1,243 | 955 | 1,394 | 833 | 1,615 |
| | NHDL | 4,302 | 1,572 | 1,451 | 977 | 1,468 | 946 | 1,786 |
| | Average | 4,013 | 1,530 | 1,347 | 966 | 1,431 | 915 | 1,700 |
| 10. | CEMENT | | | | | | | |
| | NHSL | 285 | 223 | 217 | 172 | 217 | 168 | 191 |
| | NHDL | 292 | 227 | 222 | 175 | 221 | 172 | 195 |
| | Average | 289 | 225 | 219 | 173 | 219 | 170 | 193 |

(Contd.)

ANNEXURE 5.15 (Concld.)

| Sl. No. (1) | Commodity/Highway situation (2) | RAIL SITUATION (BROAD GAUGE) DSL-WL (3) | DDL-WL (4) | DSL-BL (5) | DDL-BL (6) | EDL-WL (7) | EDL-BL (8) | Average (kms) (9) |
|---|---|---|---|---|---|---|---|---|
| 11. | LIVE STOCK (BUFFALOES) | | | | | | | |
| | NHSL | 492 | 331 | 304 | 253 | 317 | 245 | 324 |
| | NHDL | 506 | 339 | 312 | 258 | 324 | 250 | 332 |
| | Average | 499 | 335 | 308 | 256 | 320 | 248 | 328 |
| 12. | STEEL (CR/HR COILS & SHEETS) | | | | | | | |
| | NHSL | 316 | 245 | 230 | 184 | 239 | 180 | 217 |
| | NHDL | 325 | 250 | 235 | 188 | 243 | 184 | 222 |
| | Average | 320 | 247 | 232 | 186 | 241 | 182 | 220 |
| 13. | SMALL | | | | | | | |
| | NHSL | 646 | 384 | 384 | 286 | 369 | 278 | 391 |
| | NHDL | 673 | 394 | 396 | 292 | 378 | 284 | 403 |
| | Average | 659 | 389 | 390 | 289 | 373 | 281 | 397 |

Notes:

Transport Situations

BL : Block Load
WL : Wagon Load
NHSL : National Highway Single Lane
NHDL : National Highway Double Lane
DSL-WL : Diesel Single Line Wagon Load
DDL-BL : Diesel Double Line Block Load
EDL-WL : Electric Double Line Wagon Load
EDL-BL : Electric Double Line Block Load
DDL-WL : Diesel Double Line Wagon Load
DSL-BL : Diesel Single Line Block Load

2. * Rail cost is higher for all the distance slabs.

ANNEXURE 5.16

SHIFTS IN BREAK-EVEN POINTS DUE TO INCREASE IN POL PRICES

| Sl. No. (1) | Commodity (2) | Average B.EP. (Kms) (3) | Percentage Downward Shift Under Assumption I (4) | II (5) | III (6) |
|---|---|---|---|---|---|
| 1. | Wheat | 280 | 32 | 49 | 60 |
| 2. | Cotton (Raw) | 530 | 43 | 59 | 68 |
| 3. | Potatoes | 380 | 39 | 56 | 65 |
| 4. | Coal | 232 | 36 | 54 | 65 |
| 5. | Fertilisers (Urea) | 184 | 32 | 49 | 60 |
| 6. | Sugar | 324 | 35 | 52 | 62 |
| 7. | POL (HSD) | 67 | 65 | 85 | 94 |
| 8. | Tea | C | 985 *Kms | 525 *Kms | 331 *Kms |
| 9. | Cotton textiles | C | 679 *Kms | 383 *Kms | 269 *Kms |
| 10. | Cement | 193 | 32 | 50 | 60 |
| 11. | Livestock (Buffaloes) | 328 | 36 | 53 | 63 |
| 12. | Steel (CR/HR coils & sheets) | 220 | 32 | 50 | 60 |
| 13. | Small machinery, packages, drums, etc. | 397 | 40 | 57 | 66 |

B.E.P. : Break - Even Point
Assumption-I 100% hike in price
Assumption-II 200% hike in price
Assumption-III 300% hike in price

C - The Break-Even Point Lies beyond the range of consideration i.e., 1,250 kms.
* - Downward shift to the indicated distance levels under the impact of the fuel price escalation.

Fuel Efficiency: Railways - 13.46 litres per 1000 GT KMS
Highways - 19.07 to 20.34 litres per 1000 GT KMS

ANNEXURE 6.1

TRENDS OF RAIL AND ROAD TRAFFIC & RELATED VARIABLES

| Year End March (1) | RLFRT BTKM (2) | RLPAX BPKM (3) | RDFRT BTKM (4) | RDPAX BPKM (5) | TLFRT BTKM (6) | TLPAX BPKM (7) | GNP BN.RS (8) | IND INDEX (9) | POP BN (10) | UB.POP MN (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 44 | 67 | 6 | 31 | 50 | 98 | 175 | 29 | 0.36 | 62 |
| 1952 | 47 | 63 | 6 | 31 | 53 | 94 | 178 | 31 | 0.37 | 64 |
| 1953 | 47 | 60 | 7 | 37 | 54 | 97 | 185 | 33 | 0.38 | 65 |
| 1954 | 48 | 60 | 7 | 40 | 56 | 100 | 197 | 36 | 0.38 | 67 |
| 1955 | 52 | 62 | 8 | 43 | 61 | 104 | 202 | 38 | 0.39 | 69 |
| 1956 | 60 | 62 | 9 | 51 | 69 | 113 | 209 | 39 | 0.40 | 70 |
| 1957 | 66 | 67 | 10 | 45 | 76 | 112 | 220 | 43 | 0.41 | 72 |
| 1958 | 75 | 69 | 12 | 41 | 86 | 110 | 216 | 46 | 0.41 | 74 |
| 1959 | 76 | 68 | 13 | 64 | 90 | 132 | 234 | 50 | 0.42 | 75 |
| 1960 | 82 | 74 | 15 | 71 | 97 | 144 | 238 | 50 | 0.43 | 77 |
| 1961 | 88 | 78 | 17 | 81 | 105 | 159 | 254 | 54 | 0.44 | 79 |
| 1962 | 91 | 82 | 21 | 87 | 112 | 169 | 263 | 60 | 0.45 | 81 |
| 1963 | 101 | 84 | 25 | 96 | 126 | 180 | 268 | 66 | 0.46 | 84 |
| 1964 | 107 | 89 | 27 | 106 | 134 | 195 | 282 | 72 | 0.47 | 87 |
| 1965 | 107 | 93 | 31 | 117 | 138 | 210 | 304 | 78 | 0.48 | 90 |
| 1966 | 117 | 96 | 35 | 124 | 152 | 220 | 288 | 83 | 0.49 | 93 |
| 1967 | 117 | 102 | 39 | 139 | 156 | 241 | 291 | 87 | 0.50 | 96 |
| 1968 | 119 | 107 | 43 | 158 | 162 | 265 | 316 | 91 | 0.51 | 99 |
| 1969 | 125 | 107 | 47 | 172 | 172 | 279 | 325 | 94 | 0.52 | 102 |
| 1970 | 128 | 113 | 52 | 189 | 180 | 302 | 345 | 98 | 0.54 | 105 |
| 1971 | 127 | 118 | 57 | 210 | 185 | 328 | 365 | 100 | 0.55 | 109 |
| 1972 | 133 | 125 | 62 | 225 | 195 | 351 | 370 | 106 | 0.56 | 112 |
| 1973 | 137 | 134 | 51 | 223 | 188 | 356 | 366 | 109 | 0.57 | 116 |
| 1974 | 122 | 136 | 54 | 257 | 176 | 392 | 385 | 112 | 0.59 | 120 |
| 1975 | 134 | 126 | 56 | 293 | 190 | 419 | 390 | 114 | 0.60 | 123 |
| 1976 | 148 | 149 | 59 | 308 | 207 | 457 | 428 | 120 | 0.61 | 127 |
| 1977 | 157 | 164 | 65 | 318 | 222 | 482 | 431 | 134 | 0.63 | 131 |
| 1978 | 163 | 177 | 68 | 397 | 230 | 573 | 468 | 140 | 0.64 | 137 |
| 1979 | 155 | 193 | 76 | 409 | 231 | 602 | 496 | 144 | 0.66 | 143 |
| 1980 | 156 | 199 | 84 | 421 | 240 | 620 | 472 | 148 | 0.67 | 151 |
| 1981 | 159 | 209 | 98 | 543 | 256 | 752 | 507 | 154 | 0.69 | 160 |
| 1982 | 174 | 221 | 113 | 595 | 287 | 815 | 535 | 167 | 0.70 | 166 |
| 1983 | 178 | 227 | 129 | 597 | 307 | 824 | 549 | 174 | 0.72 | 172 |
| 1984 | 178 | 223 | 145 | 674 | 323 | 897 | 593 | 183 | 0.73 | 178 |
| 1985 | 182 | 227 | 161 | 739 | 343 | 965 | 614 | 197 | 0.75 | 185 |
| 1986 | 206 | 241 | 193 | 850 | 399 | 1,091 | 643 | 210 | 0.76 | 192 |
| 1987 | 223 | 257 | 210 | 893 | 433 | 1,149 | 668 | 229 | 0.77 | 201 |

Rlfrt = Rail Freight Traffic in Billion Tkm.
Rlpax = Rail Passenger Traffic in Billion Pkm.
Rdfrt = Road Freight Traffic in Billion Tkm.
Rdpax = Road Passenger Traffic in Billion Pkm.
Tlfrt = Total Freight = Rlfrt + Rdfrt.
Tlpax = Total Passenger Traffic = Rlpax + Rdpax.
Gnp = Gnp at Constant 1970/71 Prices.
Ind = Index of Industrial Production (Base 1970/71).
Pop = Total Population in Billion.
Ub.Pop = Urban Population in Billion.

ANNEXURE 6.2

SEMILOG TRENDS FOR TRANSPORT DEMAND PERIOD: 1950-51 TO 1986-87

| Dependent Variable (1) | Alpha (2) | Beta (3) | R-Square (4) |
|---|---|---|---|
| Rail-Freight | 3.93 | 0.0404 | 0.93 |
| | | 0.0018 | |
| Rail-Pax | 3.91 | 0.0434 | 0.98 |
| | | 0.0011 | |
| Road-Freight | 1.77 | 0.0953 | 0.97 |
| | | 0.0027 | |
| Road-Pax | 3.28 | 0.0953 | 0.99 |
| | | 0.0012 | |
| Total-Freight | 3.98 | 0.0545 | 0.97 |
| | | 0.0017 | |
| Total-Pax | 4.27 | 0.0731 | 0.99 |
| | | 0.0011 | |

Note: Figures below Beta Coefficients indicate the corresponding statistical errors.
Fitted regression lines are:
ln Y = ALPHA + BETA TIME
BETA is the growth rate during the period.

ANNEXURE 6.3

LOG-LINEAR REGRESSION RESULTS FOR TRANSPORT DEMAND PERIOD: 1950-51 TO 1986-87

| Dependent Variable (1) | Independent Variable (2) | Alpha (3) | Beta (4) | R-Square (5) |
|---|---|---|---|---|
| Rail-Freight | Population | 5.88 | 1.86 | 0.92 |
| | | | 0.09 | |
| Rail-Pax | " | 6.03 | 2.00 | 0.98 |
| | | | 0.05 | |
| Road-Freight | " | 6.04 | 4.39 | 0.97 |
| | | | 0.14 | |
| Road-Pax | " | 7.93 | 4.40 | 0.99 |
| | | | 0.06 | |
| Total-Freight | " | 6.63 | 2.51 | 0.96 |
| | | | 0.09 | |
| Total-Pax | " | 7.84 | 3.38 | 0.99 |
| | | | 0.04 | |
| Rail-Freight | Urb. Population | -0.91 | 1.22 | 0.89 |
| | | | 0.07 | |
| Rail-Pax | " | -1.49 | 1.35 | 0.99 |
| | | | 0.03 | |
| Road-Freight | " | -9.82 | 2.00 | 0.93 |
| | | | 0.11 | |
| Road-Pax | " | -8.42 | 2.00 | 0.98 |
| | | | 0.06 | |
| Total-Freight | " | -2.65 | 1.65 | 0.94 |
| | | | 0.07 | |
| Total-Pax | " | -4.77 | 2.24 | 1.00 |
| | | | 0.03 | |

Note: Figures below Beta indicate corresponding standard errors.

ANNEXURE 6.4

TIME TRENDS FOR RAIL TRANSPORT COEFFICIENTS OF MAJOR GOODS DURING 1970-71 TO 1985-86

| Sl. No. | Commodities | Linear Trend | | | Semilog Trend | | |
|---|---|---|---|---|---|---|---|
| | | Alpha | Beta | $R^2$ | Alpha | Beta | $R^2$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1. | Steel | 108.70 | -0.06 | 0.59 | 4.69 | -0.006 | 0.59 |
| | | (2.73) | (0.15) | | (0.03) | (0.001) | |
| 2. | Coal | 88.17 | -1.03 | 0.68 | 4.48 | -0.013 | 0.68 |
| | | (3.48) | (0.19) | | (0.04) | (0.002) | |
| 3. | Iron ore | 44.99 | -0.002 | 0.00 | 3.80 | 0.0003 | 0.00 |
| | | (4.71) | (0.26) | | (0.11) | (0.006) | |
| 4. | Cement | 74.06 | -1.72 | 0.69 | 4.31 | -0.028 | 0.68 |
| | | (5.61) | (0.31) | | (0.10) | (0.005) | |
| 5. | Foodgrains | 13.89 | 0.15 | 0.17 | 2.63 | 0.01 | 0.17 |
| | | (1.63) | (0.09) | | (0.11) | (0.006) | |
| 6. | Fertilisers | 91.62 | -2.31 | 0.67 | 4.52 | -0.031 | 0.65 |
| | | (7.95) | (0.43) | | (0.1) | (0.006) | |
| 7. | POL products | 49.13 | -0.14 | 0.07 | 3.89 | -0.003 | 0.07 |
| | | (2.51) | (0.14) | | (0.05) | (0.003) | |

Notes: Figures in parentheses indicate standard errors.

ANNEXURE 6.5

TIME TRENDS FOR AVERAGE LEAD OF MAJOR COMMODITIES BY RAIL DURING THE PERIOD 1970-71 TO 1985-86

| Sl. No. | Commodities | Linear Trend | | | Semilog Trend | | |
|---|---|---|---|---|---|---|---|
| | | Alpha | Beta | $R^2$ | Alpha | Beta | $R^2$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1. | Coal | 610 | -1.31 | 0.11 | 6.41 | -0.002 | 0.11 |
| | | (27.2) | (1.09) | | (0.04) | | |
| 2. | Raw material for steel plants | 175 | 1.99 | 0.67 | 5.17 | 0.010 | 0.65 |
| | | (10.6) | (0.43) | | (0.05) | (0.002) | |
| 3. | Iron & Steel | 806 | 16.12 | 0.89 | 6.70 | 0.016 | 0.89 |
| | | (43.2) | (1.74) | | (0.04) | (0.002) | |
| 4. | Iron ore | 528 | 4.72 | 0.36 | 6.26 | 0.008 | 0.39 |
| | | (48.9) | (1.89) | | (0.08) | (0.003) | |
| 5. | Foodgrains | 715 | 24.39 | 0.80 | 6.61 | 0.024 | 0.83 |
| | | (90.9) | (3.66) | | (0.08) | (0.003) | |
| 6. | Fertilisers | 655 | 18.23 | 0.83 | 6.51 | 0.024 | 0.86 |
| | | (62.18) | (2.50) | | (0.06) | (0.003) | |
| 7. | POL products | 565 | 4.80 | 0.23 | 6.50 | 0.021 | 0.86 |
| | | (65.29) | (2.63) | | (0.06) | (0.003) | |
| 8. | Other goods | 644 | 14.36 | 0.99 | 6.48 | 0.018 | 0.98 |
| | | (12.61) | (0.51) | | (0.06) | (0.001) | |
| 9. | Cement | 442 | 12.55 | 0.70 | 6.07 | 0.025 | 0.72 |
| | | (66.36) | (2.67) | | (0.12) | (0.005) | |
| 10. | Total | 599 | 6.61 | 0.89 | 6.39 | 0.010 | 0.90 |
| | | (17.70) | ((0.71) | | (0.03) | (0.001) | |

Notes: Figures in parentheses indicate standard errors.

ANNEXURE 6.6

LIST OF HEAVY DENSITY RAILWAY CORRIDORS

| Sl. No. (1) | Rail Sections (2) | Existing Capacity (3) | Required Capacity (4) |
|---|---|---|---|
| 1. | Delhi-Sonipat-Panipat-Karnal | 37 | 75 |
| 2. | Karnal-Kurukshetra | 20 | 75 |
| 3. | Kurukshetra-Ambla Cantt | 33 | 73 |
| 4. | Ambala Cantt-Rajpura | 58 | 88 |
| 5. | Rajpura-Sirhand-Ludhiana | 41 | 74 |
| 6. | Ludhiana-Phillaur-Phagwara | 50 | 65 |
| 7. | Delhi-Shahadra-Ghaziabad | 69 | 112 |
| 8. | Ghaziabad-Khurja-Aligarh-Hathras | 50 | 99 |
| 9. | Hathras-Barhan-Tundla West-Tundla | 53 | 105 |
| 10. | Tundla-Shikohabad-Etawah-Kanpur Cantt | 51 | 127 |
| 11. | Kanpur-Cantt-Fatehpur-Allahabad | 51 | 121 |
| 12. | Allahabad-Mirzapur-Mughalsarai | 50 | 145 |
| 13. | Mughalsarai-Sasaram-Anugraha-Gaya | 48 | 135 |
| 14. | Gaya-Hazaribagh Rd-Gomoh | 45 | 125 |
| 15. | Dhanbad-Sitarampur | 64 | 91 |
| 16. | Khanna-Burdwan | 117 | 160 |
| 17. | Burdwan-Saktigarh | 67 | 108 |
| 18. | Saktigarh-Bandel-Hooghly-Belur | 29 | 74 |
| 19. | Malda Town-Kumudpur | 22 | 51 |
| 20. | New Jalpaiguri-Jalpaiguri | 14 | 47 |
| 21. | Kooch Behar-Fakiragram-Kokrajhar | 17 | 47 |
| 22. | Howrah-Tikiapara | 55 | 81 |
| 23. | Panskura-Kharagpur | 57 | 85 |
| 24. | Rupsa-Balasore | 32 | 69 |
| 25. | Nergundi-Cuttack-Barang | 24 | 75 |
| 26. | Samalkot-Rajahmundry-Nidadavolu | 36 | 68 |
| 27. | Nidadavolu-Eluru-Vijayawada | 36 | 64 |
| 28. | Delhi-New Delhi | 36 | 60 |
| 29. | New Delhi-Tilak Bridge-H. Nizamuddin | 60 | 115 |
| 30. | H. Nizamuddin-Palwal-Mathura | 47 | 97 |
| 31. | Mathura-Bayana-Gangapur-Sawaimodhopur | 32 | 68 |
| 32. | Sawaimodhopur-Lakheri-Kesaripatan | 38 | 69 |
| 33. | Kesaripatan-Kota | 41 | 102 |
| 34. | Kota-Nagda-Ratlam-Dahod | 33 | 85 |
| 35. | Dahod-Piplod-Godhra | 40 | 86 |
| 36. | Godhra-Sevalia-Anand | 21 | 48 |
| 37. | Anand-Nadiad-Kankaria-Ahmedabad | 49 | 96 |
| 38. | Godhra-Vadodara-Bharuah-Surat-Udhna | 30 | 70 |
| 39. | Morena-Gwalior | 32 | 63 |
| 40. | Bhopal-Hoshangabad-Itarsi | 30 | 64 |
| 41. | Nagpur-Butibari-Wardha-Chandrapur | 30 | 66 |
| 42. | Peddapali-Kazipet-Dornakal-Vijayawada | 33 | 77 |
| 43. | Vijayawada-Krishna Canal | 55 | 105 |
| 44. | Krishna Canal-Ongole-Nellore-Gundur Jn | 40 | 85 |
| 45. | Jharsuguda-Raigarh | 18 | 82 |
| 46. | Kanham-Nagpur-Wardha-Badnera | 30 | 74 |
| 47. | Badnera-Kota-Malkapur-Bhusaval | 31 | 62 |
| 48. | Bhusaval-Jalgaon | 50 | 95 |
| 49. | Jalgaon-Pachora-Manmad-Nasik Road | 37 | 68 |
| 50. | Nasik Road-Igatpuri-Kasara-Titwala | 31 | 71 |
| 51. | Newmulund-Kuria-Dadar | 44 | 84 |
| 52. | Villivakkam-Avadi-Tiruvallur | 43 | 70 |
| 53. | Arakkonam-Sholinghur-Katpedi Jn | 36 | 68 |
| 54. | Katpedi Jn-Salem-Sankaridrug | 31 | 60 |
| 55. | Titwala-Asangaon-Kasara-Igatpuri | 31 | 70 |
| 56. | Igatpuri-Nasik Road | 31 | 70 |
| 57. | Nasik Road-Manmod-Pachora | 31 | 68 |
| 58. | Pachora-Jalgaon-Bhusaval-Jalamb | 31 | 67 |
| 59. | Jalamb-Akola-Bandera-Phulgaon | 31 | 62 |
| 60. | Phulgaon-Majri-Chandrapur | 30 | 56 |
| 61. | Udhana-Surat | 52 | 83 |
| 62. | Anand-Nadiad-Kankaria-Ahmedabad | 49 | 96 |

ANNEXURE 6.7

LIST OF HEAVY DENSITY HIGHWAYS

| Sl. No. | Section | Length in Kms | 1985 | | | | 2000 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cars | Buses | Trucks | PCUs | Cars | Buses | Trucks | PCUs |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 1. | DELHI-JAMMU (NH 1 AND 1 A) | | | | | | | | | |
| | Delhi-Panipat | 85 | 3,020 | 1,310 | 3,000 | 15,950 | 8,300 | 3,600 | 8,200 | 43,700 |
| | Panipat-Ambala | 117 | 1,900 | 1,000 | 2,700 | 13,000 | 5,200 | 2,700 | 7,400 | 35,700 |
| | Ambala-Jalandhar | 167 | 2,100 | 1,100 | 2,510 | 12,930 | 5,700 | 3,000 | 6,900 | 35,500 |
| | Jalandhar-Pathankot | 109 | 1,300 | 500 | 2,000 | 8,800 | 3,500 | 1,300 | 5,500 | 24,200 |
| | Pathankot-Jammu | 108 | 1,000 | 200 | 1,500 | 6,100 | 2,700 | 500 | 4,100 | 16,700 |
| 2. | DELHI-HISSAR (NH 10) | | | | | | | | | |
| | Delhi-Rohtak | 71 | 1,900 | 600 | 2,400 | 10,900 | 5,200 | 1,600 | 6,600 | 29,905 |
| | Rohtak-Hissar | 90 | 800 | 400 | 1,600 | 6,800 | 2,200 | 1,100 | 4,400 | 18,700 |
| 3. | DELHI-GHAZIABAD (NH 24) | | | | | | | | | |
| | Delhi-Ghaziabad | 19 | 3,000 | 1,000 | 5,000 | 21,000 | 8,200 | 2,700 | 13,700 | 54,700 |
| 4. | DELHI-AHMEDABAD-BOMBAY (NH 8) | 31 | 3,400 | 1,100 | 4,125 | 19,075 | 9,300 | 3,000 | 11,300 | 52,400 |
| | Delhi-Gurgaon | 228 | 650 | 450 | 3,000 | 11,000 | 1,700 | 1,200 | 8,200 | 30,200 |
| | Gurgaon-Jaipur | 138 | 800 | 350 | 2,800 | 11,250 | 2,200 | 900 | 7,700 | 28,200 |
| | Jaipur-Ajmer | 269 | 500 | 300 | 2,000 | 7,400 | 1,300 | 800 | 5,500 | 20,300 |
| | Ajmer-Udaipur | 251 | 1,750 | 850 | 2,000 | 10,300 | 4,800 | 2,300 | 5,500 | 28,300 |
| | Udaipur-Ahmedabad | 119 | 3,500 | 1,100 | 4,700 | 20,900 | 9,200 | 3,000 | 13,000 | 57,500 |
| | Ahmedabad-Baroda | 71 | 1,500 | 700 | 5,200 | 19,200 | 4,100 | 1,900 | 14,300 | 52,700 |
| | Baroda-Broach | 159 | 1,700 | 700 | 5,400 | 20,000 | 4,600 | 1,900 | 14,800 | 55,000 |
| | Broach-Vapi | 206 | 2,000 | 600 | 5,500 | 20,300 | 5,500 | 1,600 | 15,000 | 55,800 |
| | Vapi-Bombay | | | | | | | | | |
| 5. | DELHI-KANPUR-CALCUTTA (NH 2) | | | | | | | | | |
| | Delhi-Agra | 200 | 1,600 | 800 | 2,000 | 10,000 | 4,400 | 2,200 | 5,500 | 27,500 |
| | Agra-Kanpur | 290 | 800 | 800 | 2,000 | 9,200 | 2,200 | 2,200 | 5,500 | 25,300 |
| | Kanpur-Allahabad | 173 | 1,200 | 800 | 2,000 | 9,600 | 3,300 | 2,200 | 5,500 | 26,400 |
| | Allahabad-Varanasi | 122 | 1,200 | 800 | 2,200 | 10,200 | 2,400 | 2,200 | 6,000 | 27,900 |
| | Varanasi-Barhi | 278 | 900 | 500 | 2,200 | 9,000 | 3,800 | 1,400 | 6,000 | 24,600 |
| | Barhi-Dhanbad | 120 | 1,400 | 800 | 3,000 | 12,800 | 3,800 | 2,200 | 8,200 | 35,000 |
| | Dhanbad-Durgapur | 103 | 1,400 | 600 | 4,000 | 15,200 | 1,600 | 1,600 | 11,000 | 41,800 |
| | Durgapur-Calcutta | 157 | 600 | 300 | 3,500 | 12,000 | | 800 | 9,600 | 33,000 |

*(Contd.)*

ANNEXURE 6.7 (Contd.)

| Sl. No. | Section | Length in Kms | 1985 | | | | 2000 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cars | Buses | Trucks | PCUs | Cars | Buses | Trucks | PCUs |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 6. | LUCKNOW-KANPUR (NH 25) | | | | | | | | | |
| | Lucknow-Kanpur | 79 | 500 | 700 | 2,200 | 9,200 | 1,400 | 1,900 | 6,000 | 25,100 |
| 7. | AGRA-INDORE-BOMBAY (NH 3) | | | | | | | | | |
| | Agra-Gwalior | 119 | 850 | 500 | 1,200 | 5,900 | 2,300 | 1,400 | 3,300 | 16,400 |
| | Gwalior-Shivpuri | 114 | 550 | 300 | 1,200 | 6,200 | 1,500 | 800 | 3,800 | 15,500 |
| | Shivpuri-Biaera | 193 | 200 | 300 | 1,200 | 5,300 | 500 | 800 | 3,300 | 12,900 |
| | Biaera-Indore | 180 | 600 | 700 | 1,900 | 8,400 | 1,600 | 1,900 | 5,200 | 22,900 |
| | Indore-Dhule | 258 | 600 | 200 | 1,400 | 5,500 | 1,600 | 700 | 3,800 | 15,200 |
| | Dhule-Nashik | 156 | 1,000 | 400 | 2,400 | 9,400 | 2,700 | 1,100 | 6,600 | 25,800 |
| | Nashik-Bombay | 184 | 1,100 | 700 | 3,700 | 14,300 | 3,000 | 1,900 | 10,100 | 39,300 |
| 8. | BOMBAY-BANGALORE-MADRAS (NH 4) | 155 | 2,000 | 1,500 | 3,700 | 17,600 | 5,500 | 4,100 | 10,100 | 48,400 |
| | Bombay-Pune | 233 | 800 | 600 | 2,400 | 9,800 | 2,200 | 1,600 | 6,600 | 26,900 |
| | Pune-Kolhapur | 103 | 700 | 400 | 2,200 | 8,500 | 1,900 | 1,100 | 6,000 | 23,300 |
| | Kolhapur-Belgaum | 304 | 600 | 500 | 1,900 | 7,800 | 1,600 | 1,300 | 5,200 | 21,400 |
| | Belgaum-Chitradurga | 202 | 600 | 500 | 2,400 | 9,300 | 1,600 | 1,300 | 6,600 | 25,300 |
| | Chitradurga-Bangalore | 221 | 800 | 700 | 2,200 | 9,500 | 2,200 | 1,900 | 6,600 | 27,700 |
| | Bangalore-Ranipet | 113 | 800 | 700 | 2,200 | 9,500 | 2,000 | 1,900 | 6,600 | 27,700 |
| | Ranipet-Madras | | | | | | | | | |
| 9. | BANGALORE-COCHIN-TRIVANDRUM (NH 7 & 47) | | | | | | | | | |
| | Bangalore-Salem | 205 | 500 | 600 | 1,900 | 8,000 | 1,300 | 1,600 | 5,200 | 22,000 |
| | Salem-Coimbatore | 158 | 900 | 700 | 2,800 | 11,400 | 2,400 | 1,900 | 7,700 | 30,700 |
| | Coimbatore-Trichur | 109 | 1,500 | 1,000 | 2,300 | 11,400 | 4,100 | 2,700 | 6,300 | 31,300 |
| | Trichur-Cochin | 68 | 2,500 | 1,000 | 2,600 | 13,300 | 6,900 | 2,700 | 7,100 | 36,300 |
| | Cochin-Quilon | 126 | 2,200 | 900 | 1,400 | 9,100 | 6,000 | 2,400 | 4,000 | 25,200 |
| | Quilon-Trivandrum | 71 | 2,500 | 900 | 1,300 | 9,300 | 6,800 | 2,400 | 4,000 | 25,200 |
| 10. | MADRAS-VISHAKHAPATNAM-BHUBANESWAR-CALCUTTA (NH 5) | | | | | | | | | |
| | Madras-Gudur | 145 | 900 | 800 | 1,250 | 6,050 | 2,500 | 2,200 | 3,400 | 19,300 |
| | Gudur-Ongole | 152 | 600 | 500 | 2,500 | 9,600 | 1,600 | 1,300 | 6,800 | 25,900 |
| | Ongole-Guntur | 103 | 1,700 | 1,700 | 3,000 | 15,800 | 4,600 | 4,600 | 8,200 | 43,000 |

*(Contd.)*

ANNEXURE 6.7 *(Concld.)*

| Sl. No. | Section | Length in Kms | 1985 | | | | 2000 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cars | Buses | Trucks | PCUs | Cars | Buses | Trucks | PCUs |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| | Guntur-Vijayawada | 32 | 1,500 | 1,550 | 2,500 | 13,650 | 4,100 | 4,100 | 6,800 | 36,800 |
| | Vijayawada-Rajah Mundry | 175 | 1,000 | 900 | 2,200 | 10,300 | 2,700 | 2,500 | 6,000 | 28,200 |
| | Rajah Mundry-Vishakhapatnam | 195 | 700 | 700 | 2,500 | 10,300 | 1,900 | 1,900 | 6,800 | 28,000 |
| | Vishakhapatnam-Bhubaneswar | 426 | 1,400 | 500 | 3,500 | 13,400 | 3,800 | 1,300 | 9,600 | 36,500 |
| | Bhubaneswar-Cuttack | 45 | 1,400 | 800 | 3,000 | 12,800 | 3,800 | 2,200 | 8,200 | 35,000 |
| | Cuttack-Kharagpur | 340 | 900 | 500 | 2,500 | 9,900 | 2,500 | 1,300 | 6,800 | 26,800 |
| | Kharagpur-Calcutta | 91 | 900 | 500 | 2,500 | 9,900 | 2,500 | 1,300 | 6,800 | 26,800 |
| 11. | MADRAS-DINDIGUL-MADURAI (NH 45 & 7) | | | | | | | | | |
| | Madras-Chinglepet | 59 | 2,000 | 2,500 | 6,000 | 11,300 | 5,500 | 6,800 | 16,500 | 75,400 |
| | Chinglepet-Villupuram | 101 | 1,000 | 1,500 | 4,000 | 6,700 | 2,700 | 4,100 | 11,000 | 48,000 |
| | Villupuram-Tiruchirappally | 159 | 900 | 1,400 | 3,000 | 14,100 | 2,500 | 3,800 | 8,200 | 38,500 |
| | Tiruchirappally-Dindigul | 79 | 400 | 800 | 2,000 | 8,800 | 1,100 | 2,200 | 5,500 | 24,200 |
| | Dindigul-Madurai | 63 | 800 | 500 | 1,300 | 6,200 | 2,200 | 1,300 | 3,500 | 16,600 |
| 12. | DHULE-NAGPUR-RAIPUR-(NH 6) | | | | | | | | | |
| | Dhule-Akola | 280 | 500 | 200 | 1,800 | 6,500 | 1,400 | 500 | 4,900 | 17,600 |
| | Akola-Nagpur | 250 | 300 | 200 | 1,100 | 4,200 | 800 | 500 | 3,000 | 11,300 |
| | Nagpur-Durg | 240 | 800 | 300 | 1,100 | 6,500 | 2,200 | 800 | 3,000 | 13,600 |
| | Durg-Raipur | 37 | 1,200 | 700 | 2,000 | 9,300 | 3,300 | 1,900 | 5,500 | 25,500 |
| 13. | HYDERABAD-VIJAYAWADA (NH 9) | | | | | | | | | |
| | Hyderabad-Suryapet | 133 | 400 | 500 | 1,600 | 6,700 | 1,100 | 1,400 | 4,400 | 18,500 |
| | Suryapet-Vijayawada | 138 | 500 | 400 | 1,400 | 5,900 | 1,400 | 1,100 | 3,800 | 16,100 |
| 14. | BANGALORE-MYSORE (SH) | 120 | 800 | 300 | 1,200 | 5,300 | 2,200 | 800 | 3,300 | 14,500 |

ANNEXURE 13.1

ESSENTIAL COMMODITIES CARRIED AT CONCESSIONAL RATES BELOW COSTS
STATEMENT OF LOSSES

(Rs Crore)

| Sl. No. (1) | COMMODITY (2) | LOSSES 1984-85 (3) |
|---|---|---|
| 1. | Food Grains | 90.39 |
| 2. | Salt (for edible use) | 21.46 |
| 3. | Fodder | 14.86 |
| 4. | Fruits & Vegetables | 11.84 |
| 5. | Timber Wrought | 5.75 |
| 6. | Firewood & Charcoal | 5.15 |
| 7. | Oil Seeds (others) | 4.96 |
| 8. | Edible Oils | 3.57 |
| 9. | Other Ores | 3.13 |
| 10. | Bamboo | 2.87 |
| 11. | Livestock | 1.91 |
| 12. | Cotton Raw (unpressed) | 1.86 |
| 13. | Sugarcane | 1.46 |
| 14. | Cotton Manufactured & Other Price Goods | 1.35 |
| 15. | Others | 3.04 |
| | Total | 173.60 |

Source: Indian Railways Year Book 1984-85.

ANNEXURE 13.3

ESTIMATED OPERATING RATIO DUE TO ABOLITION
OF SECOND CLASS ORDINARY FARES

| Sl. No. (1) | (2) | 1984-85 (3) | 1985-86 (4) |
|---|---|---|---|
| 1. | Total working expenditure (Rs in crore) | 5,142.17 | 5,823.14 |
| 2. | Gross traffic receipts - Actual (Rs in crore) | 5,358.77 | 6,428.10 |
| 3. | Additional earnings if second class ordinary fares abolished (Rs in crore) | 576.00 | 607.00 |
| 4. | Gross traffic receipts - Putative (Rs in crore) | 5,934.77 | 7,735.10 |
| 5. | Operating Ratio - Actual | 96.25 | 90.58 |
| 6. | Operating Ratio - Putative | 86.65 | 82.77 |

ANNEXURE 13.5

SHARE OF GRANT VIS-A-VIS LOSS ON UNECONOMIC BRANCH LINES

(Rs in lakh)

| State (1) | Share of the grant as fixed by the Seventh Finance Commission (2) | Loss on uneconomic branch lines in 1981-82 (3) |
|---|---|---|
| Andhra Pradesh | 162 | 25 |
| Assam | 57 | - |
| Bihar | 220 | 65 |
| Gujarat | 122 | 91 |
| Haryana | 46 | 2 |
| Himachal Pradesh | 3 | - |
| Jammu & Kashmir | 17 | - |
| Karnataka | 74 | 8 |
| Kerala | 60 | 22 |
| Madhya Pradesh | 135 | 19 |
| Maharashtra | 367 | - |
| Manipur | - | - |
| Meghalaya | - | - |
| Nagaland | 6 | - |
| Orissa | 40 | 37 |
| Punjab | 88 | - |
| Rajasthan | 127 | 44 |
| Sikkim | - | - |
| Tamil Nadu | 158 | 18 |
| Tripura | 1 | - |
| Uttar Pradesh | 429 | 145 |
| West Bengal | 200 | 20 |
| | 2,312 | 496 |

ANNEXURE 13.2

COMPARATIVE RAIL FARE (II CLASS ORDINARY & MAIL/EXPRESS) AND BUS FARES OF VARIOUS STATE ROAD TRANSPORT CORPORATIONS

| Distance (kms) | Rail Fair (II class) | | Bihar | Karnataka | UP | Andhra Pradesh | Mahara-shtra | Kerala | Tamil Nadu | Assam | MP | West Bengal | Orissa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ordy. | Mail/Exp. | | | | | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| 5 | 1.00 | 3.00 | 0.60 | 0.55 | 0.55 | 0.50 | 0.50 | 0.50 | 0.45 | 0.50 | 0.60 | 0.50 | 0.60 |
| 10 | 1.00 | 3.00 | 1.10 | 1.10 | 1.10 | 1.00 | 1.00 | 1.00 | 0.85 | 0.95 | 1.20 | 1.00 | 1.10 |
| 15 | 1.00 | 3.00 | 1.70 | 1.65 | 1.65 | 1.50 | 1.50 | 1.50 | 1.30 | 1.45 | 1.80 | 1.50 | 1.70 |
| 20 | 2.00 | 4.00 | 2.25 | 2.20 | 2.20 | 2.00 | 2.00 | 2.00 | 2.00 | 1.90 | 2.40 | 2.00 | 2.20 |
| 25 | 2.00 | 4.00 | 2.85 | 2.75 | 2.75 | 2.50 | 2.50 | 2.50 | 2.15 | 2.40 | 3.00 | 2.50 | 2.80 |
| 30 | 2.00 | 5.00 | 3.35 | 3.30 | 3.30 | 3.00 | 3.00 | 3.00 | 2.55 | 2.90 | 3.60 | 3.00 | 3.40 |
| 35 | 3.00 | 5.00 | 3.95 | 3.85 | 3.85 | 3.50 | 3.90 | 3.35 | 3.00 | 3.40 | 4.20 | 3.50 | 4.00 |
| 40 | 3.00 | 5.00 | 4.50 | 4.40 | 4.50 | 4.00 | 4.70 | 3.40 | 3.80 | 4.20 | 4.80 | 4.00 | 4.60 |
| 45 | 3.00 | 6.00 | 5.10 | 4.95 | 5.05 | 4.50 | 5.20 | 4.20 | 3.85 | 4.30 | 5.40 | 4.50 | 5.20 |
| 50 | 3.00 | 6.00 | 5.60 | 5.50 | 5.55 | 5.00 | 5.80 | 4.90 | 4.25 | 4.70 | 6.00 | 5.00 | 5.70 |
| 60 | 4.00 | 8.00 | 6.70 | 6.60 | 6.65 | 6.00 | 6.90 | 5.90 | 5.10 | 5.60 | 7.20 | 6.00 | 6.80 |
| 70 | 6.00 | 9.00 | 7.80 | 7.70 | 7.75 | 7.00 | 8.00 | 6.90 | 5.95 | 6.55 | 8.40 | 7.00 | 7.90 |
| 80 | 6.00 | 10.00 | 9.00 | 8.80 | 8.85 | 8.00 | 9.10 | 7.90 | 6.80 | 7.50 | 9.60 | 8.00 | 9.00 |
| 90 | 7.00 | 10.00 | 10.10 | 9.90 | 9.95 | 9.00 | 10.20 | 8.90 | 7.65 | 8.45 | 10.80 | 9.00 | 10.10 |
| 100 | 7.00 | 11.00 | 11.25 | 11.00 | 11.10 | 10.00 | 11.20 | 9.90 | 8.50 | 9.30 | 12.50 | 10.00 | 11.40 |
| 150 | 10.00 | 18.00 | 16.85 | 16.50 | 16.65 | 15.00 | 17.00 | 14.80 | 12.75 | 14.00 | 18.50 | 15.00 | 17.10 |
| 200 | 13.00 | 23.00 | 22.50 | 22.00 | 22.20 | 20.00 | 23.40 | 19.70 | 17.00 | 18.60 | 25.00 | 20.00 | 22.80 |
| 250 | 17.00 | 26.00 | 28.10 | 27.50 | 27.75 | 25.00 | 29.25 | 24.60 | 21.25 | 23.25 | 31.25 | 25.00 | 28.50 |
| 300 | 19.00 | 30.00 | 34.75 | 33.00 | 33.30 | 30.00 | 35.10 | 29.55 | 25.50 | 27.90 | 37.50 | 30.00 | 34.20 |
| 350 | 22.00 | 35.00 | 40.35 | 38.50 | 38.85 | 35.00 | 40.80 | 34.45 | 29.75 | 32.55 | 43.75 | 35.00 | 39.90 |
| 400 | 24.00 | 38.00 | 46.00 | 44.00 | 44.40 | 40.00 | 40.95 | 39.40 | 34.00 | 37.20 | 50.00 | 40.00 | 45.60 |
| 450 | 26.00 | 42.00 | 51.60 | 49.50 | 49.95 | 45.00 | 52.65 | 34.30 | 38.50 | 41.85 | 56.25 | 45.00 | 51.30 |
| 500 | 29.00 | 45.00 | 56.25 | 55.00 | 55.00 | 50.00 | 58.50 | 49.25 | 42.50 | 46.50 | 62.50 | 50.00 | 57.00 |

Source: Rail Fares: N. Rly Time Table October, 1986.
Road Fares: *A Study on the Performance of State Road Transport Undertakings*, Planning Commission Transport Division, May 1986.

# Book Reviews

I- Satpal Sangwan, *Science, Technology and Colonisation: An Indian Experience, 1757-1857,* National Institute of Science, Technology and Development Studies, Anamika Prakashan, Delhi, 1991, Pp. xiv+196, Price Rs 250.

II- Deepak Kumar (ed), *Science and Empire, Essays in Indian Context (1700-1947),* National Institute of Science, Technology and Development Studies, Anamika Prakashan, Delhi, 1991, Pp. xvi+205, Price Rs 200.

These two books (referred to as I and II respectively in the following) come from the National Institute of Science, Technology and Development Studies, and are focussed on the same theme broadly indicated by their titles. II is a collection of papers read at an international seminar held in Delhi in 1985. It ranges over a wider period and a wider field than I. Though there is an overarching theme round which the papers cluster, they remain separate pieces or studies of particular problems. In contrast I is more compact both in regard to the period and the field covered. Its impact is more pointed than that of II. Both the books explore a little-explored field of Indian history during the British period and as such are welcome and valuable though with certain reservations as detailed below.

I is confined to the period 1757-1857, that is, to the last hundred years of the East India Company's existence. It begins by briefly sketching the state of technology and science in India before Plassey and then goes on to describe in detail the successive introduction by the government of the East India Company of land surveys and map-making, the botanical and zoological surveys and much later the geological survey. A detailed description of the introduction of new techniques in shipping (steam navigation), railways, telegraph, construction of macadamized roads, irrigation works by building dams across rivers, textile technology (ginning and pressing), agricultural technology by way of new crops, seeds, iron ploughs and other agricultural implements, etc. This is followed by an assessment of the reception and adaptation of these by the Indian people. A chapter is devoted to narrate the hesitant steps that the Company's government took in regard to scientific and technical education of Indians. In conclusion the author observes that "the Company's government had no cohesive policy to administer scientific works in India. Development of science and technology during the period therefore depended mainly on circumstances and individual enthusiasm .... In fact what the Company had aimed at was, what was called 'productive science, that is, science for profit and for the maximum utilization of local resources'. At the same time they deliberately discriminated against Indians" (I-Pp. 146-149). "Propagated as purely a political-commercial necessity, colonial science offered very little scope for local people to be associated with its progress, especially on the theoretical side" (I. p. 151).

II is, as mentioned earlier, a collection of papers with their focus on India. It opens with Rahman's inaugural address suggesting and listing the wide range of subjects in the assessment of the nature of the processes and impacts unleashed during the British colonial regime in India. In *Part I - Reflections on Policy* two papers deal with the "so-called" imperial and colonial sciences, one favourably and the other sceptically. *Part II - Before the Conquest* has two papers, one dealing with why the scientific revolution did not take place in India and the other with the state of textile industry in South India before British conquest. *Part III - After the Conquest* deals with Indian response and adaptation of the new techniques of production in silk filatures and silk production, irrigation development in Tamilnadu and colonial government's response to malaria control in the twentieth century. *Part IV - Indian Receptivity* comprises six papers mainly dealing with developments when English - educated Indians began to pursue science on their own initiative and this development came to be supported by the Indian National Congress. Science was then being seen increasingly as purely an intellectual exercise. Institutionalization of scientific education and research in India is also extensively dealt with.

While these careful and detailed explorations in this part of India's economic and social history are welcome, the undergirdling thesis of their analysis is questionable and needs revision in the light of more recent historical happenings and researches. The thesis is that of the twin concepts of an imperial and a "Colonial" science and how the latter was the product of the deliberate policy of the imperial state to develop a sort of scientific

imperialism whereby science in the colonial countries was suppressed and maintained in a servile state. More specifically "Colonial science is a dependent science wherein the result-oriented research in applied science supercedes the curiosity-oriented research of pure science" (II-p 6). It is a science as a means of producing wealth rather than an intellectual exercise. In the pursuit of this science Indians provided cheap labour.

'Imperialism', 'empire' and 'colonies' have in modern times become words charged with ideology and emotion. Accordingly, imperialism is such a moral evil that all the acts of commission and omission on its part are regarded as evil and harmful to the colonial countries and their peoples. The whole paradigm in this regard can be put baldly as follows: Britain, in the first place, should not have conquered India. They had no moral right. Having committed this unpardonable sin, they should have at least compensated it by ruling and administering India in a way in which modern Indians themselves would have, with a view to bringing about an all-sided economic and social transformation of the Indian society to make it fit for the modern world. By not doing so the British compounded the sin and therefore deserve no benefit of doubt but only condemnation that flows from the thesis of the imperial and colonial sciences.

This is an understandable argument from the populist angle but hardly one which serious historians and scholars can or should accept at face value. The whole thesis is long on misconceptions and ideological preoccupations and short on historical perspective and objectivity. There is little historical evidence to show that there was ever a body of statesmen and politicians at imperial headquarters shaping and orchestrating a science policy with objectives and means to achieve them at their disposal. As Worboys points out in his paper "Science was never organized or practised on an empire-wide basis; there was no imperial science" (II p. 13). Sangwan in his concluding chapter admits that "the Company government, it seems, had no cohesive policy to administer scientific works in India", but ignores his own finding elsewhere (I-p. 148).

A critical examination of the thesis shows that it is a fiction and was the product of the ambience of colonial days. What happened in India in this respect was the result of attempts made by British rulers to meet the exigencies of the conquest of a foreign land and the consequent responsibility of administering it. It was characterised by a total lack of design to be anywhere near a long term policy. Let us probe a little (that is all that is possible here) to get a glimpse of the underlying truth.

No historian can expect any people, whether British or Indian or any other, to act out of their native character. As everybody else the British rulers of India had their own culture, values, norms of behaviour and their intellectual furniture born out of their home experience and bringing up in their own country. As conquerors and rulers of India they acted as Britishers and no historian can expect them to behave in any other way. As rulers of India their first task was to set up an administration and government which they understood, were familiar with and could operate. They could not have operated with the kind of administration that the pre-British rulers in India could do with. Naturally drawing on their home experience the Britishers proceeded to set up in India an impersonal, bureaucratic and centralized administration and government which was based on institutions rather than individuals. This was completely in contrast with pre-British Indian governments and administrations. As a matter of historical record, this was the first and the primary technical change the British introduced in India. Such an administrative and government machine required much more information, more developed communications than that under the pre-British rulers for its smooth operation. The new system, therefore, had to have maps and land surveys, surveys of flora and fauna, and much later, geological surveys and the information provided by them. It also required more and better roads, better land and water communications by way of steam boats, railways, telegraphs, etc., and these they proceeded to acquire as quickly as possible in the course of time. They met the problems as and when they arose and there was no well thought-out policy either in conception or execution.

The gravest charge against the British rulers was that they introduced technology or applied or

use-induced science as against curiosity - induced theoretic or pure science. The implicit suggestion is that science is essentially theory and a science without a theory is not science. This is totally wrong. Theory is not the *sine qua non* of science. There are many natural sciences, except physics, that have no theory; for example chemistry, biology, geology. Even in physics, after Einstein, there is not a consistent theory covering the whole field from the atom to the universe. But ignoring this another possible implication of the above charge is that the curiosity-induced science would have been able to promote the social transformation of the Indian society whereas the use-induced science could not. We know from history that these two together by themselves could not have brought about a social transformation in Indian society because they are perhaps necessary but not sufficient for bringing such a transformation about. When theoretical science was introduced into India later it did annex a Nobel prize but could not do much about social transformation. In the last forty and odd years of Independence, science and technology have been vigorously pushed but the absence of social transformation is so patent as not to be ignored. It may be useful in this regard to restore the proper historical perspective to remind ourselves that the rulers of independent India have lost no opportunity to exhort the Indian scientists not to lose themselves in theoretical conundrums and to engage in research that had practical use and could be taken to the villages. Why are the British rulers blameworthy for doing exactly the same thing, for introducing 'science for profit and for maximum utilisation of local resources' (I-p. 149)? What is sauce for the goose, is it not sauce for the gander?

Another charge against the British rulers was that they did not think of manufacturing in India the tools that were necessary for the operation of the new techniques introduced by them. They imported them from England. Again, in historical perspective, this is an ignorant charge. Supposing that the British wanted to do this the relevant question was, there the necessary infrastructure in India for starting these industries at that time? There obviously was not. Persistence in such a policy would have meant considerable delay in the introduction of the new techniques, a delay the British rulers could not afford in the face of pressing needs of the administration. Besides, in those days when England was regarded as the 'workshop of the world' no Britisher could have conceived of any other country, let alone India, which could have manufactured these tools and instruments as well and as cheap as England could have. The British were not acting out of their character.

A relevant and sobering historical fact in this connection may be recalled. Most of the pre-British rulers in India had been buying guns and ammunition from the Portuguese, the French and the British for at least a couple of centuries. And yet they did not seem to have made any conserted efforts to start manufacturing them in India so as to reduce their dependence on the foreigners. What did not occur to the indigenous rulers of India why should it have occurred to the British rulers who were after all foreigners?

A third charge against the British rulers was that they did not encourage the education of sciences and technology in India and instead laid stress on literary education (I-Pp. 149-150). Let us again bear in mind that the British rulers could not have acted out of their character in this respect too. They were doing exactly in India what was being done at home and were drawing on their experiences, which of course they regarded as the best in the world. Education in England was then dominated by Oxford and Cambridge and there the literary tradition was overwhelming. Macaulay was only trying to reproduce in India this system because it was the one that he knew.

This charge also partly springs from ignorance about the conditions and state of technical education in England at that time. From the ill-founded, imaginative and romantic interpretations in the writings of the late Victorian period about the "so-called" industrial revolution in England it is assumed that everything was the best in England in this regard. As later and more objective studies in this regard confirm this assumption was untrue. As compared to Germany and France, England in this regard was backward and chaotic. The governments in England were most niggardly in financing scientific education or research as compared to France and Germany

whose governments spent huge amounts on these matters. The English government's attitude to science is reflected revealingly in their action in removing an epoch-making scientist like Newton from the Cambridge University and appointing him the master of the mint. There was little or no contact between the technicians who made and invented the new gadgets that led to the so-called industrial revolution (and who by the way were not trained in theoretical science) and scientists in academies in England. It is unnecessary to add that the state of technical education in England was haphazard and retarded. This was brought home to the English when the Great Exhibition of 1851 was held. It showed to them conclusively that the British industrial techniques and productivity had been overtaken by those of France, Germany and U.S.A. and that England was already lagging behind. There was some awakening in England then, and some efforts to improve the state of technical education in England were made but without much success. This technological weakness of England persisted as late as the second world war. The British rulers of India, even if they had wanted, could not have made a good job of the setting up of scientific or technical education in India.

The most preposterous charge against the British rulers of India was that for whatever instruction or education they started in regard to technology and science in India they used the English medium (I-p. 68, II-p. 139). Because of this, instead of playing the role it did in Europe, it became isolated.

In what other language than English could the British rulers have been expected to educate Indians in science and technology? In Hindi or Urdu and all the other regional vernaculars of India? All these lacked at that time any scientific writings of the most elementary kind and had no vocabularies for scientific terms. To make up these deficiencies and then start the instruction would have delayed it by decades. But apart from delay it was a tall order, which even the governments of independent India have not been able to fulfil during the last forty and odd years. Even today we continuously hear grave warnings being given against replacing the English medium by vernacular mediums in the teaching of science as this will cut off India from the mainstream of scientific advance in the world. Is it not an irony of history how the same things appear different to you when you change to the opposite side of the table?

These are only a few probings into the main underlying thesis of these two books sufficient to indicate how questionable it is in historical perspective. While praising the two books for their careful explorations in this indifferently-ploughed area of Indian history one would like these scholars to look more deeply into these ideological preconceptions and correct them in the wider perspectives of history so that their findings may shine even brighter.

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*The Right to Know* by S.P. Sathe, N.M. Tripathi Private Ltd., Bombay, 1991, Pp. 58, Price Rs 50/-.

This monograph covering 58 printed pages comprises three endowment lectures delivered in 1990 by S.P. Sathe, Principal ILS College, Pune, under the auspices of the Law Centre of the University of Delhi. The booklet with a brilliant foreword by Upendra Baxi, India's another academic expert of eminence in the field of law and a student of Sathe himself, provides an incisive glimpse into the rights of the Indian people to *information* and to *knowledge* under their laws and the Constitution.

In the first lecture entitled 'Information: Fuel for Indian *Perestroika* and *Glasnost*', Sathe discusses the various problems the Indian people face in this field, resulting from the prevailing massive illiteracy, let alone their lack of free access to simple or expertise knowledge about matters that affect their day to day lives and their governance by their elected representatives and the bureaucracy. At the end of the lecture Sathe identifies various situations in which a person has a right to know and duty to give information to another in two broad fields: (A) relationship

between individuals such as between buyers and sellers or landlord and tenant or husband and wife, etc., and (B) relationship between the individual and the State.

The first lecture rightly highlights that if the people are to be the real sovereign to exercise their power of appointing and dismissing governments and to approve or disapprove of their policies, they must be *well-informed.* In the absence of such well-informed people, selfish and unscrupulous politicians can manipulate the people, resorting to populism, fundamentalism, communalism, or racism. In fact today the Indian people are victims of such unscrupulous manipulation. He has rightly observed that 'A well informed people is therefore the best guarantee of the survival and strengthening of the democratic process' (p. 2).

Sathe has pointed out the two important levels at which people acquire information and knowledge (a) 'the infrastructural level where knowledge is acquired to possess capacity for acquiring knowledge' by ability to read, write and learn, that is, at the literacy level, and (b) 'higher knowledge which will help one gain skills, expertise, academic distinction, etc.,' (p. 2). In the elementary literacy field itself we have miserably failed. Article 45 from the Directive Principles of the State Policy in the Constitution directed that: "The State shall endevour to provide, within a period of ten years free and compulsory education for all children until they complete the age of fourteen years". Even 41 years after the commencement of the Constitution, we are far from attaining the goal. The statistics about literacy quoted by Sathe from the Population Census of 1981 expose our miserable failure and our utter unconcern in the field (p. 1). In the year 1991 we are patting our backs that one solitary State of Kerala has attained near-full literacy with the cooperation of voluntary organisations. The tremendous impact that full literacy, particularly among women, can have on the improvement of quality of life of our people by controlling population - explosion, providing gainful employment, curbing social evils and feudal overlordship, etc., is self-evident.

In respect of the field of acquisition of higher knowledge, Sathe has referred to the leading cases of the Supreme Court led by *Balaji vs Mysore* (AIR 1963 SC 649). In fact the battle for access to higher education is still being waged in the Court of Law through plethora of litigation relating to entry in institutions of higher education between the privileged and the underprivileged, the upper and the lower castes, a fact of life the Indian society cannot wish away. The Mandal controversy is a manifestation of that reality.

Then again, in the first lecture Sathe has drawn pointed attention to various problems, among others to 'the culture of secrecy in our administration'. He has rightly observed that 'Secrecy breeds corruption, openness promotes equality and objectivity and impartiality' (p. 7). With several sacred cows such as defence, nuclear energy, official secrets, appointment of incumbents to high offices, including the judiciary, secret movements of files in the corridors of power and even non-availability of bare texts of enactments passed by our elected bodies, leave alone the latest amendments, our people have lack of information which makes a mockery of the assumption of a democratic polity and an open society in our country. Sathe rightly makes a strong plea that, 'Right to information is therefore the most basic right without which there will be no *glasnost* and without such *glasnost* there can be no *perestroika* meaning change in the character of the Indian State' p.6).

Lecture I concludes by making a reference to a subtle distinction made by Hohfeld between right and liberty. In the case of a right of one person there is a corresponding duty on another, whereas a person can have liberty without a corresponding duty being imposed on any one else. Finally, as stated earlier Lecture I concludes by identifying the various situations in which a person has a right to know and another has a corresponding duty to give information. These situations are dealt with in detail in Lecture 2 entitled "The Right to Know - Constitutional and Jurisprudential Perspectives" under various headings such as (1) when is an individual bound to give information to another individual? (2) when is a person free not to give information to another person? (3) when is a person bound to give information to the State? (4) when is a person entitled to be informed by the State? (5) when is a person free not to give information to the State? and (6) when is the State

at liberty not to give information to a person? Under these topics Sathe has discussed the relevant provisions of various Indian enactments and of the Constitution of India, as also the relevant decisions of the Supreme Court and High Courts. Among others, references are made to the relevant provisions of the Consumer Protection Act, 1956, Drugs and Magic Remedies (Objectionable Advertisement) Act, 1954, the Post Office Act, the different Preventive Detention Acts, the archaic Official Secrets Act, 1921 drawn on the model 1911 Act of England and the Atomic Energy Act, 1962. It is notorious that the Official Secrets Act and the Atomic Energy Act protect the establishment and prevent citizens from getting vital information affecting their lives. The clauses similar to the secrecy clauses in the Atomic Energy Act operate in all countries being calculated to prevent people from knowing the secret preparation by their respective governments of processing material for developing nuclear warheads, through projects for the development of nuclear energy, ostensibly for peaceful purposes.

In Lecture 3 under the caption 'The Right to Know: Proposed Constitutional and Legislative Strategies' Sathe has discussed the relevant provisions of the Declaration of Human Rights 1948, and the International Covenant on Civil and Political Rights adopted by the General Assembly of the United Nations in 1976 on the subject of the right to know and the right to information as well as the strategies adopted in this behalf by various countries such as Sweden, England, Denmark, Norway, United States, Canada and the USSR. He also discusses the relevant judgements of our Supreme Court including the ones in the *Sakal Newspapers* case, *Bennett Coleman* case and the *Indian Express* case, highlighting the recognition by the apex court that restrictions on freedom of the press is in effect denial of information to the citizens. He therefore pleads that 'right to information must have an independent existence' and further argues as follows: 'Right to education is also a basic right without which no right to information can become meaningful. Therefore, both right to education and right to information, have to be recognised as basic human rights' (p. 46). At a later stage in his argument Sathe outlines a legislative strategy for achieving these objectives by enumerating certain steps and measures to be adopted, and pleads for enactment of a comprehensive Right to Information Act in India (p. 54). Finally, he concludes: 'Right to know, right to work, right to shelter and right to health care are the emerging human rights of the twenty-first century. Let India not step into this new century with the backlog of illiteracy, poverty and exploitation' (p. 58). Ironically, only recently the Vice President of India announced that half the number of the illiterates in the world reside in India.

As one of our leading and eminent academic experts in the field of Law, Sathe deals with the human subject of 'The Right to Know' from the point of view of jurisprudence, in the context of the Constitutional and Legal provisions and decisions of the Courts of Law and the political and social goals of the Indian people as reflected in our Constitution. The problem of the Right to Know is really a basic philosophical problem related to human freedom. Human being is a unique animal which has acquired a highly developed brain and a cerebral system in the course of evolution as a species. With his highly advanced brain, man is capable of comprehending his surroundings, his environment, the laws that govern nature and the Universe as well as himself, and of analysing that knowledge. This analysis helps him to bring about his advancement and progress. 'The quest for freedom and search for truth constitute the basic urge of human progress. The quest for freedom is the continuation on a higher level of intelligence and emotion, of the biological struggle for existence. The search for truth is a corollary thereof. Increasing knowledge of nature enables man to be progressively free from the tyranny of natural phenomena and physical and social environments. Truth is the content of knowledge'. If these formulations of M.N. Roy made in 1946 in his manifesto of New Humanism are valid, it is obvious that the right to know is a basic human fact of life as well as a human value which is an inextricable part and pre-condition of human freedom. The latter cannot be achieved without the former. Baxi in his foreword refers to the common wisdom proclaiming "Knowledge is power". Both the learned

Professors draw a vital distinction between mere the *right to information* and the *right to know*.

On the eve of the twentyfirst century humanity is caught in a grave dilemma. With increasing tendency of man to bid farewell to rationalism and humanism, to resort to the bullet and the bomb in solving problems and to increasing abuse of knowledge available to mankind, a grave doubt is being expressed as to whether acquisition of knowledge is going to result in emergence of a saner individual and a sane, peaceful and progressing society. For example, would not proliferation of the knowledge of explosives or of nuclear fission result in increasing human violence and even threaten the very existence of the human race? I am not answering these questions in this review. However I am raising a counter-question: will not the knowledge that use of bombs and bullets is counter-productive and use of the nuclear weapons can lead to mutual destruction, act as a deterrent against mis-use of knowledge? Knowledge cannot be permitted to be the monopoly of a few philosopher Kings as we tried in ancient India or as is the practice in totalitarian societies.

I would end this review by referring to the delightful and witty BBC serials "Yes Minister" and "Yes Prime Minister" written by the brilliant co-authors Jonathan Lynn and Antony Jay. The serials demonstrate how the concepts of open society of the simple-minded Right Hon. James Hacker first elevated as a Minister in the British Cabinet are frustrated by his wily Cabinet Secretary, Sir Humprey Appleby and then after being elevated as the Prime Minister, again frustrated by Sir Bernard Woolley, his former Private Secretary later promoted as Cabinet Secretary. The people's elected representatives occupying high ministerial offices are easily taken for a ride by the bureaucracy forming a closed club and a steel frame. These evils can be mitigated if not totally eliminated by diffusion of information and knowledge among the entire people through the various media.

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# ANNOTATED INDEX OF BOOKS AND ARTICLES IN INDIA

EDITOR'S NOTE

These abstracts are prepared by the author of each book/article sent to us voluntarily in response to our invitation through the Economic and Political Weekly. These cover publications after 1st January 1986. Only abstracts of books/articles so received are published. The index therefore is not exhaustive and complete.

The limit of 250 words and 100 words for abstracts of books and articles respectively is strictly enforced. Only a minimum amount of copy editing is done in order to bring the abstracts within the prescribed limits. The readers should approach the author of the abstract, not this Journal, for any clarifications.

ARTICLES

*1990*

Bhatia, D.P. 'Capital Stocks in the Manufacturing Sectors of India, the UK and the US - Estimates and Comparisons' *The Journal of Income and Wealth* Vol. 12, No. 2, July 1990.

In the present paper estimates of capital stocks split into structure, plant and equipment, and vehicles in the manufacturing sectors of India, the UK and the US have been obtained by using purchasing power parity ratios. First a model for estimation is presented. Capital stocks per employee and capital-output ratios (COR) are also presented. Estimates for 1960 and 1985 (at 1975 prices) reveal that gross fixed capital stocks (GFCS) in India as a percentage to that in the US were 3.2 in 1961 and rose to about 10 by 1985. India's GFCS formed 11.6 per cent to that in the UK in 1961 and rose to 45.5 per cent in 1985.

Bhatia, D.P. 'Misleading Growth Rates in the Manufacturing Sector of India' *Journal of Income and Wealth* Vol. 12, No. 2, July 1990.

In order to obtain estimates of value added at constant prices in the manufacturing sector in India, Central Statistical Organisation deflates the value added at current prices by the wholesale price index (WPI). This methodology is defective as value added is factor income whereas WPI contains material input prices, factor payment, taxes, etc. Thus dimensionally the former cannot be deflated by the latter. This, in the past has led to erroneous estimates and misleading growth rates in the manufacturing sector. A correct methodology is that both inputs and outputs are deflated and then subtracting inputs from output, value added at constant prices is obtained.

The Journal will publish in each issue Annotated Bibliography of Books and Articles on Indian Economy, Polity and Society, published after January 1, 1986. Authors are requested to send their entries with full details of publication and annotation not exceeding 250 words for books and not exceeding 100 words for articles. Use separate sheet for each entry.

# BOOKS RECEIVED IN INDIAN SCHOOL OF POLITICAL ECONOMY

Dantwala, M.L. (Editor) - *Indian Agricultural Development Since Independence*, Second (Revised) Edition, Indian Society of Agricultural Economics, Oxford & IBH Publishing Co. Pvt. Ltd., Bombay, 1991.

This revised and updated second edition of the book contains 20 essays grouped under 16 chapters contributed by senior agricultural economists in the country. It critically examines various aspects of Indian agriculture and rural development as well as their problems and suggests policy measures to overcome them. The first section containing eight chapters examines the strategy of agricultural development, agriculture's role in the national economy, agrarian structure, changes in the composition of labour force and its employment, pace and pattern of growth of agricultural production, irrigation and water management, technological change in Indian agriculture, and issues relating to animal husbandry, poultry, fisheries and forestry in India. The second section includes four chapters which respectively review and discuss the institutional aspects of saving and capital formation in the agricultural sector, rural credit, agricultural marketing, and agricultural price policy and terms of trade. The third section comprising four chapters examines the public finance aspects of Indian agriculture , agricultural labour and rural employment, trade in agricultural commodities and approaches, and issues relating to rural development.

Das, Dilip K. - *Import Canalisation*; Sage Publications, New Delhi, 1991.

The pros and cons of import canalisation using India as a case study are discussed in this book. The principal finding is that given the way the strategy has been implemented in most developing countries, its costs far outweigh its returns. Not only has it failed to realise the possible advantages to be garnered for bulk imports, but import canalisation has in fact led to inefficiency, delayed decision making and bureaucratic wrangling which in turn has often meant having to pay higher prices as well as generating X-inefficiencies in the economic system.

Analysis of the manner in which import canalisation has worked in India reveals that business acumen tends to be replaced by a risk-averse and procedure-oriented approach. Since the canalising agencies are *de facto* monopolies in the domestic markets, they manifest many of the frailties associated with monopolistic behaviour. This economic practice either needs to be thoroughly modified and made to function in an effective, efficacious and therefore, commercially viable manner, or dismantled altogether. Partial canalisation or voluntary canalisation could be feasible alternatives.

Mahindra Dev S., Kirit S. Parikh and M.H. Suryanarayana - *Rural Poverty in India: Incidence, Issues, and Policies*, Indira Gandhi Institute of Development Research, Bombay, 1991.

This report was prepared as part of the Asian Development Bank Project on Rural Poverty. The report examines a number of issues relating to rural poverty in India. The issues examined in this report include (a) India's performance in terms of economic development during pre- and post-independence periods, (b) the dimensions of rural poverty, both quantitative and qualitative, (c) relationship between land resources and rural poverty, (d) interconnections between human resources and rural poverty, (e) macro-economic policies followed so far for poverty eradication, (f) impact of global environment on poverty, (g) effect of the political economy on poverty in India, and (h) the policy changes needed to achieve the goal of eradication of poverty. The study is divided into eight chapters.

Shanker, Kripa - *Land Transfers, A Case Study* - Gian Publishing House, New Delhi 110 002, 1991.

The study is confined to the delineation of the magnitude of land alienation, its direction and the reasons for land alienation, and the manner in which various classes and castes have been affected. The study is limited to the state of Uttar Pradesh and only land transfers which were duly registered have been taken into account. Land transfers by way of lease or mortgage have not been studied as, among other things, they are not final transfers. The study found that land was being sold by marginal and small farmers; nearly two-thirds of such land being purchased by semi-medium, medium and large farmers. Medium and large farmers accounted for 40 per cent of the net gain in land transactions. One-fifth of the land alienation was on account of repayment of old debts.

Srivastava, U.K., Bakul H. Dholakia, S. Vathsala and K. Chidambaram - *Fishery Sector of India*, Indian Institute of Management, Ahmedabad, Oxford & IBH Publishing Co. Pvt. Ltd., Bombay, 1991.

This study was sponsored by the World Bank through Ministry of Food Processing Industries, Government of India and the Planning Commission. The study covers all aspects of the fisheries sector viz., marine fisheries including deep sea and brackishwater fisheries and inland fisheries (capture, culture and capture-cum-culture). It examines the present constraints and future prospects that characteries the fishery sector in India, specially the commercial marketing and processing of fishery products, shrimp aquaculture, operation of deep sea vessels. The book also discusses the policy support, investment opportunities and financial assistance requirements of the fishing industry over the next five years.

Thakur, D.R. and T.V. Moorti - *Economics of Potato in Himachal Pradesh*, Daya Publishing House, Delhi 110 006, 1991.

The study pertains to the economics of potato cultivation in Himachal Pradesh with special reference to the Lahaul-Spiti district. It aims at popularising optimum method of potato cultivation along with other important crops and efficient marketing systems for highlighting the problems and constraints on the production and marketing fronts. The study further explores the possibilities for enhancing the incomes of tribal farmers.

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Maital, S., 1973; 'Public Goods and Income Distribution', *Econometrica*, Vol. XLI, May, 1973.

Chakravarty, S. 1987; *Development Planning: The Indian Experience*, Clarendon Press, Oxford, 1987.

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