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OUTPUT GROWTH AND TECHNOLOGICAL CHANGE IN MAHARASHTRA AGRICULTURE: A DISTRICTWISE ANALYSIS

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This paper attempts to measure and analyse output and productivity changes in Maharashtra agriculture. Since the State is characterized by considerable heterogeneity in agro-climate, resource endowments and economic and economic performance (7), we have started from the district level.

Two related aspects have been focused upon in this paper. To start with, an attempt has been made to examine the pattern of output, input and productivity growth in all the 25 districts of the State over the period 1951-52 to 1971-72. The analysis is based on the index number approach to productivity measurement (6). Subsequently, an attempt has also been made to examine whether these movements are related to differences in natural resource endowments. The paper thus aims at sorting out the following questions: (*a*) How have different districts in Maharashtra performed during the last twenty years or so? (*b*) What has been the contribution of input growth and technological improvements to output growth in different districts? (*c*) Did all districts behave identically or were the movements related to natural resource endowments ?

MEASUREMENT OF PRODUCTIVITY

This study is based on total factor productivity which is defined as the ratio of output to the aggregate of all factor inputs. Apart from being a more satisfactory measure of productivity, this has the added advantage of providing a measure of technological advance.[1]

We have used Solow's geometric index of a total factor productivity (8). Conceptually, geometric aggregation implies an aggregate production function of the Cobb-Douglas form:

$$Y = P\ X_1^{b_1}\ X_2^{b_2}\ \ldots\ldots\ldots X_n^{b_n}$$

where P is the geometric index of productivity; b_1, b_2....., b_n are elasticities of production for X_1, X_2.....X_n factors respectively and Y is an output index. Taking time derivatives on both sides, the following growth equation results.

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1. See (2) and (4) for comprehensive reviews on the evolution of this concept, its implications and uses.

$$\frac{\dot{Y}}{Y} = \frac{\dot{P}}{P} + b_1 \frac{\dot{X}_1}{X_1} + b_2 \frac{\dot{X}_2}{X_2} \ldots\ldots\ldots + b_n \frac{\dot{X}_n}{X_n}$$

or $$\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \sum_{i=1}^{n} \left[b_i \frac{\dot{X}_i}{X_i} \right].$$

The above relation states that the rate of change in total factor productivity is the difference between the rate of change in output and a weighted sum of the rates of change in factor inputs. Under perfectly competitive equilibrium assumptions, factor shares equal the respective production elasticities and the growth equation becomes:

$$\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \sum_{i=1}^{n} \left[s_i \frac{\dot{X}_i}{X_i} \right]$$

where s_i are the respective factor shares. This Divisia index of productivity change is appropriate only for short periods of time and, therefore, the factor shares (s_i) should be calculated for relatively shorter time periods. A chain-linked index of weighted growth rates of inputs (and outputs) with frequently changing weights is, therefore, desirable.

METHODOLOGY

The analysis involves measurement of growth rates of output and inputs for each of the 25 districts of Maharashtra.

The *output index* constructed by us is the sum of quantity indexes of 23 crops[2] weighted by their respective value shares. Output index series for each crop was constructed using the average quantity of three years—1961-62 to 1963-64, as base. Output value shares for each crop were calculated at five points of time (1951, 1956, 1961, 1966 and 1971) using current quantities and prices and, for intervening years, by linear interpolation. The aggregate output index was finally obtained as:

$$O = C_1 Y_1 + \ldots\ldots\ldots + C_{23} Y_{23}$$

where Y is the quantity index and C is the value share.

2. The 23 crops considered were: rice, jowar, bajra, maize, *ragi*, small millets, wheat, barley gram, *tur*, other pulses, groundnut, castor, sesamum, mustard, linseed, cotton, mesta, potato, sugarcane, chillies, ginger and tobacco. Districtwise figures were obtained from Estimates of Area and Production of Principal Crops in India, Vol II, Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, *Agricultural Situation in India* and Season and Crop Reports for Maharashtra State, Government of Maharashtra.

The *aggregate input index* is similarly defined as the sum of quantity indexes of 14 inputs[3] weighted by their respective factor shares as:

$$I = s_1X_1 + s_2X_2 + \ldots\ldots + s_{14}X_{14}$$

where X is the quantity index and s its respective factor share. The quantity index had average of the triennium ending 1963 as base. Factor shares (s_i) were also estimated at five points of time (1951, 1956, 1961, 1966 and 1971 and linear interpolation was done for the intervening years.

Output growth rates worked out on the basis of the actual index series may present a distorted picture because of irregular fluctuations. This could be quite serious if the terminal year happened to be an abnormal one. In order to overcome this difficulty, a series of five-yearly moving average of output index was constructed and this series was used for growth rate calculations. Disaggregation of total input (I) growth rate in terms of growth rates of individual inputs can be done easily. In this study total input growth rate has been disaggregated into growth rates of traditional and modern inputs.

In order to obtain a better idea of productivity changes over time, the whole period of 21 years was split into two-sub periods based on the observed link in output series for most districts. The first period covered 1951-52 to 1960-61 and the second, from 1961-62 to 1971-72. The results for these two sub-periods have been presented separately.

The study also envisages to examine the relationship between agricultural performance (as shown by output and productivity growth) and natural resource endowments. For this purpose the whole State was divided into five agro-climatic zones (Table I).

TABLE I—AGRO-CLIMATIC ZONES OF MAHARASHTRA

Zone No.	Rainfall (mm.)	Districts included
Zone I	Greater than 2,500	Ratnagiri, Kolaba, Thana.
Zone II	Less than 700*	Kolhapur, Sangli, Satara, Poona, Ahmednagar, Nasik, Dhulia, Sholapur.
Zone III	700 to 900	Jalgaon, Buldhana, Aurangabad, Bhir, Parbhani, Osmanabad.
Zone IV	900 to 1,250	Nanded, Yeotmal, Akola, Amaraoti, Wardha, Nagpur.
Zone V	Greater than 1,250	Bhandara, Chanda.

* Very high rainfall is recorded on the western tip of this zone.

3. The 14 inputs considered were: unirrigated land, irrigated land, labour, animal power, wooden ploughs, iron ploughs, bullock carts, sugarcane crushers, bullock operated and power operated, oil pumps, electric pumps, tractors, nitrogenous and phosphatic fertilizers. For want of space, details regarding data sources, etc., have not been given here. These can be had from the authors on request. Prices of these inputs were collected from a number of diverse sources including published and unpublished official records and on the basis of the price and quantity figures, factor shares were calculated.

RESULTS AND DISCUSSION

Period I : 1951-52 to 1960-61

Table II gives the output, input and total factor productivity growth rates for this period. Of the 25 districts, 18 recorded positive output growth. Extremely high variation in output growth, from 5.22 per cent for Nagpur to 8.22 per cent for Ahmednagar, highlighted the diverse nature of Maharashtra agriculture. The overall performance during the fifties was fairly satisfactory with nearly 50 per cent of the districts recording output growth rates in excess of 3.5 per cent per annum.

Zone I, comprising the coastal districts of Ratnagiri, Kolaba and Thana, showed small, positive output growth rates. Districts in zone 2 did very well—all districts recorded more than 3 per cent rate of growth and as many as five had more than 5 per cent output growth. In zone III, Aurangabad and Buldhana had small output growth, while in the other districts output grew at more than 5.5 per cent per annum. All districts in zones IV and V (except Chanda) recorded negative output growth.

Growth in inputs was found to be more stable, varying between 0.82 per cent in Ratnagiri to 2.89 per cent per annum in Osmanabad. Growth in modern inputs accounted for a negligible fraction of total input. Rank correlation coefficients were worked out between output and total input growth rates, output and traditional inputs and output and modern inputs growth rates. These were 0.47, 0.51 and 0.05 respectively. These figures indicated that traditional inputs had a greater impact on output growth during this period.

Total factor productivity growth rates were positive in 14 out of 25 districts. The western part of the State showed positive productivity growth while the eastern part showed signs of decline in productivity. Districts in zone II performed well during this period. Output growth in districts in this zone exceeded 3 per cent while factor productivity growth was more than 1.75 per cent per annum. The fact that this zone comprised mostly dry land areas makes the results interesting. High productivity growth suggests, contrary to popular belief, that a substantial 'technological slack' existed even during the fifties and this was exploited. This slack, however, was not related to modern inputs and was probably the effect of rapid expansion of extension and availability of a fair amount of research results appropriate for dry areas which extension could effectively disseminate. This, *prima facie*, appears to be surprising because it is commonly believed that research appropriate for dry areas was non-existent in the fifties. In fact, however, a lot of research was available on soil conservation and this programme was widely extended in this zone.[4]

Districts in zone III also performed well (with the exception of Aurangabad and Buldhana). The costal area (zone I) had relatively small output

4. The first author himself was actively involved in the execution of this programme as an extension officer in this area.

and productivity growth rates. Zones IV and V fared poorly. Districts in these two zones form the agricultural heartland of the State. Poor performance of this region could be due to the fact that these areas were integrated in Maharashtra State only around 1956 and, therefore, suffered from lack of attention during the fifties.

TABLE II—AVERAGE ANNUAL PERCENTAGE GROWTH RATE IN AGRICULTURE IN MAHARASHTRA DISTRICTS:* PERIOD I (1951-52 TO 1960-61)

Sr. No.	Districts	Output growth	Input growth	Traditional inputs	Modern inputs	Total factor productivity
1.	Ahmednagar	8.22	2·74	2·56	0·18	5·48
2.	Sholapur	7·62	1·70	1·66	0·04	5·92
3.	Osmanabad	5·68	2·89	2·97	—0·08	2·79
4.	Nasik	5·62	1·86	1·78	0·08	3·75
5.	Jalgaon	5·58	2·16	2·00	0·16	3·41
6.	Poona	5·48	1·96	1·87	0·09	3·53
7.	Dhulia	5·38	1·40	1·30	0·10	3·98
8.	Sangli	4·50	1·96	1·82	0·15	2·54
9.	Bhir	4·11	1·72	1·65	0·07	2·39
10.	Satara	4·07	1·41	1·30	0·11	2·66
11.	Parbhani	3·86	1·61	1·59	0·02	2·25
12.	Kolhapur	3·79	1·88	1·53	0·35	1·91
13.	Thana	1·85	1·39	1·31	0·03	0·45
14.	Ratnagiri	1·67	0·82	0·84	0·02	0·85
15.	Buldhana	1·48	1·86	1·79	0·07	—0·38
16.	Aurangabad	1·30	2·30	2·19	0·11	—1·00
17.	Kolaba	0·86	1·06	0·86	0·20	—0·21
18.	Chanda	0·50	2·79	2·78	0·01	—2·29
19.	Amaraoti	—2·15	1·78	1·52	0·26	—3·93
20.	Bhandara	—2·45	1·60	1·53	0·07	—4·05
21.	Akola	—3·27	1·94	1·84	0·10	—5·21
22.	Wardha	—4·61	1·27	1·24	0·03	—5·88
23.	Yeotmal	—5·03	1·55	1·47	0·08	—6·58
24.	Nanded	—5·59	1·30	1·25	0·05	—6·89
25.	Nagpur	—5·92	0·94	0·80	0·15	—6·88
	Maharashtra	3·37	1·84	1·75	0·09	1·53

* Districts are arranged in descending order of output growth.

In the 14 districts with recorded productivity gains, total inputs accounted for 22 to 75 per cent of the output growth. In general, for districts recording high output growth, productivity gain was the more dominant causal factor.

With the exception of the coastal strip (zone I) output growth generally fell as one moved inwards towards the east. This was probably the reason

TABLE V—DISTRIBUTION OF DISTRICTS RECORDING RELATIVE GAIN OR DECLINE IN RESIDUAL PRODUCTIVITY GROWTH BETWEEN TWO PERIODS

Category	Districts
Gain* in productivity growth	Ratnagiri, Nanded, Yeotmal, Akola, Amaraoti, Wardha, Nagpur, Bhandara.
Decline in productivity growth	Kolhapur, Sangli, Satara, Sholapur, Poona, Ahmednagar, Nasik, Dhulia, Jalgaon, Aurangabad, Buldhana. Parbhani, Osmanabad, Chanda, Thana, Kolaba, Bhir.

* Reduction in the rate of decline in productivity has also been considered as gain.

Out of 25 districts, 8 gained in productivity and 17 lost. As was the case with output growth, districts which recorded low or negative productivity growth in the fifties generally gained, and those which had positive and high productivity growth in the earlier decade registered declines. It was thus evident that districts which showed gain in output growth did so primarily on account of a deceleration in the rate of decline in productivity, *i.e.*, districts which were sliding rapidly down during the fifties started a recovery in the sixties. Contrary to expectations, the engine doing this work was not modern inputs but real improvement in productivity or technological advance.

The case of the other group of districts which witnessed relative decline in output and factor productivity growth rates during the sixties was more intriguing. Obviously, rapid decline in factor productivity resulted in slackening of output growth and this happened despite fairly rapid growth in modern inputs. The technological stock which served these districts so well in the fifties got completely exhausted and real depreciation started. This technological bankruptcy completely nullified the contribution of modern inputs.

All this suggests that it is erroneous to presume that growth in modern inputs *per se* would lead to growth in output. Modern inputs play their role *only* if a suitable (transferable) technology is available. It is probably in the lack of appreciation of this fact that planning for agricultural development in Maharashtra has erred. It concentrated on achieving rapid growth in modern inputs and neglected the crucial area of technology generation, agricultural research.

It is now necessary to examine these changes in relation to agro-climatic zones. Zones I, IV and V receive relatively high rainfall and zones II and III, particularly the former, are dry. Zones II and III cover the bulk of Maharashtra's dry land agriculture.

Zones III, IV and V came to Maharashtra in 1956. These areas remained backward in the fifties because serious developmental efforts could not be undertaken till the beginning of the Third Plan. Districts in zone II, which were part of the State from the beginning, performed well in the fifties because a stock of research results was available and it became possible to transfer this knowledge with the help of unprecedented extension effort. Thus, while zone II and, to some extent, zone III recorded productivity gains,

and productivity growth rates. Zones IV and V fared poorly. Districts in these two zones form the agricultural heartland of the State. Poor performance of this region could be due to the fact that these areas were integrated in Maharashtra State only around 1956 and, therefore, suffered from lack of attention during the fifties.

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4.	Nasik	5·62	1·86	1·78	0·08	3·75
5.	Jalgaon	5·58	2·16	2·00	0·16	3·41
6.	Poona	5·48	1·96	1·87	0·09	3·53
7.	Dhulia	5·38	1·40	1·30	0·10	3·98
8.	Sangli	4·50	1·96	1·82	0·15	2·54
9.	Bhir	4·11	1·72	1·65	0·07	2·39
10.	Satara	4·07	1·41	1·30	0·11	2·66
11.	Parbhani	3·86	1·61	1·59	0·02	2·25
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17.	Kolaba	0·86	1·06	0·86	0·20	—0·21
18.	Chanda	0·50	2·79	2·78	0·01	—2·29
19.	Amaraoti	—2·15	1·78	1·52	0·26	—3·93
20.	Bhandara	—2·45	1·60	1·53	0·07	—4·05
21.	Akola	—3·27	1·94	1·84	0·10	—5·21
22.	Wardha	—4·61	1·27	1·24	0·03	—5·88
23.	Yeotmal	—5·03	1·55	1·47	0·08	—6·58
24.	Nanded	—5·59	1·30	1·25	0·05	—6·89
25.	Nagpur	—5·92	0·94	0·80	0·15	—6·88
	Maharashtra	3·37	1·84	1·75	0·09	1·53

* Districts are arranged in descending order of output growth.

In the 14 districts with recorded productivity gains, total inputs accounted for 22 to 75 per cent of the output growth. In general, for districts recording high output growth, productivity gain was the more dominant causal factor.

With the exception of the coastal strip (zone I) output growth generally fell as one moved inwards towards the east. This was probably the reason

prompting a major reallocation of agricultural development expenditures in favour of the Virdarbha and Marathwada regions in the Third Five Year Plan (3).

Period II: 1961-62 to 1971-72

Information on output, input and residual productivity growth for each district in this period has been presented in Table III. As compared to the fifties, the tempo of output growth in this period slowed down and very high output growth rates became uncommon. Out of 25 districts, 23 were found to have positive output growth, of which only 9 had growth rates of over 2.5 per cent per annum. It must be borne in mind that even though a perceptible slackening of growth in output occurred during this period, the number of districts recording positive growth increased from 18 in the fifties to 23 in the sixties. We shall come back to this later. The table did not reveal any systematic pattern with respect to geographic contiguity or agro-climatic zones.

Total inputs, on the contrary, grew at a rapid pace of 3.12 per cent per annum at the State level and the bulk of this was due to growth in modern inputs (2.19 per cent). Surprisingly, output growth did not seem to be related with growth in either traditional or modern inputs. Evenson and Jha (1) also obtained a similar picture in their results for this State.

TABLE III—AVERAGE ANNUAL PERCENTAGE GROWTH RATE IN AGRICULTURE IN MAHARASHTRA DISTRICTS:* PERIOD II (1961-62 TO 1971-72)

Sr. No.	Districts	Output growth	Input growth	Traditional inputs	Modern inputs	Total factor productivity
1.	Nanded	6·93	4·97	1·71	3·26	1·95
2.	Wardha	5.82	6·35	1·02	5·32	—0·52
3.	Akola	4·74	3·66	1·34	2·32	1·08
4.	Ratnagiri	4·07	2·78	0·22	2·56	1·29
5.	Nasik	3·49	3·52	0·57	2·95	—0·03
6.	Bhir	2·99	7·09	1·47	5·62	—4·10
7.	Buldhana	2·82	3·56	0·62	2·94	—0·74
8.	Kolhapur	2·70	2·73	0·97	1·76	—0·03
9.	Osmanabad	2·51	5·23	0·74	4·49	—2·72
10.	Kolaba	1·80	3·52	1·19	2·33	—1·72
11.	Aurangabad	1·65	6·35	1·00	5·35	—4·70
12.	Parbhani	1·56	11·10	1·28	9·82	—9·54
13.	Thana	1·49	3·53	1·64	1·89	—2·04
14.	Amaraoti	1·48	2·78	1·30	1·48	—1·30
15.	Satara	1·47	3·83	0·43	3·40	—2·36
16.	Bhandara	1·35	2·27	1·38	0·89	—0·91
17.	Yeotmal	1·34	5·79	1·74	4·05	—4·45
18.	Chanda	1·28	4·06	1·41	2·65	—2·78
19.	Sangli	0·57	3·41	0·66	3·36	—2·84
20.	Dhulia	0·53	3·97	0·69	3·29	—3·45
21.	Nagpur	0·47	4·75	1·09	3·66	—4·28
22.	Sholapur	0·42	3·87	0·50	3·37	—3·45
23.	Poona	0·14	3·96	0·48	3·48	—3·81
24.	Jalgaon	—0·24	3·51	0·68	2·83	—3·75
25.	Ahmednagar	—0·79	2·37	0·76	1·61	—3·16
	Maharashtra	0·67	3·12	0·93	2·19	—2·45

* Districts are arranged in descending order of output growth.

others suffered declines. It was also evident that the technological stock which was relevant for these areas did not last long. As is now common knowledge, research for dry areas has generally been deficient. This perhaps was the major factor behind declining factor productivity in dry land areas (zones II and III).

For the relatively better endowed areas (rainfallwise), the decade of sixties offered considerable technological improvements. The bulk of agricultural research in India, till recently, was relevant only for irrigated or high rainfall areas. Availability of this stock of unused knowledge coupled with a deliberate attempt to concentrate development resources in eastern Maharashtra led to improvements in agricultural performance. The above analysis highlights the fact that the 'state of technological stock' generated by agricultural research was perhaps the most significant factor determining the performance of Maharashtra districts during the last two decades.

CONCLUSION

The most important lesson flowing from these results was that it would be futile to expect that growth in modern inputs like fertilizers and machines would be enough to bring about rapid output growth. This does not happen unless an appropriate technology exists. Technology generating and disseminating activities, like agricultural research and extension, thus have the most critical role.

The results suggested that according to present trends, areas which receive relatively higher rainfall (zones I, IV and V) were likely to record further advances in output growth. Availability of research results from similar areas outside the State and also the recent strengthening of research in these areas themselves, supports this contention. Zone II and, to a lesser extent, zone III, were found to be the really depressed areas of Maharashtra. Research for these dry land areas was neglected for long. The current emphasis on dry land agriculture research, however, offers hope for the future of these areas.

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