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# Impact of Infrastructure and Technology on Agricultural Productivity in Uttar Pradesh

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**Abstract**

The trends of composite and individual infrastructural indicators, fertilizer and HYVs have been examined and their impacts on agricultural productivity in Uttar Pradesh have been reported. The trend of composite infrastructure index has shown sharp fluctuations, while electrified villages and rural roads have indicated a rising trend. The agricultural productivity and fertilizer have shown increasing trend with marginal fluctuations, while HYVs have illustrated an increasing trend at a decreasing rate. The impact of composite infrastructure index, fertilizer and HYVs on agricultural productivity has been found positive and significant. Analysis of the impact of individual infrastructural indicators has revealed that the electrified villages along with fertilizer and HYVs have positive and significant impact, while rural roads have an insignificant impact.

## Introduction

The growth in agricultural productivity has varied widely across the states in India due to variations in agro-climatic conditions and adoption of technology. Uttar Pradesh (UP), the most populous state of India, has rural-based economy, with 79.2 per cent population living in villages. The annual compound growth rate of productivity in the state had increased from 1.8 per cent in 1970-73 to 2.4 per cent in 1980-83. Despite this fact, a large inter-state disparity in productivity persists between UP and other states of India (Appendix I). It is mostly due to difference in the levels of application of agricultural inputs and infrastructural facilities (Appendix III). In comparison with some agriculturally-developed states like Haryana and Punjab, the productivity of foodgrains and its growth in UP is low. In 2006-07, the productivity of foodgrains in Haryana was 33.93 q/ha and in Punjab, 40.17 q/ha while in UP, it was only 20.57 q/ha (DAC, 2007). Therefore, there was a need to analyze the trend of determinants of agricultural productivity along with their impacts. As UP is a major producer of many agricultural crops with low productivity, such a study may help in understanding the causes of poor productivity and may provide corrective measures. The present study has analyzed the trends and impacts of factors influencing agricultural productivity in UP.

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## Infrastructure and Technology in Agricultural Productivity

Infrastructure plays a strategic role in producing large multiplier effects in the economy with growth in agriculture (Mellor, 1976). It is estimated that, across the world, 15 per cent of crop produce is lost between farm gate and consumer because of poor roads and inappropriate storage facilities (World Bank, 1997). Parikh (1999) in India Development Report has also placed UP in the deficient category in terms of electricity, roads, storage, credit facilities, etc. According to CMIE (2000) the value of Composite Development Index (CDI) for UP is

112.04, which is though above the national value of 100, lags behind several agriculturally-developed states like Punjab and Haryana.

Binswanger *et al.* (1993), in a study of 13 Indian states, have found that investments in rural infrastructure lowered transportation costs, increased farmers' access to markets, and led to substantial agricultural expansion. Fan *et al.* (2000) have found that government expenditure on productivity growth was most effective when it was spent on rural infrastructure and agricultural research and development. Bhalla and Singh (2001) have also noted that the investment in irrigation and tubewells, and additional use of fertilizers and new seeds, helped in raising the productivity levels. They have also found higher production elasticities for fertilizers, tubewells, tractors, irrigation and regulated markets. They have suggested that production was more responsive to modern inputs and infrastructure. The spread of technology in agriculture also depends on physical and institutional infrastructure. According to Majumdar (2002), the transport infrastructure significantly affects the agricultural output and development in India.

For analyzing the impact of infrastructure on agricultural development, Thorat and Sirohi (2002) have used ten explanatory variables, viz. transport, power, irrigation, tractors, research, extension, access to agricultural credit societies, regulated and wholesale markets, access to fertilizer sale points and commercial banks, covering physical, financial and research infrastructures. They have reported that transport, power, irrigation and research were the four critical components affecting agricultural productivity significantly. With improved access to power, irrigation rises along with productivity. Development of transport facilitates access to fertilizer sale points, markets, credit facilities and extension services.

Adoption of modern agricultural technology has been another crucial factor for raising agricultural productivity in India, especially in the northern states like Punjab and Haryana. Bhalla and Singh (2001) have observed that the annual compound growth rate of agricultural productivity for UP during 1962-65 to 1992-95 was 2.30 per cent, which was though at par with the national level, was lower than that of agriculturally-developed states like Punjab (3.13%) and Haryana (3.21%). The green revolution introduced the high-yielding varieties (HYVs) of wheat and rice during 1960s and early-1970s in Punjab, Haryana and western UP. Along with the HYVs, the increased consumption of fertilizer also contributed towards raising yield and output. Desai and Namboodiri (1997) have found that factors like HYVs and fertilizer have greater influence on the growth of agricultural productivity in India.

The study was carried out with the following objectives in the state of Uttar Pradesh:

- To examine the trends of composite infrastructure index, and technology such as fertilizer, HYVs, and agricultural productivity,
- To analyze the impact of individual infrastructural indicators and technology on agricultural productivity, and
- To analyze the impact of composite infrastructure and technology on agricultural productivity.

## Methodology

The study is based on the secondary data of infrastructure, technology and agricultural productivity, collected from *District Statistical Handbooks*, and *Statistical Abstracts* from the Department of Economics and Statistics, UP for the period 1989-90 to 2005-06 (data was not available in the required format prior to 1989-90). Multivariate regression analysis of Cobb-Douglas functional form was used to analyze the impact of infrastructure and technology on agricultural productivity. The data considered in this study was of UP as a whole, excluding the Hill region, as the hill region became a new state (Uttarakhand) from 2000-01.

The method used by Centre for Monitoring Indian Economy (CMIE) for developing the Composite Development Infrastructural Index (CDII) was used with minor modifications. The infrastructural indicators considered for developing CDII were: (i) proportion of rural roads; (ii) proportion of electrified villages; (iii) gross irrigated area; (iv) bank branches per lakh population; (v) post

offices per lakh population; (vi) telephone lines per 100 persons; (vii) junior basic schools per lakh population; (viii) primary health centres per lakh population; and (ix) hospital beds per lakh population. The value for individual indices for seven infrastructural factors was calculated using Equation (1):

$$IF_{it} = (X_{nt}/\text{Average value of } X_{nt}) \times 100 \quad \ldots(1)$$

where,

$X_{nt}$ = Observation of individual infrastructure indicators in time t,

$IF_{it}$ = Index value of infrastructural factors such as power, transport, irrigation, communication, banking, education and health. Here, i = 1,…..,7 in time t.

The weighted values were obtained by multiplying these indices value with the weights assigned by CMIE to the individual infrastructural factors and dividing by hundred. Thus, the CDII was obtained by adding all the weighted values of individual infrastructural factors in time t as per Equation (2):

$$CDII = \sum_{i=1}^{7}\{(IF_{it}) \times W_i\}/100 \quad \ldots(2)$$

where,

$IF_{it}$ = Index value of seven infrastructural factors,

$W_i$ = Weights assigned by CMIE to individual infrastructural factors, and

t = Time (years).

The regression was run using the functional form given by Equation (3):

$$\ln Y_t = \alpha + \beta_1 \ln X_{1t} + \beta_2 \ln X_{2t} + \beta_3 \ln X_{3t} + u_t \ldots (3)$$

where,

Y = Agricultural productivity (q/ha),

$X_1$ = Composite Development Infrastructure Index (CDII),

$X_2$ = Fertilizer consumption (kg/ha),

$X_3$ = Proportion of area under HYVs,

$\alpha$ = Constant,

$\beta_1$, $\beta_2$ and $\beta_3$ = Regression coefficients,

u = Stochastic disturbance term, and

t = Time (years).

In the study, railway route length was not taken into account as the data were not available for UP excluding the hill region. Since the data for surfaced and unsurfaced road lengths for the rural areas were not available separately, the proportion of rural roads was taken as a proxy to the surfaced and unsurfaced road lengths as the major agricultural production was from the rural UP. The functional form is given by Equation (4):

$$\ln Y_t = \alpha + \beta_1 \ln X_{1t} + \beta_2 \ln X_{2t} + \beta_3 \ln X_{3t} + \beta_4 \ln X_{4t} + u_t \quad \ldots(4)$$

where,

Y = Agricultural productivity (q/ha),

$X_1$ = Proportion of rural roads,

$X_2$ = Fertilizer consumption (kg/ha),

$X_3$ = Proportion of area under HYVs,

$X_4$ = Proportion of electrified villages,

$\alpha$ = Constant,

$\beta_1$, $\beta_2$, $\beta_3$, and $\beta_4$ = Regression coefficients,

u = Stochastic disturbance term and,

t = Time (years).

The study has examined the impact of CDII along with per hectare fertilizer consumption (N+K+P) and proportion of area under HYVs on agricultural productivity. The areas of rice and wheat were considered for measuring the proportion of areas under HYVs, as majority of the area under HYVs in UP was under these two crops. The impact of individual infrastructural indicators along with fertilizer and HYVs on agricultural productivity was studied.

## Results and Discussion

It has been found that agricultural productivity in UP increased with marginal fluctuations, which could be due to adoption of HYVs and fertilizer during the green revolution period in the state (Figure 1).

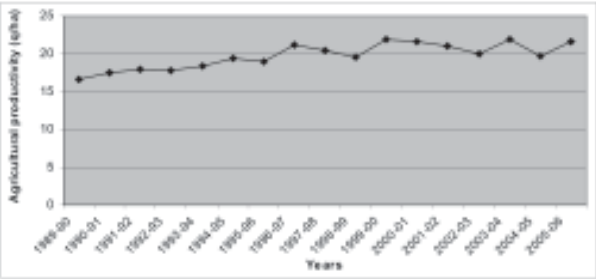


**Figure 1. Trends in agricultural productivity in UP: 1989-90 to 2005-06**

The trend for the combined infrastructural indicators measured through CDII has shown sharp fluctuations, with marginal growth in infrastructure in UP (Figure 2). It reflects that development of infrastructure in the state has not been encouraging.

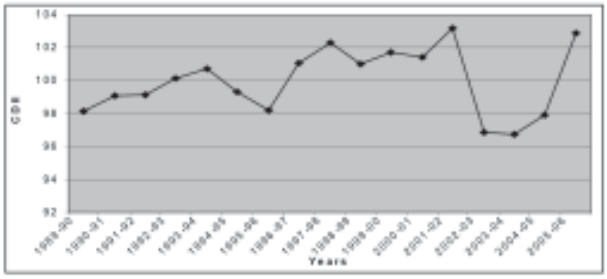


**Figure 2. Trends in CDII in UP: 1989-90 to 2005-06**

A perusal of Table 1 reveals that the status of individual infrastructural factors such as communication, banking, education, health has declined in recent years, i.e. during 2002-03 to 2005-06. On the contrary, only power and irrigation factors have shown improvements in the state, whereas the transport factor has remained constant. However, due to a quantum raise in the power sector in 2005-06, the value of CDII increased from 98 in 2004-05 to 103 in 2005-06. On the whole, the CDII has depicted a fluctuating trend during the period 1989-90 to 2005-06.

The trends for electrified villages and rural roads have been presented in Figure 3 and Figure 4, respectively. The number of villages having electricity supply had gradually increased, and the fall in the power sector during 2002-03 to 2005-06 could be on account of the data available for villages having electricity supply through LT Mains only. On the other hand, the data for electrified villages, from 1989-90 to 2001-02, was not segregated on the basis of sources of electricity supply.

The number of villages connected with roads has also increased over the years, with a fall during 1994-97 (Figure 4). The proportion of rural roads has shown a marginal increase of 5.76 per cent, from 78.87 per cent in 1989-90 to 84.63 per cent in 2005-06 in UP. It is because of low investments on the maintenance and construction of rural roads. The trends in electrified villages and rural roads have reflected a poor condition of infrastructure in the state.

Besides infrastructure, other important variables considered in the study were fertilizer consumption and area under HYVs. The consumption of fertilizer in UP had increased during 1989-90 to 2005-06, with marginal fluctuations (Figure 5). It was mainly due to the adoption of green revolution technologies in the state. According to Bhalla and Singh (2001), the consumption of fertilizer in UP during 1962-65 was 4.06 kg/ha, which increased to 75.36 kg/ha in 1980-83. However, they have observed that during 1992-95 the consumption of fertilizer was 134.27 kg/ha, which was more than the all-India level of 89.08 kg/ha. Similarly, the CMIE Agriculture data during 1989-90 to 2003-04 has shown that the consumption of fertilizer in UP has been higher than the national average and was rising at an increasing rate. However, UP still lagged behind the states like Punjab and Haryana (Appendix III).

The area under HYVs has shown an increasing trend at a decreasing rate (Figure 6). It may be due to either decline in the area under HYVs or inefficient irrigation as required by the HYVs. In UP, HYV wheat was introduced in late-1960s, followed by the HYV rice in early-1970s. This resulted in a considerable increase in yield in the state. During 1972-73 to 2001-02, the rice yields in UP had increased by about 66 per cent, while the increase was of 43 per cent in Punjab and of 36 per cent in Haryana (CMIE, 2004). However, yield of wheat in UP had increased from 1.23 t/ha in 1972-73 to 2.8 t/ha in 2001-02. In contrast, wheat yield had increased from 1.76 t/ha to 4.1 t/ha in Haryana and from 2.2 t/ha to 4.5 t/ha in Punjab during this period (CMIE, 2004).

**Table 1. Indices values of seven infrastructural sectors and CDII in Uttar Pradesh: 1989-90 to 2005-06**

| Year | Power | Transport | Irrigation | Communication | Banking | Education | Health | CDII |
|---|---|---|---|---|---|---|---|---|
| 1989-90 | 98 | 98 | 85 | 108 | 117 | 90 | 106 | 98 |
| | (23.50) | (25.44) | (16.96) | (6.45) | (13.99) | (5.42) | (6.37) | |
| 1990-91 | 100 | 98 | 87 | 105 | 115 | 94 | 107 | 99 |
| | (24.08) | (25.57) | (17.34) | (6.30) | (13.74) | (5.63) | (6.39) | |
| 1991-92 | 101 | 99 | 91 | 100 | 109 | 90 | 110 | 99 |
| | (24.20) | (25.61) | (18.21) | (5.97) | (13.04) | (5.42) | (6.61) | |
| 1992-93 | 102 | 99 | 94 | 105 | 109 | 89110 | 100 | |
| | (24.43) | (25.69) | (18.74) | (6.30) | (13.04) | (5.32) | (6.60) | |
| 1993-94 | 102 | 99 | 97 | 105 | 107 | 89 | 110 | 101 |
| | (24.58) | (25.79) | (19.33) | (6.29) | (12.82) | (5.32) | (6.58) | |
| 1994-95 | 104 | 92 | 98 | 104 | 105 | 89 | 110 | 99 |
| | (24.97) | (23.90) | (19.68) | (6.24) | (12.59) | (5.32) | (6.61) | |
| 1995-96 | 104 | 87 | 99 | 103 | 105 | 92 | 108 | 98 |
| | (25.02) | (22.58) | (19.77) | (6.19) | (12.59) | (5.53) | (6.50) | |
| 1996-97 | 105 | 97 | 100 | 103 | 103 | 96 | 104 | 101 |
| | (25.20) | (25.29) | (20.08) | (6.16) | (12.36) | (5.74) | (6.26) | |
| 1997-98 | 106 | 103 | 100 | 103 | 103 | 96 | 99 | 102 |
| | (25.44) | (26.72) | (19.95) | (6.15) | (12.36) | (5.74) | (5.95) | |
| 1998-99 | 107 | 100 | 101 | 99 | 97 | 92 | 99 | 101 |
| | (25.62) | (26.04) | (20.26) | (5.97) | (11.68) | (5.53) | (5.94) | |
| 1999-00 | 108 | 102 | 104 | 98 | 96 | 92 | 93 | 102 |
| | (25.89) | (26.61) | (20.74) | (5.87) | (11.55) | (5.52) | (5.56) | |
| 2000-01 | 108 | 104 | 103 | 98 | 92 | 94 | 91 | 101 |
| | (25.84) | (26.95) | (20.56) | (5.88) | (11.09) | (5.63) | (5.46) | |
| 2001-02 | 108 | 104 | 105 | 96 | 92 | 111 | 94 | 103 |
| | (25.97) | (26.95) | (21.06) | (5.79) | (11.09) | (6.67) | (5.65) | |
| 2002-03 | 79 | 104 | 108 | 97 | 91 | 118 | 93 | 97 |
| | (18.96) | (27.05) | (21.52) | (5.80) | (10.87) | (7.09) | (5.58) | |
| 2003-04 | 80 | 105 | 107 | 95 | 89 | 118 | 91 | 97 |
| | (19.26) | (27.20) | (21.44) | (5.70) | (10.64) | (7.09) | (5.44) | |
| 2004-05 | 83 | 105 | 109 | 93 | 87 | 127 | 89 | 98 |
| | (19.81) | (27.30) | (221.82) | (5.61) | (10.42) | (7.61) | (5.35) | |
| 2005-06 | 105 | 105 | 112 | 90 | 83 | 123 | 85 | 103 |
| | (25.25) | (27.30) | (22.47) | (5.38) | (9.96) | (7.40) | (5.12) | |

*Notes:* CDII = Composite Development Infrastructure Index
Figures within the parentheses are the weighted values

Analysing the impact of infrastructure index (CDII) and technology (fertilizer and HYV), it is found that both fertilizer and area under HYVs have positive and significant impact on agricultural productivity at one per cent probability level. However, CDII has significant impact on agricultural productivity only at ten per cent level of significance. The independent variables all together have explained 85.5 per cent variation of agricultural productivity (Table 2).

A perusal of Table 2 has shown that the coefficient value for fertilizer consumption to be 0.26. It means that one per cent rise in consumption of fertilizer may lead to an increase of agricultural productivity by 0.26 q/ha. The value of coefficient for area under HYVs was 0.78, which means that

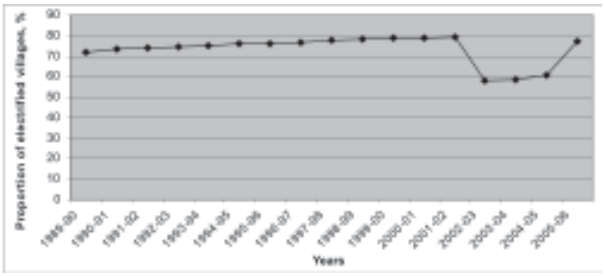


**Figure 3. Trends in electrified villages in UP: 1989-90 to 2005-06**

*Note:* From 2002-03 onwards, the data are given for villages electrified by LT mains only.

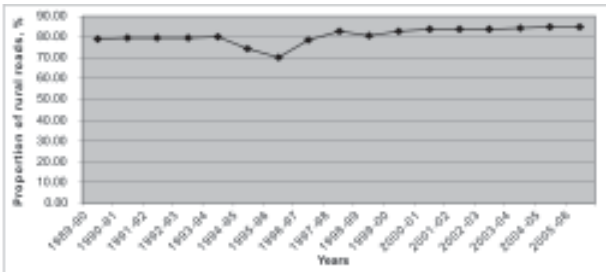


**Figure 4. Trends in villages linked with roads in UP: 1989-90 to 2005-06**

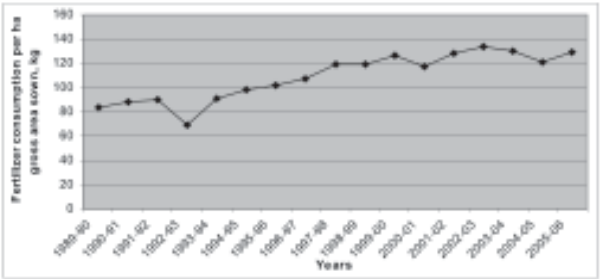


**Figure 5. Trends in fertilizer consumption in UP: 1989-90 to 2005-06**

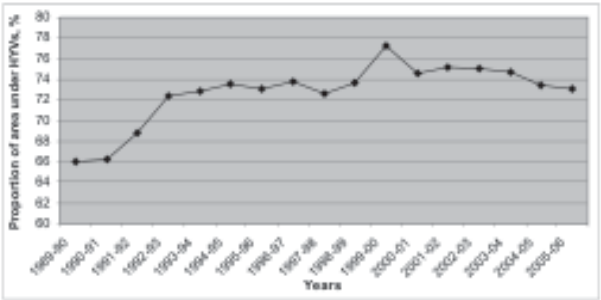


**Figure 6. Trends in area under HYVs in UP: 1989-90 to 2005-06**

one per cent increase in the area under HYVs may raise the agricultural productivity by 0.78 q/ha. However, CDII had a positive impact on agricultural productivity, i.e. improvement in the infrastructural facilities in UP would lead to better agricultural productivity. Thus, the study has shown that if the fertilizer and area under HYVs increase, the agricultural productivity will also go up in the state.

The impact analysis of all constituting indicators of CDII individually along with fertilizer and HYVs on agricultural productivity has shown that there existed the problem of serial autocorrelation and multicollinearity (Appendix II). The presence of multicollinearity and serial autocorrelation was detected through Durbin-Watson test and H-test. The heteroscedasticity was tested by KB-test. The indicators related to CDII were found highly correlated, thus did not convey any significant result. Therefore, analysis was carried out by removing the highly correlated independent variables like commercial bank, irrigated area, junior school, post office, telephone, hospital beds, and PHCs. The individual infrastructural indicators considered for analysis were proportion of rural roads and electrified villages along with fertilizer consumption and area under HYVs. It was found that these four independent variables explained 87.3 per cent of the variations in agricultural productivity. The HYVs, fertilizer and electrified villages had a positive and significant influence on agricultural productivity, whereas the influence of rural roads was insignificant (Table 3).

A perusal of Table 3 reveals that for one per cent change in fertilizer and HYVs area, the change in agricultural productivity was 0.24 q/ha and 0.91 q/ha, respectively. However, the change of one per cent in electrified villages would lead to 0.16 q/ha increase in agricultural productivity. Thus, agricultural productivity increases by increasing fertilizer consumption and area under HYVs. The lower influence of electrified villages and insignificant influence of rural roads on agricultural productivity (Table 3) might be due to the poor supply of electricity and poor rural roads in the state. On surveying the electricity supply scenario at village level in UP, Pant (2000) has reported that villages in the eastern and western regions of the state had electric supply for only 6.2 hours and 6.3 hours per day, respectively. The poor supply of electricity affects the agricultural productivity since about 71 per cent of area in UP is irrigated by

**Table 2. Multivariate regression analysis for CDII, fertilizer and HYVs on agricultural productivity in Uttar Pradesh during 1989-90 to 2005-06**

| Dependent variable | Independent variables | Beta coefficients | Standard error | t-value | $R^2$ (F-value) | $\bar{R}^2$ |
|---|---|---|---|---|---|---|
| Agricultural productivity | Constant | -5.236 | 2.130 | -2.458** | 0.855 (25.541***) | 0.821 |
| | CDII | 0.792 | 0.445 | 1.781* | | |
| | Fertilizer | 0.259 | 0.063 | 4.119*** | | |
| | HYVs area | 0.784 | 0.282 | 2.783*** | | |

*Notes:* *** Significant at 0.01 level, ** Significant at 0.05 level, * Significant at 0.10 level.

**Table 3. Multivariate regression analysis for rural roads, electrified villages, fertilizer and HYVs on agricultural productivity in Uttar Pradesh during 1989-90 to 2005-06**

| Dependent variable | Independent variables | Beta coefficients | Standard error | t-value | $R^2$ (F-value) | $\bar{R}^2$ |
|---|---|---|---|---|---|---|
| Agricultural productivity | Constant | 2.278 | 0.413 | 5.511*** | 0.873 (20.661***) | 0.831 |
| | Rural roads | 0.267 | 0.215 | 1.241 | | |
| | Electrified villages | 0.164 | 0.091 | 1.800* | | |
| | Fertilizer | 0.236 | 0.071 | 3.334*** | | |
| | HYVs area | 0.910 | 0.282 | 3.232*** | | |

*Notes:* *** Significant at 0.01 level, ** Significant at 0.05 level, * Significant at 0.10 level.

tubewells and about 29 per cent depends on the rainfall (Govt. of UP, 2004). The HYVs in UP do not receive the required irrigation, (Sharma and Poleman, 1993; Pant, 2004) and this was one of the reasons for low agricultural productivity of UP than states like Punjab and Haryana (Appendix III).

The influence of fertilizer has been found significant on the agricultural productivity of the state. The consumption of fertilizer in UP has increased from 87.95 kg/ha in 1990-91 to 134.56 kg/ha in 2004-05. However, it is much lower in UP than in agriculturally-developed states like Haryana (from 99.05 kg/ha in 1991 to 159.97 kg/ha in 2004) and Punjab (from 162.57 kg/ha in 1991 to 195.20 kg/ha in 2004) (Appendix III).

Similarly, the impact of area under HYVs has been found positive and significant on agricultural productivity in UP. The adoption of HYVs of wheat and rice increased their productivity in UP, but it remained much lower in comparison to that in Punjab or Haryana. In 2001-02, the production of wheat in UP was 2760 kg/ha in an area of about 9 million hectares, whereas Punjab and Haryana produced 4530 kg/ha in an area of 3.4 million hectares and 4100 kg/ha in an area of 2.3 million hectares, respectively. Similarly, UP produced 2120 kg/ha of rice in an area of about 5.9 million hectares, while Punjab produced 3540 kg/ha in an area of 2.5 million hectares. Although, Haryana was not a major producer of rice, its yield was 2650 kg/ha. The yield of Haryana and Punjab were 20 per cent and 40 per cent, respectively, higher than the UP's yield (CMIE, 2004).

The results obtained in the present study are consistent with the earlier findings of Bhalla and Singh (2001), Fan *et al.* (2000), and Binswanger *et al.* (1993). Bhalla and Singh (2001) have found that the coefficients of modern farm inputs and infrastructure variables were positive and statistically significant.

## Summary and Conclusions

The study has revealed that composite infrastructure index (CDII) shows sharp fluctuations, while individual infrastructural indicators such as percentage of electrified villages and rural roads have shown a rising trend in UP. However, fertilizer consumption has shown a rising trend and HYVs-

area has illustrated an increasing trend at a decreasing rate. The impact of technological variables such as fertilizer consumption and area under HYVs has been found positively significant at one per cent probability level, while that of CDII has been observed positive and significant at ten per cent significance level on agricultural productivity in UP. Altogether these variables have explained 85.5 per cent variations in agricultural productivity. However, the impact of individual infrastructural indicators such as proportion of electrified villages on agricultural productivity has been found positively significant at ten per cent of probability level, whereas proportion of rural roads is insignificant. The effect of fertilizer and HYV-area remains significant at one per cent level of significance. The variation explained by all these variables is 87.3 per cent in agricultural productivity in UP.

The study has concluded that there exists sufficient scope for alleviating agricultural productivity by improving infrastructural facilities in the state, particularly in banking, education, communication and health sectors. The analysis of individual infrastructural indicators has revealed that power and transportation indicators have higher influence in raising the agricultural productivity. Since irrigation largely depends on electricity-operated tubewells and pumpsets in the state, there is a need of un-interrupted electricity supply. Similarly, considering the higher productivity through investment in rural road connectivity and its maintenance, the centre and state governments should take immediate steps in this direction.

The study could not consider a few important variables like tractors, regulated markets, credit societies, etc., due to unavailability of time series data for most of these variables. The data for proportion of electrified villages from 2002-03 onwards were available for LT Mains only; however, for the previous years, i.e. from 1989-90 to 2002-03, the data were not segregated on the basis of sources, and were considered as per the availability. The agricultural productivity considered in the study represented only land productivity or yield. Further research may be directed towards examining the factors influencing total factor productivity and its growth. It should be carried out at the disaggregated levels, to find the disparities, if any in the state.

## Note

The CMIE, Mumbai, after assessing the importance and contribution of seven major economic as well as social infrastructural factors has worked out their individual weighted values as: (a) Transport–26, (b) Energy–24, (c) Irrigation–20, (d) Banking–12, (e) Communication–6, (f) Education–6, and (g) Health–6. Further, CMIE has chosen the following 11 development indicators relating to these seven major infrastructures to form the Composite Development Index (CDI): (i) surfaced roads per 100 sq km area, (ii) un-surfaced roads per 100 sq km area, (iii) railway route length per 100 sq km area, (iv) percentage of villages electrified, (v) gross cropped area (irrigated), (vi) bank branches per lakh population, (vii) post offices per lakh population, (viii) telephone lines per 100 persons, (ix) primary schools per lakh population, (x) primary health centres per lakh population, and (xi) hospital beds per lakh population.

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## Appendix I

**State-wise growth of crop productivity during 1962-65, 1970-73, 1980-83 and 1992-95 (at 1990-93 constant prices)**

| State | Per cent annual compound growth rate of average agricultural productivity* | | | |
|---|---|---|---|---|
| | 1992-95 over 1962-65 | 1970-73 over 1962-65 | 1980-83 over 1970-73 | 1992-95 over 1980-83 |
| Haryana | 3.30 | 2.04 | 4.13 | 3.21 |
| Punjab | 4.16 | 2.65 | 2.85 | 3.13 |
| Uttar Pradesh | 1.64 | 1.80 | 3.15 | 2.30 |
| All India | 1.64 | 1.80 | 3.15 | 2.30 |

*Notes:* *Average productivity = (Value of output of 43 crops/area under 43 crops)

*Source:* Bhalla and Singh (2001)

## Appendix II

**Multivariate regression analysis for infrastructure indicators, fertilizer and HYVs on agricultural productivity in Uttar Pradesh: 1989-90 to 2005-06**

| Dependent variable | Independent variables | Beta coefficients (β) | Standard error | t-value | $R^2$ (F-value) | $\bar{R}^2$ |
|---|---|---|---|---|---|---|
| Agricultural productivity | (Constant) | 4.813 | 3.786 | 1.271 | 0.890 (3.668*) | 0.647 |
| | Fertilizer | 0.042 | 0.379 | 0.110 | | |
| | HYV area | 0.478 | 1.847 | 0.259 | | |
| | Electrified villages | 0.162 | 0.216 | 0.751 | | |
| | Gross irrigated area | 0.782 | 1.998 | 0.391 | | |
| | Rural roads | 0.157 | 0.520 | 0.301 | | |
| | Commercial banks | 0.489 | 2.089 | 0.234 | | |
| | Junior schools | 0.020 | 0.455 | 0.044 | | |
| | Post offices | -0.191 | 1.349 | -0.141 | | |
| | Telephones | -0.012 | 0.158 | -0.073 | | |
| | Hospital beds | -0.544 | 0.887 | -0.613 | | |
| | Primary health centres | 0.189 | 0.575 | 0.328 | | |

*Note:* * Significant at 0.10 level.

## Appendix III

**State-wise level of inputs used: 1990-91 to 2005-06**

| Inputs | State | 1990-91 | 1991-92 | 1992-93 | 1993-94 | 1994-95 | 1995-96 | 1996-97 | 1997-98 | 1998-99 | 1999-2000 | 2000-2001 | 2001-2002 | 2002-2003 | 2003-2004 | 2004-2005* | 2005-2006* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gross | Haryana | 71.58 | 77.91 | 89.75 | 77.64 | 77.01 | 78.22 | 78.78 | 78.61 | 79.76 | 84.99 | 85.41 | 84.06 | 86.19 | - | 86.30 | 85.20 |
| irrigated | Punjab | 94.05 | 94.59 | 94.58 | 94.95 | 95.14 | 95.16 | 94.07 | 95.58 | 96.74 | 90.86 | 101.41 | 96.59 | 97.09 | 96.99 | 97.50 | 97.60 |
| area (%) | UP | 57.97 | 61.02 | 62.31 | 64.06 | 65.36 | 65.80 | 63.59 | - | 68.50 | 66.35 | 67.32 | 71.25 | 70.61 | - | 70.50 | 71.60 |
| | All India | 34.03 | 36.04 | 35.99 | 36.48 | 37.56 | 38.25 | 38.66 | 38.31 | 39.43 | 40.23 | 40.18 | 41.12 | 41.46 | 40.30 | 44.20 | 45.50 |
| Fertilizer | Haryana | 99.09 | 114.35 | 104.00 | 115.51 | 119.45 | 121.16 | 125.36 | 136.49 | 137.73 | 146.80 | 151.46 | 155.74 | 153.21 | 159.97 | 163.43 | |
| consumption | Punjab | 162.57 | 167.86 | 158.82 | 157.35 | 167.05 | 162.97 | 154.01 | 163.45 | 172.19 | 179.75 | 163.27 | 169.97 | 184.24 | 195.20 | 193.66 | - |
| (kg/ha) | UP | 87.95 | 88.94 | 84.90 | 89.72 | 96.37 | 101.00 | 105.93 | 114.26 | 119.40 | 123.52 | 113.48 | 131.73 | 128.62 | 127.78 | 134.56 | |
| | All India | 67.55 | 69.84 | 65.53 | 66.34 | 72.13 | 74.38 | 75.49 | 84.90 | 87.92 | 94.72 | 87.18 | 91.13 | 91.45 | 88.11 | 93.67 | |
| No. of | Haryana | | 143.59 | | | 113.54 | 113.38 | 113.00 | 112.63 | 113.08 | 115.72 | 121.22 | | 125.95 | 123.24 | | |
| pumpsets | Punjab | - | 169.40 | - | - | 162.58 | 171.52 | 175.46 | 17.62 | 175.78 | 178.18 | 191.43 | - | 197.83 | 198.92 | - | - |
| (per 1000 ha | UP | | 33.19 | | | 42.64 | 43.75 | 44.55 | 45.12 | 47.99 | 48.67 | - | | 50.35 | 50.08 | | |
| of NSA) | All India | | 77.61 | | | 74.99 | 78.08 | 80.98 | 83.43 | 85.67 | 88.61 | 93.14 | | - | - | | |
| Agricultural | Haryana | 23.48 | 25.37 | 25.84 | 26.31 | 29.84 | 25.30 | 28.44 | 27.06 | 29.32 | 30.47 | 30.61 | 31.27 | 31.01 | 30.82 | 30.92 | 30.45 |
| productivity | Punjab | 33.90 | 34.78 | 35.15 | 36.81 | 36.84 | 34.71 | 37.86 | 35.96 | 37.41 | 40.28 | 40.34 | 40.40 | 38.32 | 39.33 | 40.40 | 39.86 |
| of foodgrains | UP | 17.4 | 17.89 | 17.85 | 18.44 | 19.37 | 18.95 | 21.03 | 20.44 | 19.61 | 22.12 | 21.02 | 21.73 | 20.29 | 22.01 | 19.61 | 20.57 |
| (q/ha) | All India | 13.80 | 13.82 | 14.57 | 15.01 | 15.46 | 14.91 | 16.14 | 15.52 | 16.27 | 17..4 | 16.26 | 17.34 | 15.35 | 17.2 | 16.52 | 17.15 |
| Cropping | Haryana | 2.99 | 1.59 | 1.68 | 1.66 | 1.68 | 1.67 | 1.68 | 1.69 | 1.74 | 1.70 | 1.73 | 1.77 | 1.74 | 1.81 | 1.82 | |
| intensity | Punjab | 1.78 | 1.78 | 1.82 | 1.81 | 1.83 | 1.87 | 1.89 | 1.94 | 1.83 | 1.94 | 1.86 | 1.86 | 1.85 | 1.88 | 1.90 | - |
| (GCA/NSA) | UP | 1.48 | 1.47 | 1.49 | 1.48 | 1.49 | 1.48 | 1.50 | 1.51 | 1.44 | 1.48 | - | 1.51 | 1.52 | 1.53 | 1.47 | - |
| | All India | 1.30 | 1.29 | 1.30 | 1.31 | 1.32 | 1.31 | 1.33 | 1.34 | 1.35 | 1.34 | 1.33 | 1.35 | 1.33 | 1.35 | 1.35 | |

*Source:* CMIE Agriculture, various years

**Source:* Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi

*Notes*: — Data not found

GCA = Gross cropped area; NSA = Net sown area.