PATTERNS OF AGRICULTURAL DEVELOPMENT IN INDIA: DETERMINANTS OF LAND PRODUCTIVITY IN MAHARASHTRA'S DISTRICTS, 1971

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DURING the mid-1970s India's foodgrain progress has once again swung with the rhythm of monsoons towards comparative abundance. Output has pushed into the range of 120 to 125 million tons per year and at least 20 million tons of foodgrains are in storage. After poor crop years early in this decade, actual production is now back above the secular growth trend of about 3 per cent that has characterized India's agricultural performance since independence [6, pp. 92–96], and alarmist interpreters of India's agricultural performance have shifted from forecasting famine to deploring India's struggle to cope with the storage and transport necessary to hold and distribute bumper crops. The reasons behind India's agricultural growth are now fairly well understood: the new seeds, more fertilizers, better water control, and a nationwide extension service of some effectiveness [7] [4]. Down at the village and farm level there is some question about the distributional consequences of the new technologies: the rich are certainly richer, but are the poorer segments of society being made absolutely worse off, absolutely better off but relatively worse off, or absolutely and relatively better off? The evidence is unclear and controversial.[1]

This paper will deal directly with none of these matters, but rather with patterns of agricultural development at the district level in a single state.[2] Certainly one of the most obvious features of India's rural development has been its regional

[1] [7, Chaps. 10–13]. Francine Frankel, *India's Green Revolution: Economic Gains and Political Costs* (Bombay: Oxford University Press, 1971). Contrasting with Frankel's perhaps premature pessimism about the distributional effects of agricultural development are: Peter van Blackenberg, "Who Leads Agricultural Modernization? A Study of Progressive Farmers in Mysore and Punjab," *Economic and Political Weekly*, September 30, 1972, pp. A94–A112; and P. C. Aggarwal, *The Green Revolution and Rural Labor* (New Delhi: Sri Ram Centre, 1973).

[2] Related cross-section studies include: John Adams and Balu Bumb, "The Economic, Political and Social Dimensions of an Indian State: A Factor Analysis of District Data for Rajasthan," *Journal of Asian Studies*, Vol. 33 (November 1973), pp. 5–23; Irma Adelman and Cynthia Taft Morris, *Society, Politics, and Economic Development: A Quantitative Approach* (Baltimore: Johns Hopkins Press, 1967); Irma Adelman and George Dalton, "A Factor Analysis of Modernization in Village India," in *Economic Development and Social Change: The Modernization of Village Communities*, ed. G. Dalton (New York: Natural History Press, 1971), pp. 492–517; Biplab Dasgupta, "Socioeconomic Classification of Districts: A Statistical Approach," *Economic and Political Weekly*, August 14, 1971, pp. 1763–74.

diversity and its complex involvement of social, technological, ecological, administrative, and infrastructural elements—in addition to the traditional inputs: human labor, animal power, rainfall, and land. Indeed, it has often proven difficult to determine whether policy attention should be devoted more to input packages, infrastructure such as roads, power, irrigation, and financial institutions, or to the social context of rural life. It is fortunate that readily comparable data describing many of these variables are available for many of India's districts. By application of an appropriate method it may be feasible to determine the importance of these various indicators insofar as they influence agriculture.

Maharashtra is, of course, a highly urbanized and industrialized state. It contains twenty-six districts, one of which is metropolitan Bombay (see Figure 1). Because our interest is with rural development, we have chosen to omit this district from our analysis. The specific district indicators we will use are listed and described in Table I. The key variable is agricultural productivity per hectare (No. 1). This is formally defined as total crop value divided by hectares of net area sown and measures average land productivity. We will study the effects of seventeen additional variables upon this indicator of agricultural performance. In order to cope with this number of explanatory dimensions simultaneously we will utilize factor analysis, a procedure that will also allow us to determine how the twenty-five districts of Maharashtra compare to one another in terms of a

Fig. 1. Districts of Maharashtra State

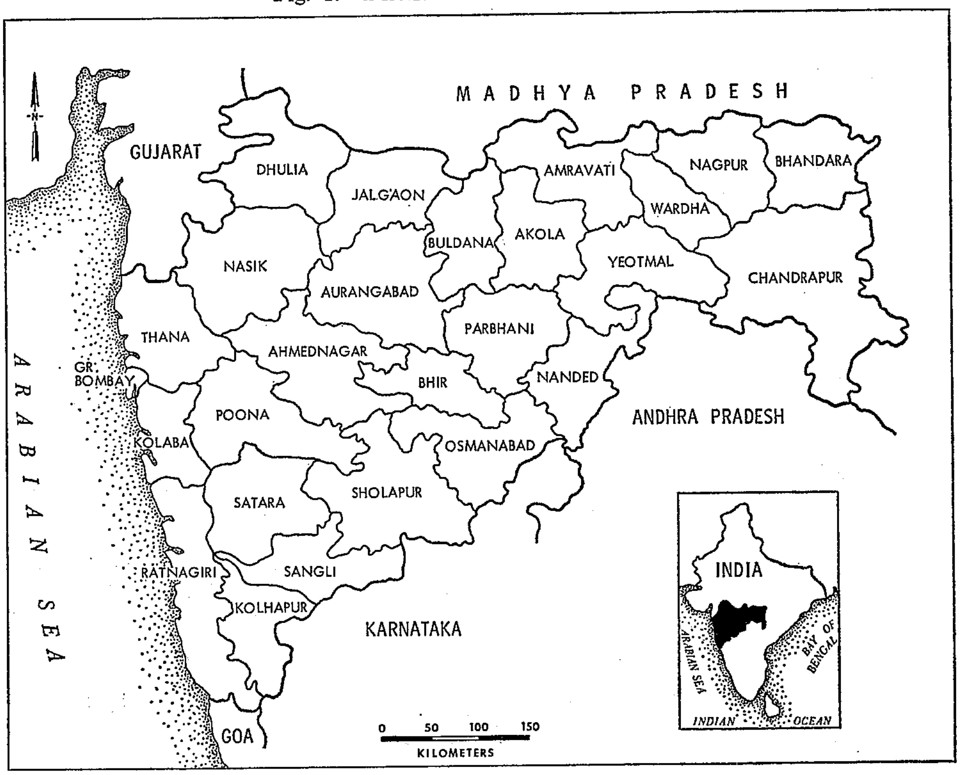

TABLE I

THE VARIABLES

Number (1)	Name (2)	Specification (3)	Mean (4)	Standard Deviation (5)	Range (6)
1.	Agricultural productivity	Total crop value/hectare nas (Rs.)	557.81	429.32	191.58–1600.98
2.	Rainfall	Annual rainfall (cm)	116.76	71.76	57.90–330.60
3.	Irrigation	Irrigated area/total cropped area (%)	8.07	5.85	1.01–24.40
4.	Farm labor	Agricultural workers and cultivators/100 hectares nas (no.)	76.31	36.98	44.13–157.27
5.	Animal power	Number of working livestock/hectare nas (no.)	1.60	0.56	0.95–2.74
6.	Tractors	Tractors/1,000 hectares nas (no.)	0.32	0.27	0.03–1.15
7.	Pumps	Pumps/1,000 hectares nas (no.)	18.20	12.34	2.39–50.66
8.	Fertilizer	Kilograms/hectare	12.67	6.07	6.43–29.95
9.	Cooperative credit	Agricultural loans/hectare nas (Rs.)	70.53	38.03	18.74–193.16
10.	Bank credit	Loans to agricultural sector/1.000 hectares nas (Rs.)	1783.00	2185.52	63.00–8167.00
11.	Roads	Kilometers of all-weather roads/1,000 sq. kilometers land area (km)	224.33	124.12	54.64–526.11
12.	Rural electrification	Proportion of villages electrified (%)	36.54	10.09	10.71–59.78
13.	Cropping intensity	Double-cropped area/nas (%)	5.86	4.32	0.42–18.60
14.	Commercial cropping	Cash crop value/total value (%)	48.26	25.62	0.97–89.55
15.	Urban population	Urban population/total population (%)	20.63	10.91	8.40–54.32
16.	Literacy	Literate population/total population (%)	35.31	6.68	22.80–45.30
17.	Modern sector employment	Proportion of work force in manufacturing, construction, transport, trade, and commerce (%)	12.97	7.18	5.73–33.29
18.	Radios	Radios/1,000 of population (no.)	18.34	9.97	8.02–49.01

Sources: Variables 1–3, 9, 11–16, and 18 are derived from information available in the *Statistical Abstract of Maharashtra State, 1970–71* (Nagpur: Government Press, 1974). Variables 4 and 17 are taken from the *Maharashtra, General Population Tables,* Census of India, 1971. Variables 5–7 are calculated from data available in *Maharashtra: An Economic Review, 1974* (Nagpur: Government Press, 1975). Variables 8 and 10 are calculated, respectively, from data available in *Fertilizer Statistics, 1971–72* (New Delhi: Fertilizer Corporation of India, 1973) and "Statistical Profile: Districts of India," mimeographed (New Delhi: Government of India Press, 1974).

Notes: 1. The total value of food and cash crops was computed from output and price data for twenty-one crops. The output of each crop was multiplied by the state average harvest price in order to obtain an estimate of value.

2. "Net area sown" is abbreviated in this table as "nas."

small set of independent underlying factor components. By looking at factor scores on these several dimensions we will be able to gain some insight into the spatial aspects of agricultural development.

Variables 2, 3, 4, and 5 are traditional inputs: rainfall (No. 2), irrigation (No. 3), farm labor force (No. 4), and animal power (No. 5). Their detailed specifications are given in Table I. We hypothesize, of course, that all of these measures will be positively related to land productivity.[3] As we have noted in a previous paper on Rajasthan [1], a traditional regression analysis of these input variables in a production function format breaks down because of high multicollinearity.[4] In Maharashtra, too, inputs of human and animal labor are closely correlated: the simple coefficient is 0.92. Additionally, rainfall had correlation coefficients of 0.85 and 0.91 with animal power and labor inputs, respectively. To delete one or two of these variables results in substantial bias of the remaining coefficients and misrepresents their contributions to land productivity levels.[5] Because of these limitations to the use of regression analysis, we have chosen factor analysis to study the influence of these highly correlated inputs on land productivity. This technique clusters such correlated measures into a single factor that can be treated as a latent dimension explaining a portion of inter-district yield variation.[6]

Land productivity depends not only upon these traditional inputs but upon mechanization, fertilizer use, and the availability of credit. Variable 6 is the number of tractors in use per 1,000 hectares, and variable 7 is the similarly normalized number of pumps employed. Fertilizer application is our eighth

[3] Various people have verified the influence of these variables on agricultural output. Using time series data for the Punjab, Raj Krishna estimated the rainfall elasticity of agricultural output to be about 0.30, implying that a 10 per cent variation in rainfall changes output by 3 per cent. See his "The Growth of Aggregate Agricultural Output in the Punjab," *Indian Economic Journal,* Vol. 12 (July–September 1964), pp. 53–59. In his cross-section study of farms in Ferozpur District, Punjab, P. Bardhan identified irrigation and human labor as two important factors influencing agricultural output. See his "Size, Productivity, and Returns to Scale," *Journal of Political Economy,* Vol. 81 (November–December 1973), pp. 1370–86. Similarly, after surveying several estimated production functions for Indian agriculture, Paul Zarembka concluded that "the most important inputs in terms of factor costs for the farmer are land, human labor and bullock labor." See his *Towards a Theory of Economic Development* (San Francisco: Holden-Day, 1972), Chapter 10.

[4] Multicollinearity results when various independent variables in a regression analysis show high degrees of intercorrelation. Multicollinearity leads to instability in estimating regression coefficients and increases the standard errors of the estimated coefficients, thereby reducing their statistical significance. See J. Johnston, *Econometric Methods* (New York: McGraw-Hill, 1972), pp. 159–68; and H. Theil, *Principles of Econometrics* (New York: John Wiley & Sons, 1971), pp. 147–54.

[5] Deleting relevant variables from a regression model leads to biased and inconsistent results. For detailed discussion, see H. H. Kelejian and W. E. Oates, *Introduction to Econometrics: Principles and Applications* (New York: Harper & Row, 1974), pp. 217–20.

[6] The standard work on factor analysis is H. H. Harman, *Modern Factor Analysis* (Chicago: University of Chicago Press, 1972). A brief introduction to the method is provided by J. P. van de Geer, *Introduction to Multivariate Analysis for the Social Sciences* (San Francisco: W. H. Freeman, 1971), Chapters 13 and 15.

indicator. Variable 9 is the amount of agricultural loans outstanding from cooperatives; variable 10 is the amount of bank credit to agriculture. Both are on a per hectare base. We expect mechanization, fertilizer use, and the availability of credit to be some extent interdependent and to exert positive influence on land productivity.

A number of persons have noted that innovation and agricultural productivity are highest in areas that have well-developed infrastructures [5]. We have already included irrigation as an input, but the density of roads (variable 11) and the amount of rural electrification (variable 12) are additional measures of infrastructure development. A good road network is likely to stimulate the marketing of crops and also to make easier the flow of inputs to farmers. In addition, communication and particularly extension contact may be enhanced. Rural electrification is important in powering pumpsets and other equipment.

Two types of cropping practice may affect land productivity: double cropping or cropping intensity (variable 13) and the proportion of cash cropping (variable 14).

Finally, since Maharashtra has the highest proportion of its population living in cities of any Indian state, and has significant industrial development, it is of interest to examine the urban-impact hypothesis [8] [3, pp. 72ff.] [2, pp. 34ff.]. Briefly, the urban-impact hypothesis states that agricultural development or farm productivity will be highest near cities. The basis for this belief is that there will be important output and input market linkages between a city and its rural hinterland and that communication will be most intensive near an urban area. It may also be that the more modern outlook typical of a city's educated, more aware and informed population will spill over into adjacent rural areas. We employ four standard urban indicators to test the urban impact thesis: the proportion of the population living in towns and cities (variable 15), the literacy rate (variable 16), the proportion of the labor force in modern sector employment (variable 17), and the number of radios per capita (variable 18). We anticipate high intercorrelations among these urban measures and their emergence as elements of an urbanization dimension that may have a positive influence on the level of land productivity.

The results of our factor analysis are presented in Table II. Agricultural productivity and the seventeen remaining variables are arranged into four rather clear factor dimensions. Variables are assigned to a factor on the basis of their highest factor loading. A factor loading is a correlation coefficient between the variable and the underlying factor. Each variable is to some extent related to all factors, however, and at the far right is the communality, or sum of the squared factor loadings.

The first factor includes three input variables: rainfall, farm labor force, and animal power. One infrastructural indicator, road density, is somewhat weakly attached to this dimension. Fertilizer use is greatest in heavy rainfall areas and its application varies with the traditional inputs. Surprisingly, commercial cropping is associated with low, not high, levels of land productivity. Looked at as a whole, the first factor explains about 81 per cent of the inter-district variation in land productivity. The most productive districts in Maharashtra are those with high levels of rainfall and traditional inputs, above average road densities, and heavier application of chemical fertilizers. For the most part such districts grow food (mainly rice) rather than commercial crops such as oilseeds or cotton.

The second factor brings to light another important dimension of agricultural development in Maharashtra. There is a close association between mechanization and the availability of cooperative or bank credit. Both cooperative and rural bank lending are used for pumps and tractors. Rural electrification is also associated with mechanization and credit availability. The simple correlations of rural electrification with the other four characteristics are not particularly high, and as can be seen from the positive connection of rural electrification with the first factor (a low but noticeable loading of 0.276) rural electrification is also high in districts with intensive cultivation. The second factor accounts for about 8 per cent of the variation in land yields, which is a not unimportant amount. There is apparently a group of districts with more mechanization, better access to credit, and a start on rural electrification that have higher land productivity.

It should be noticed that roads, fertilizer use, and commercial cropping with a positive sign also have secondary loadings in this factor. Road density is also higher where mechanization is higher and credit more available. And about 13 per cent of the variation in fertilizer use is associated with this facet of rural development.

TABLE II

ROTATED FACTOR MATRIX

Variable Name	Factor Loadings				
	F_1	F_2	F_3	F_4	R^2
1. Agricultural productivity	0.907	0.287	−0.021	0.187	0.94
2. Rainfall	0.921	−0.194	0.026	−0.165	0.91
3. Farm labor force	0.969	−0.044	0.003	−0.010	0.94
4. Animal power	0.947	−0.029	0.066	0.225	0.95
5. Roads	0.462	0.333	0.170	−0.171	0.38
6. Fertilizer	0.851	0.358	0.107	−0.149	0.89
7. Commercial cropping	−0.780	0.272	−0.189	−0.345	0.84
8. Pumps	−0.137	0.813	0.249	0.038	0.74
9. Tractors	0.130	0.861	0.141	0.239	0.84
10. Cooperative credit	−0.066	0.944	−0.098	−0.131	0.92
11. Bank credit	0.042	0.564	0.452	0.107	0.54
12. Rural electrification	0.276	0.615	0.221	−0.318	0.61
13. Urban population	−0.115	0.034	0.898	−0.165	0.85
14. Literacy	0.184	0.204	0.552	−0.228	0.43
15. Modern sector employment	0.227	0.097	0.955	0.022	0.97
16. Radios	0.032	0.160	0.909	0.017	0.85
17. Irrigation	0.074	0.370	−0.028	0.830	0.83
18. Cropping intensity	0.074	−0.222	−0.182	0.742	0.64
Total variance explained (%)	31	51	69	78	

Note: The maximum likelihood factor analysis method with varimax rotation was used to extract factors.

The third factor represents an urban component. All four of the urban indicators—urban population, literacy, modern sector employment, and radios—are most closely linked to F_3. This factor explains none of the variation in land productivity, lending no support to the urban impact hypothesis and suggesting a fairly clear urban-rural dualism. Of the other variables only bank credit shows any tendency to associate with urbanization. The lack of urban influence is somewhat surprising since many village studies and investigations of market town linkages do report strong employment, informational, social, and other spillover effects from cities to rural areas. We did, however, find the same lack of a relationship between land productivity and urban development in Rajasthan [1].

Lastly, the fourth factor contains two variables, cropping intensity and irrigation. Their simple correlation is only 0.59, but they relate even more weakly to other indicators. Irrigation is mildly correlated with tractor use and land productivity as single variables, but the relationship is much weaker than one might expect for an Indian state. For most Maharashtrian districts, irrigation and double cropping are not important elements of agriculture. This factor as a whole accounts for only about 3 per cent of the variation in land productivity.

Overall, land productivity in Maharashtra's districts is mostly determined by the availability of conventional inputs—human and animal power and rainfall. Yet, there are indications of significant modernization, since fertilizer use is also a critical determinant. To a lesser extent pump and tractor mechanization supported by cooperative and bank credit have helped elevate land yields. Urban influences appear negligible, and multiple cropping with irrigation is not a major differentiating feature of district performance.

In order to obtain a notion of the extent to which individual districts manifest the attributes of factor one, two, and four, factor scores may be computed. These are shown in Table III. Factor scores are derived so that districts which strongly display the characteristics that define a particular factor will rank highest on that dimension. Thus for factor one, a district with high land productivity, high rainfall, above average use of human and animal power, and so on, would have a high score on this component.

Kolaba, Ratnagiri, and Thana districts have the highest ranks on the first dimension; in fact, they stand somewhat apart from most of Maharashtra's other districts. As Figure 1 shows, they span the seacoast and clearly manifest the high rainfall and denser populations of that region. In addition, rice rather than commercial cropping dominates. Kolhapur, just inland of Ratnagiri, is fourth ranked, but Bhandara (an IADP district) and Chandrapur also have above average land yields and are in the far east. The five lowest ranking districts are Aurangabad, Sholapur, Parbhani, Bhir, and Osmanabad. They form a low yield core in the south central part of the state.

On the second factor, Kolhapur has a particularly high relative rank. Kolhapur is a center for production of diesel engines, including those for pumps. Sangli and Ahmednagar are also differentiated by their superior degress of mechanization and credit access. Very low on this dimension of rural development are Ratnagiri and Thana on the coast. Nanded, Bhir, Parbhani, Aurangabad, and

TABLE III

DISTRICT FACTOR SCORES ON F_1, F_2, AND F_4

F_1		F_2		F_4	
District	Score	District	Score	District	Score
Kolaba	2.57	Kolhapur	3.28	Bhandara	2.50
Ratnagiri	1.94	Sangli	1.90	Chandrapur	2.04
Thana	1.88	Ahmednagar	1.11	Sholapur	0.73
Kolhapur	1.49	Satara	0.67	Ahmednagar	0.70
Bhandara	1.25	Jalgaon	0.54	Dhulia	0.66
Chandrapur	0.49	Nasik	0.53	Poona	0.66
Nasik	−0.16	Amravati	0.43	Nasik	0.64
Dhulia	−0.21	Dhulia	0.21	Satara	0.60
Nagpur	−0.24	Bhandara	−0.06	Aurangabad	0.37
Satara	−0.25	Poona	−0.14	Bhir	0.33
Sangli	−0.32	Sholapur	−0.21	Osmanabad	0.03
Wardha	−0.36	Yeotmal	−0.31	Sangli	−0.06
Jalgaon	−0.36	Osmanabad	−0.34	Jalgaon	−0.10
Yeotmal	−0.40	Wardha	−0.35	Thana	−0.26
Poona	−0.46	Nagpur	−0.37	Parbhani	−0.34
Buldana	−0.53	Buldana	−0.39	Nagpur	−0.37
Nanded	−0.56	Kolaba	−0.39	Nanded	−0.49
Amravati	−0.61	Akola	−0.44	Kolhapur	−0.65
Ahmednagar	−0.61	Aurangabad	−0.48	Ratnagiri	−0.68
Akola	−0.69	Parbhani	−0.60	Buldana	−0.88
Osmanabad	−0.70	Bhir	−0.74	Kolaba	−0.90
Bhir	−0.70	Nanded	−0.74	Yeotmal	−1.00
Parbhani	−0.72	Chandrapur	−0.80	Akola	−1.10
Sholapur	−0.84	Thana	−0.88	Wardha	−1.03
Aurangabad	−0.90	Ratnagiri	−1.46	Amravati	−1.42

Akola are also in the bottom third of the districts and form a south central zone of low mechanization and scant financial intermediation.

The district scores on F_4 show a regional focus of irrigation and intensive cropping in the far east in Bhandara and Chandrapur.

To some extent, then, the factor scores suggest three ways in which Maharashtra's districts differ in their fundamental agrarian characteristics. The most important polarity is between high- and low-yield districts, with the coastal and far eastern regions standing in sharp contrast to the south-central region. We must not rush to the conclusion, however, that the high-scoring districts are necessarily more prosperous per person since we have not examined labor productivity. It is perhaps more appropriate to speak of more intense cultivation of the coastal and far eastern areas than of a higher level of development. The scores on factors two and four make explicit two other contrasts, between mechanized and unmechanized, and irrigated and non-irrigated districts. Except for the extreme cases, however, these are not telling features of a district's agriculture.

What do these findings tell us about India's overall agricultural progress? In the main, they are confirmatory of the generally advanced reasons for that growth:

rising land yields attributable to additional application of traditional inputs; a biological dimension of technological change represented in our study by fertilizer use; a mechanical-credit vector marking a break in certain regions with the intensive pattern; and, to a small degree only in Maharashtra's case, a role for irrigation. What parts of the picture are missing as contrasted to the national level on the one hand and the village on the other? This particular set of variables does not include the effects of national agrarian policies such as land reform and extension nor does it deal with intra-village tension associated with rural change. Neither do we get much feel for the social or human factors in rural development: the education, outlook, and attitudes of the farmers, their attitudes to the risks of change, their reactions to profit and price incentives. It is a reflection of the complexity of rural change in India that even our list of eighteen important variables is not comprehensive enough to include these matters. Yet, our model does account in itself for over 90 per cent of the variation in land yields in Maharashtra in 1971 and, we believe, does point the way to a means of obtaining a more objective and comprehensive view of rural development in India.

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