# Agricultural research and urban poverty in India

**Shenggen Fan**
International Food Policy Research Institute (IFPRI), Washington, DC, USA, and Chinese Academy of Agricultural Sciences, Beijing, China

## Abstract

This paper uses state data to analyze the impact of agricultural research on reducing urban poverty in India from 1970 to 1995. In addition to substantially reducing rural poverty, agricultural research investments have played a major role in the reduction of urban poverty. Agricultural research investments increase agricultural production, which, in turn, lowers food prices. The urban poor often benefit more from lower food prices than the non-poor since they spend a greater proportion of their income on food. Among the rural investments considered in this study, agricultural research has the largest impact on urban poverty reduction per additional unit of investment. Today, urban poverty accounts for one quarter of the total poverty in India, and this figure is expected to increase in the future. Policymakers cannot afford to be complacent about this trend, and continued investments are needed to keep food prices low. Among all government policy instruments, increased agricultural research is still the most effective way to achieve this objective.

**Keywords:** urban poverty, developing countries, India, agricultural research, food price

## 1. Introduction

The role of agricultural research in alleviating poverty has been an issue of debate since the Green Revolution in South Asia and Mexico in the late 1960s (PINSTRUP-ANDERSEN and HAZELL, 1985). The general consensus that has emerged is that research-led technical change not only prevented widespread starvation, but also it contributed to significant national economic growth and saved huge areas of forest, hillsides and other environmentally fragile lands from conversion to agriculture. In Asia, for example, the Green Revolution contributed to more than a doubling of the aggregate food supply over a 25-year period. More importantly, it achieved this through only a 4 % increase in the net cropped area (ROSEGRANT and HAZELL, 2000).

There is also a large amount of empirical literature on the economic returns to agricultural research investment in developing countries. ALSTON et al. (2000) reviewed 292 studies (more than 1,886 estimates of rates of return) and obtained an average rate of return of 100 % to agricultural research investment, with a median rate of return of 48 %.

FAN, HAZELL and THORAT (2000) were the first to directly link agricultural research to rural poverty reduction. Their results for rural India indicate that of all government investments studied, agricultural research has had the largest impact on productivity, and that the benefits of research-led productivity growth have extended to the rural poor. In fact, agricultural research has had the second largest impact on rural poverty reduction in India; investment in rural roads has had the largest. Using provincial data from China, FAN, FANG and ZHANG (2001) reached a very similar conclusion: agricultural research in China has had the largest impact on agricultural production and the second largest impact on poverty (investment in rural education has the largest impact).

The links between agricultural research and food price benefits for consumers have also been quantified, using the consumer surplus as a welfare measure (AKINO and HAYAMI, 1975; MELLOR, 1975; SCOBIE and POSADA, 1978; PINSTRUP-ANDERSEN, 1979; EVENSON and FLORES, 1978). However, little work has been done on quantifying the impact of agricultural research on urban poverty reduction, despite the fact that rapid urbanization is causing urban poverty to increase in developing countries (HADDAD, RUEL and GARRET, 1999; RAVILLION, 2000). FAN, FANG and ZHANG (2001) were the first to develop a model that formally linked agricultural research to urban poverty reduction, which they applied to China.

This paper uses results from India to reinforce the findings of the China case study. The India case has its own merits, however. Firstly, the Indian economy is largely market-driven, in contrast to the centrally-planned economy found in China until the late 1970s. The distorted nature of food prices in China makes it difficult to fully capture the impact of agricultural research on urban poverty reduction through lowering of food prices. Secondly, despite considerable success in reducing poverty, India today still has more than 70 million urban poor, accounting for one third of the country's total poor. India also accounts for a large proportion (more than 40 %) of the total global urban poor. These figures illustrate that the need to develop a national strategy to prevent further increases in urban poverty is more urgent than ever.

In this paper, we first review historical trends in agricultural research investment, technology development and productivity growth in Indian agriculture and follow this with a brief discussion of changes in urban poverty. We then develop and apply a conceptual framework and model to analyze how agricultural research affects the urban poor, and discuss the estimation procedures and results. Finally, we conclude with some policy implications.

## 2. Agricultural research, technology and productivity

Government spending on agricultural research in India has increased significantly over the past four decades, but not without substantial year to year variation (table 1). Investment in agricultural research was quite modest during the 1960s, ranging from 1.6 to 1.9 billion rupees (Rs; all monetary values are expressed in 1995 prices). During the 1970s, the expenditure on agricultural research more than doubled, increasing to 4.0 billion Rs. Throughout this period, many agricultural universities and national research institutions were set up (EVENSON, PRAY and ROSEGRANT, 1998). These were the driving force behind the Green Revolution that led to a more than doubling of rice and wheat yields within a decade. During the 1980s to 1990, research expenditures continued to increase to 7 billion Rs; however, from 1990 to 1995 it increased only modestly to 7.3 billion Rs. This is of concern, given the importance of agricultural research to national food security and poverty alleviation.

As a percentage of agricultural gross domestic product (AgGDP), agricultural research investment was relatively low at 0.20 % during the 1960s, but increased dramatically to more than 0.40 % during the 1970s. In the 1980s, it continued to rise, reaching a peak of 0.50 % in 1987. In recent years, however, this figure has gradually declined to below 0.43 %. This indicates that government investment in agricultural research has increased in absolute terms over the past decade, but it has declined relative to the size of the agricultural sector.

One of the most significant changes in Indian agriculture in recent decades has been the widespread adoption of high-yielding varieties (HYVs). During the Green Revolution in the 1970s, the cropping area planted to HYVs of five major crops (rice, wheat, maize, sorghum, pearl millet) increased from about 20 % to 40 % (table 2).[1] Even after the Green Revolution, the percentage of cropping area planted to HYVs continued to increase. It reached 53 % by 1990 and 59 % by 1995. The adoption of HYVs has been one of the major forces behind productivity growth in Indian agriculture.

1 High-yielding varieties (also referred to as modern varieties) are those released by Indian national agricultural research systems and international agricultural research centers. The yields of these varieties are usually substantially higher than those of traditional varieties. The percentage of cropping area planted to HYVs is calculated as the ratio of HYV area for five major crops (rice, wheat, maize, sorghum, and pearl millet) to the total cropped areas of these five crops.

**Table 1. Agricultural research expenditure in India, 1964-1995**

| | Research expenditure[a] (million Rs) | Research intensity ratio[b] (million PPPs) | (%) |
|---|---|---|---|
| 1964 | 1,629 | 378 | |
| 1965 | 1,581 | 367 | 0.21 |
| 1966 | 1,869 | 434 | 0.25 |
| 1967 | 1,590 | 369 | 0.18 |
| 1968 | 1,684 | 391 | 0.19 |
| 1969 | 1,879 | 436 | 0.20 |
| 1970 | 1,902 | 441 | 0.20 |
| 1971 | 1,886 | 438 | 0.21 |
| 1972 | 1,973 | 458 | 0.22 |
| 1973 | 1,741 | 404 | 0.17 |
| 1974 | 2,504 | 581 | 0.26 |
| 1975 | 3,178 | 737 | 0.33 |
| 1976 | 3,471 | 805 | 0.38 |
| 1977 | 3,965 | 920 | 0.38 |
| 1978 | 4,407 | 1,022 | 0.43 |
| 1979 | 4,148 | 962 | 0.45 |
| 1980 | 3,982 | 924 | 0.38 |
| 1981 | 4,128 | 958 | 0.39 |
| 1982 | 4,292 | 995 | 0.41 |
| 1983 | 4,695 | 1,089 | 0.40 |
| 1984 | 4,978 | 1,155 | 0.43 |
| 1985 | 4,572 | 1,061 | 0.39 |
| 1986 | 5,115 | 1,186 | 0.44 |
| 1987 | 6,011 | 1,394 | 0.50 |
| 1988 | 6,517 | 1,512 | 0.48 |
| 1989 | 6,507 | 1,509 | 0.46 |
| 1990 | 7,085 | 1,643 | 0.48 |
| 1991 | 6,873 | 1,594 | 0.46 |
| 1992 | 6,754 | 1,567 | 0.44 |
| 1993 | 7,280 | 1,689 | 0.44 |
| 1994 | 7,246 | 1,681 | 0.42 |
| 1995 | 7,293 | 1,692 | 0.43 |

[a] Agricultural research expenditures were obtained from the State Planning Commission, Government of India. The GDP deflator was used to convert expenditures to 1995 prices. We then used the 1995 exchange rate based on purchasing power parity (PPP) to convert expenditures into 1995 international dollars.

[b] The agricultural research intensity ratio is defined as agricultural research expenditure as a percentage of agricultural GDP.

**Table 2. Agricultural technology, production and productivity growth in India, 1970-1995**

| | HYV[a] adoption (%) | Production growth (index) | TFP[b] growth (index) | Urban food price (index) |
|---|---|---|---|---|
| 1970 | 21 | 100 | 100 | 100.00 |
| 1971 | 24 | 100 | 99 | 98.88 |
| 1972 | 23 | 93 | 92 | n.a |
| 1973 | 25 | 97 | 98 | 101.23 |
| 1974 | 26 | 101 | 100 | 102.44 |
| 1975 | 29 | 114 | 113 | n.a. |
| 1976 | 31 | 105 | 103 | n.a. |
| 1977 | 34 | 115 | 112 | n.a. |
| 1978 | 36 | 119 | 114 | 97.37 |
| 1979 | 37 | 119 | 113 | n.a. |
| 1980 | 41 | 120 | 112 | n.a. |
| 1981 | 40 | 127 | 116 | n.a. |
| 1982 | 43 | 125 | 110 | n.a. |
| 1983 | 41 | 135 | 118 | 97.31 |
| 1984 | 45 | 131 | 114 | n.a. |
| 1985 | 44 | 141 | 120 | n.a. |
| 1986 | 46 | 133 | 114 | n.a. |
| 1987 | 48 | 136 | 114 | 95.33 |
| 1988 | 47 | 152 | 130 | 95.78 |
| 1989 | 53 | 168 | 134 | 95.78 |
| 1990 | 53 | 152 | 121 | n.a. |
| 1991 | 57 | 152 | 119 | 95.78 |
| 1992 | 56 | 153 | 118 | 94.44 |
| 1993 | 57 | 156 | 118 | 96.02 |
| 1994 | 64 | 165 | 118 | n.a. |
| 1995 | 59 | n.a. | n.a. | n.a. |
| Annual growth rate (%) | | | | |
| 1970-79 | 6.25 | 1.95 | 1.37 | |
| 1980-89 | 3.10 | 3.82 | 1.99 | |
| 1990-95 | 2.10 | 2.09 | -0.59 | |
| 1970-95 | 4.19 | 2.11 | 0.69 | |

[a] HYV = high-yielding variety.

[b] TFP = total factor productivity.

Source: HYV, production and TFP growth data are taken from FAN, HAZELL and THORAT (2000). The food price index is taken from the INDIAN STATISTICAL ABSTRACT (various years).

As a result of the rapid adoption of new technologies and improved rural infrastructure in India, agricultural production and factor productivity have increased rapidly. Between 1970 and 1995, agricultural production in India grew at 2.11 % per annum (table 2). During the 1970s, production growth was comparatively low, increasing at an average annual rate of only 1.95 %. During the 1980s, it grew at 3.82 % per annum, which was higher than most other countries achieved during the same period. Since 1990, production growth has slowed, growing at only 2.09 % per annum.

Total factor productivity (TFP) for India grew at an average annual rate of 0.69 % between 1970 and 1995 (table 2), while in the 1970s, it increased at 1.37 % per annum. During the 1980s, it increased rapidly at 1.99 % per annum; however, since 1990, the TFP growth in Indian agriculture has declined at a rate of - 0.59 % per annum.

## 3. Urban poverty

In the early 1970s, both rural and urban poverty rates were high in India: 57 % of the rural population and 47 % of the urban population lived below the poverty line (table 3). Due to rapid growth in agriculture, the rural poverty rate declined to 45 % by the mid-1980s. During the same period, the urban poverty rate also decreased to 36 %. The decline in urban poverty was due mainly to growth in urban income, although the decline in real food prices relative to non-food prices may have played a large role. From the mid-1980s to 1987, rural poverty continued to decrease to 39 %, but urban poverty changed very little. Further reductions in rural poverty were mainly due to growth in rural non-farm employment and increases in rural wages. So-called "trickle down" benefits of agricultural growth for the rural poor were almost non-existent, however, since both agricultural production and productivity growth were largely stagnant. Since agricultural growth was limited, there was little impact on urban poverty through lower food prices.

Rural and urban poverty in India fell relatively rapidly during the second half of the 1980s. A sharp increase in agricultural production and productivity was the major reason behind the reduction in rural poverty, while the growth in agricultural production and productivity may have contributed to the reduction in urban poverty by keeping food prices low. Indeed, the relative food price index dropped by two percentage points during this period.

In summary, whenever there has been significant growth in agricultural production and productivity, both rural and urban poverty have declined in India.

**Table 3. Poverty in India, 1970-1995**

| | Rural poverty (%) | Urban poverty (%) | Urban poor (million) | Rural poor (million) | Share of urban poor (%) |
|---|---|---|---|---|---|
| 1970 | 58 | 47 | 52 | 257 | 17 |
| 1971 | 55 | 45 | 51 | 249 | |
| 1972 | n.a. | n.a. | n.a. | n.a. | |
| 1973 | 55 | 46 | 56 | 261 | 18 |
| 1974 | 56 | 48 | 61 | 267 | 19 |
| 1975 | n.a. | n.a. | n.a. | n.a. | |
| 1976 | n.a. | n.a. | n.a. | n.a. | |
| 1977 | n.a. | n.a. | n.a. | n.a. | |
| 1978 | 51 | 41 | 60 | 260 | 19 |
| 1979 | n.a. | n.a. | n.a. | n.a. | |
| 1980 | n.a. | n.a. | n.a. | n.a. | |
| 1981 | n.a. | n.a. | n.a. | n.a. | |
| 1982 | n.a. | n.a. | n.a. | n.a. | |
| 1983 | 45 | 36 | 62 | 253 | 20 |
| 1984 | n.a. | n.a. | n.a. | n.a. | |
| 1985 | n.a. | n.a. | n.a. | n.a. | |
| 1986 | n.a. | n.a. | n.a. | n.a. | |
| 1987 | 39 | 34 | 68 | 232 | 23 |
| 1988 | 40 | 36 | 73 | 241 | 23 |
| 1989 | 39 | 37 | 77 | 242 | 24 |
| 1990 | 34 | 33 | 72 | 216 | 25 |
| 1991 | 36 | 33 | 73 | 233 | 24 |
| 1992 | 40 | 34 | 74 | 260 | 22 |
| 1993 | 37 | 31 | 72 | 242 | 23 |
| 1994 | 41 | 34 | 81 | 274 | 23 |
| 1995 | 37 | 28 | 71 | 252 | 22 |

Source: Rural and urban poverty rates are from DATT (1998). The author calculated the number of rural and urban poor using population data from FAO (2002).

## 4. Econometric model

To analyze the links between agricultural research and urban poverty, we developed an econometric model that included an agricultural production function, a price determination function, and an urban poverty equation. Three equations were included because agricultural research investments affect poverty through changes in food prices, and it is difficult to capture this link using a single equation approach.

(1) $TFP = h(RDE, RDE_{-1}, RDE_{-2}, ..., RDE_{-i}, IR, ROADS, PVELE, LITE, GCSHEL, GERDEV, GCSSL, RAIN, X)$

(2) $FP = g(TFP, GDP, POP, WPI, S)$

(3) $UP = f(FP, M, GINI, Z)$

Equation (1) models the determination of TFP growth in agriculture. The TFP growth index is the ratio of an aggregated output index to an aggregated input index. The variables included in the equation are: current and lagged government spending in agricultural research and extension (RDE, $RDE_{-1}$, ..., $RDE_{-i}$), percentage of irrigated cropped area in total cropped area (IR), literacy rate of the rural population (LITE), road density (ROADS), percentage of villages with electricity (PVELE), capital stocks of government investments in health (GCSHEL), rural development (GERDEV), soil and water conservation (GCSSL) and annual rainfall (RAIN). The first seven variables capture the productivity-enhancing effects of technologies, infrastructure, education and other government spending in rural areas. The rainfall variable captures weather effects. Inclusion of other public goods and government spending variables avoids overestimating the effects of agricultural research and allows the effects of these public investments to be compared with agricultural research. The variable X is included to capture the omitted variables that are fixed by year or state.

Equation (2) models the determination of food prices (FP). Food prices are measured as a ratio of food to non-food consumer prices. Growth in agricultural productivity (TFP) increases the supply of agricultural products and hence is expected to contribute to lower food prices. Per capita GDP (GDP) and population size (POP) are used to capture demand factors in the food markets. Food prices in India may also be affected by international market prices (WPI), although during most of the study period, the share of imports and exports in total domestic consumption was small, often less than 3 %. Variable S, which consists of a set of state dummies, is intended to capture the effect of all other factors on food prices.

Equation (3) models the determinants of urban poverty (UP).[2] Urban poverty is expected to be positively related to increases in food prices relative to non-food prices (FP), positively related to inequality in urban incomes (GINI), and negatively related to the per capita income of urban residents (M). Variable Z, which comprises year and province dummies, is included to capture the effects of all other omitted variables.

[2] To simplify the presentation, we have omitted subscripts that indicate observations in year t at the province level; hence, the variables with subscript "-1, ..., -j" indicate lagged observations for years t-1, ..., t-j.

# 5. Data and model estimation

## 5.1 Data

State data for the period 1970-1995 were used in the model estimation. Most of the data were taken from official sources of the Indian government (FAN, HAZELL and THORAT, 2000).

The head-count ratio data used in this analysis were constructed by DATT (1998), and are published in a World Bank publication (WORLD BANK, 1997). Datt used the poverty line originally defined by the Government of India Planning Commission, which is based on a nutritional norm of 2,400 calories per person per day. The poverty line is determined by the level of average per capita total expenditure at which this nutritional norm is typically attained and is equal to a per capita monthly expenditure of Rs 57 at October 1973-June 1974 all-India urban prices. The mean income and GINI coefficients are also taken from DATT (1998).

Our measure of TFP growth has already been defined; however, because of concerns that this measure may be sensitive to the cost data used in aggregating inputs, a simpler approach was also tried. By first estimating a production function for Indian agriculture using district data, production elasticities for key inputs such as land, labor, fertilizer, machinery and animals were obtained. These key inputs were then used to construct an estimate of TFP growth at the state level. The results from this approach were similar to those obtained using the cost shares (a dual approach). However, the dual approach is preferred here because the elasticities used in the primal approach do not vary between states.

The road density variable is defined as the length of road per unit of geographic area. Education (or literacy rate) is measured as the percentage of literate people above seven years of age in the total rural population. The irrigation variable is defined as the percentage of the total cropped area under irrigation. The electricity variable measures the percentage of all villages that have access to electricity. These variables were aggregated from district data obtained from the Planning Commission through the National Centre for Agricultural Policy and Economics Research, New Delhi.

The food price variable is measured as the change in food prices relative to non-food prices in urban areas. GDP and population data are taken from the World Bank database (WORLD BANK, 2002). The world food price index is a weighted average price index for rice, wheat and maize in the international market; the international prices of these commodities are taken from FAO (2002).

## 5.2 Functional form and estimation technique

We used double-log functional forms for all of the equations. More flexible functional forms, such as the translog or quadratic, impose fewer restrictions on estimated parameters, but many coefficients are not statistically significant due to multicollinearity problems among the many interactive variables.

## 5.3 Lags and distributions of research and development investments

Government investments in research and development (R&D) can have long lead times in affecting agricultural production, as well as long-term effects once they kick in. One of the thornier problems to resolve when including agricultural research investments in a production function is the choice of an appropriate lag structure. In the past, most studies have used stock variables, which are usually weighted averages of current and past government expenditures on R&D. But what weights should be used, and how many years should be included in the lag structure? These issues are currently subject to heated debate.3 Since the shape and length of investment lags are largely unknown, we use a free form lag structure in our analysis, i.e., we include current and past government expenditures on R&D in the production function. Then we use statistical tools to test and determine the appropriate length of lag for R&D expenditure.

Various procedures have been suggested for determining the appropriate lag length. The adjusted $R^2$ and Akaike's Information Criteria (AIC) are used by many economists (GREENE, 1993). In this study, we simply use the adjusted $R^2$. The optimal lag length is determined by the length of lag that maximizes the adjusted $R^2$. The AIC is similar to the adjusted $R^2$ procedure in that it rewards goodness of fit, but it penalizes for loss of degrees of freedom. The lag indicated by the adjusted $R^2$ approach is 13 years.

Another problem related to the estimation of the lag structure is that the independent variables (RDE, $RDE_{-1}$, $RDE_{-2}$, ..., and $RDE_{-i}$) are often highly correlated, making the estimated coefficients statistically insignificant. Several ways of tackling this problem have been proposed. The most popular approach is to use what are called polynomial distributed lags (PDLs). In a PDL, the coefficients are all required to lie on a polynomial of some degree d. In this study, we use PDLs of degree 2. In this case, we only need to estimate 3 instead of i + 1 parameters for the lag distribution. For more detailed information on this subject, refer to DAVIDSON and MACKINNON (1993). Once the lengths of lag are determined, we estimate the simultaneous equations system with the PDLs and appropriate lag length for research investment.

[3] ALSTON et al. (1998) argue that research lags may be much longer than previously thought, perhaps even infinite. However, this argument may be less relevant for most developing countries since their national agricultural research systems are much younger and their research tends to be more applied, hence it has a shorter useful life.

### 5.4 Estimation results

The modeling results appear in table 4. Since we used double-log functional forms, the estimated coefficients are presented in elasticity form. The estimated agricultural productivity function (equation (1)) confirms that agricultural research, improved roads, irrigation, and education all have contributed significantly to agricultural productivity. Annual rainfall is also positively and significantly correlated with higher productivity. While access to electricity, government expenditure on rural development, and soil and water conservation are positively correlated, they are not statistically significant. The coefficient reported for agricultural R&D is the sum of the past 13-years' coefficients from the PDLs distribution. The significance test is the joint t-test of the three parameters of the PDL.

The estimated food price equation (equation (2)) indicates that increases in agricultural output exert a strong downward pressure on food prices, with an elasticity of 0.231. Per capita GDP and total population size have positive, but statistically insignificant, impacts on agricultural prices. World food prices have a significant impact on domestic food prices, indicating that domestic urban food prices are linked to the international market.

The estimated poverty equation (equation (3)) shows that food prices have a very significant impact on urban poverty. For every 1 % decrease/increase in food prices, urban poverty is reduced/increased by 0.35 %. Growth in per capita income has also contributed significantly to rapid reductions in urban poverty, while a worsening income distribution in urban areas has caused urban poverty to increase.

## 6. Contribution of agricultural research to urban poverty reduction

By totally differentiating equations (1) to (3), the impact of government investment in agricultural R&D in year t-i on poverty at year t can be derived as:

(4) $$dUP/dRDE_{-i} = (\partial UP/\partial FP)\,(\partial FP/\partial Y)\,(\partial Y/\partial RDE_{-i})$$

By aggregating the total effects of all past government expenditures on R&D over the lag period, the sum of marginal effects is obtained for any particular year. This is equivalent to the marginal impact of a change in the "stock" of R&D investment at time t, where the stock RS is measured as:

$$RSt = atREt + at\text{-}1REt\text{-}13 + \ldots + at\text{-}13REt\text{-}13$$

where $a_{t-i}$ coefficients are the estimated parameters in the production function (equation (1)).

**Table 4. Estimates of the simultaneous equation system**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (1)[a] | TFP | = -0.026 | + 0.255 TRDE | + 0.215 IR | + 0.242 ROADS | + 0.062 PVELE | + 0.708 LITE | + 0.012 GCSHEL | |
| | | (-0.78) | (1.82)* | (1.83)* | (2.43)* | (0.60) | (1.95)* | (0.39) | |
| | | | + 0.022 GERDEV | + 0.0015 GCSSL | + 0.272 RAIN | | | | $R^2 = 0.301$ |
| | | | (0.63) | (0.37) | (5.47)* | | | | |
| (2)[b] | FP | = 0.025 | - 0.231 TFP | + 0.112 GDP | + 0.034 POP | + 0.271 WPI | | | $R^2 = 0.363$ |
| | | (2.22)* | (-3.03)* | (1.56) | (1.67) | (8.03)* | | | |
| (3)[c] | UP | = 7.07 | - 1.637 M | + 1.003 GINI | + 0.350 FP | | | | $R^2 = 0.911$ |
| | | (21.15)* | (-23.89)* | (15.15)* | (1.78)* | | | | |

[a] TFP = total factor productivity; RDE = government spending on agricultural research and extension; IR = % of irrigated cropped area in total cropped area; LITE = literacy rate of the rural population; ROADS = road density; PVELE = % of villages with electricity; GCSHEL = capital stocks of government investments in health; GERDEV = rural development; GCSSL = soil and water conservation; RAIN = annual rainfall. The coefficient for RDE is the sum of the coefficients for the past 13 years; the t-value of the coefficient is the joint t-value of the coefficients for the past 13 years.

[b] FP = food prices; GDP = per capita GDP; POP = population size; WPI = international market prices.

[c] UP = urban poverty; FP = food price increases relative to non-food prices; GINI = inequality in urban incomes; M = per capita income of urban residents.

Note: Numbers in parentheses are t-values; * = statistical significance at the 5 % level.

Source: The estimate of equation (1) is from FAN, HAZEL and THORAT (2000).

The estimated elasticity of urban poverty to agricultural research is -0.021. That is, for every 1 % increase in agricultural research investment, urban poverty decreases by 0.021 %.

Using this elasticity and the values of the relevant variables for specific periods of time, we can calculate the number of poor urban people raised above the poverty line with every one million Rs increase in the stock of agricultural research investment. Similarly, we can calculate the total number of urban poor lifted out of poverty each year as a result of actual investments in agricultural research. The results are shown in table 5.

**Table 5. Impact of agricultural research on urban poverty in India, 1970-1995**

| | Number of poor reduced per million Rs[a] | Total number of poor reduced (million) |
|---|---|---|
| 1970 | 196.26 | 1.21 |
| 1971 | 215.87 | 1.32 |
| 1973 | 229.58 | 1.30 |
| 1974 | 166.07 | 1.35 |
| 1978 | 102.47 | 1.46 |
| 1983 | 103.03 | 1.57 |
| 1987 | 85.10 | 1.66 |
| 1988 | 73.73 | 1.56 |
| 1989 | 74.52 | 1.57 |
| 1990 | 69.99 | 1.61 |
| 1991 | 69.49 | 1.55 |
| 1992 | 79.86 | 1.75 |
| 1993 | 64.61 | 1.52 |
| 1994 | 68.66 | 1.61 |
| 1995 | 72.11 | 1.70 |

[a] Rupee values are expressed as 1995 prices.

In 1970, each additional one million Rs increase in the stock of agricultural research investment lifted 196 urban people out of poverty. This figure had declined to 72 people by 1995. Given actual levels of investment in agricultural research, 1.21 million urban people were lifted out of poverty in 1970 and 1.70 million in 1995. This suggests that although marginal impact of agricultural research on urban poverty reduction is declining, the total number of rural poor lifted out of poverty by agricultural research has actually increased over time.

Our results shown here for the urban poor are comparable with similar calculations made by FAN, HAZELL and THORAT (2000) of the impact of agricultural research investments on the rural poor (table 6). For example, their study shows that for every one million Rs increase in the stock of agricultural research investment in 1995, 84.5 rural people were raised out of poverty, compared with 72.1 urban people, according to our calculations. The large impact on rural poverty arises not only from the direct effect of increased agricultural productivity on the rural poor, but also from indirect non-farm employment effects.

**Table 6. Number of urban and rural poor reduced per million rupees invested in agricultural research, India, 1995**

| | Urban poor | Rural poor | Total poor |
|---|---|---|---|
| Agricultural R&D | 72.11 | 84.5 | 156.61 |
| Irrigation | 7.31 | 9.7 | 17.01 |
| Rural roads | 28.39 | 123.8 | 152.19 |
| Rural education | 7.43 | 41.0 | 48.43 |
| Rural electricity | 1.44 | 3.8 | 5.24 |
| Soil and water conservation | 5.15 | 22.6 | 27.75 |
| Rural development | 5.87 | 25.5 | 31.37 |
| Rural health | 4.55 | 17.8 | 22.35 |

Note: The relationships between government investments and physical stocks for different types of government spending were taken from FAN, HAZELL and THORAT (2000). These relationships were used to calculate the marginal returns for poverty reduction.

Source: Rural poor data were taken from FAN, HAZELL and THORAT (2000); urban poor data were calculated by the author.

Among all types of investments in rural areas, agricultural research has the largest impact on urban poverty; almost three times higher than road investments, which have the second largest impact. The total poverty effect (combining both rural and urban poor) of agricultural research investment is also the largest. For every additional one million Rs spent on agricultural research, 157 poor people are lifted above the poverty line. Road investments have a slightly lower impact; each additional one million Rs spent on roads raises 152 poor people above the poverty line.

## 7. Conclusions

The impact of agricultural research investments on urban poverty in India was estimated using time series and state data and an econometric modeling approach. The model explicitly tracks the causal links between agricultural research investments and subsequent production increases in agriculture and captures how production increases impact on food prices and the incidence of urban poverty. The results show that agricultural research has played an important role in reducing urban poverty in India. Without investments in agricultural research, urban poverty in India would be much higher today. With every one million Rs increase in the stock of agricultural research investment, about the same number of urban people as rural people are raised above the poverty line.

Since 1990, however, agricultural research investment in India has stagnated. In 1997, government investment in agricultural research expressed as a percentage of agricultural GDP was only about 0.4 %, compared with 2-3 % in many developed countries and 0.5 % averaged across all developing countries. One result of this stagnation in investment is that both rural and urban poverty declined at a slower rate in the 1990s than in the 1970s and 1980s.

Today, the urban poor account for one quarter of India's total poor. This figure is projected to rise by 2030, when more than one half of the Indian population will reside in urban areas (RAVALLION, 2001). In recent decades, India has been very successful at feeding its large and growing population, and at reducing both rural and urban poverty through government investments in agricultural research, rural infrastructure, and education. However, it cannot afford to be complacent. Continued government support for these investments is still needed, otherwise food insecurity, malnutrition, poverty and social conflict will shadow India for a long time to come.

## References

AKINO, M. and Y. HAYAMI (1975): Efficiency and Equity in Public Research: Rice Breeding in Japan's Economic Development. In: American Journal of Agricultural Economics 57 (1): 1-10.

ALSTON, J., C. CHAN-KANG, M. MARRA, P. PARDEY and T. WYATT (2000): A Meta-Analysis of Rates of Return to Agricultural R&D, *Ex Pede Herculem*? Research Report 113. IFPRI, Washington, DC, USA.

ALSTON, J., B. CRAIG and P. PARDEY (1998): Dynamics in the Creation and Depreciation of Knowledge, and the Returns to Research. Environment and Production Technology Division Discussion Paper No. 35. IFPRI, Washington, DC, USA.

DATT, G. (1998): Poverty in India and Indian States: An Update. FCND Discussion Paper 47. IFPRI, Washington, DC, USA.

DAVIDSON, R. and J. MACKINNON (1993): Estimation and Inference in Econometrics. Oxford University Press, New York, USA, and London, UK.

EVENSON, R.E. and P.M. FLORES (1978): Social Returns to Rice Research. In: Economic Consequences of the New Rice Technology. IRRI, Los Banos, Philippines.

EVENSON, R., C. PRAY and M. ROSEGRANT (1998): Agricultural Research and Productivity Growth in India. Research Report 109. IFPRI, Washington, DC, USA.

FAN, S., C. FANG and X. ZHANG (2001): How Agricultural Research Affects Urban Poverty in Developing Countries: The Case of China. EPTD Discussion Paper No. 83. IFPRI, Washington, DC, USA.

FAN, S., P. HAZELL and S. THORAT (2000): Government Spending, Agricultural Growth and Poverty in Rural India. In: American Journal of Agricultural Economics 82 (4): 1038-1051.

FAO (Food and Agriculture Organization of the United Nations) (2002): FAOStat Database. Rome, Italy.

GREENE, W.H. (1993): Econometric Analysis. Prentice-Hall Inc, Englewood Cliffs, USA

HADDAD, L., M.T. RUEL and J.L. GARRET (1999): Are Urban Poverty and Undernutrition Growing? Some Newly Assembled Evidence. Food Consumption and Nutrition Division Discussion Paper No. 63. IFPRI, Washington, DC, USA.

HAZELL, P. and L. HADDAD (2001): Agricultural Research and Poverty Reduction. IFPRI 2020 Discussion Paper. IFPRI, Washington, DC, USA.

INDIAN STATISTICAL ABSTRACT (various years). Government of India, New Delhi, India.

MELLOR, J.W. (1975): The Impact of New Agricultural Technology on Employment and Income Distribution - Concepts and Policy. Occasional Paper No. 2. USAID, Washington, DC, USA.

PINSTRUP-ANDERSEN, P. (1979): Modern Agricultural Technology and Income Distribution: The Market Price Effect. In: European Review of Agricultural Economics 6 (1): 17-46.

PINSTRUP-ANDERSON, P. and P. HAZELL (1985): The Impact of Green Revolution and Prospects for the Future. In: Food Review International 1 (1): 1-25.

RAVILLION, M. (2000): On the Urbanization of Poverty. World Bank Discussion Paper. World Bank, Washington, DC, USA.

ROSEGRANT, M.W. and P.B.R. HAZELL (2000): Transforming the Rural Asian Economy: The Unfinished Revolution. Oxford University Press, Hong Kong.

SCOBIE, G. and R. POSADA (1978): The Impact of Technological Change on Income Distribution: The Case of Rice in Colombia. In: American Journal of Agricultural Economics 60 (1): 85-92.

WORLD BANK (1997): Achievements and Challenges in Reducing Poverty. Report No. 16483-IN. Washington, DC, USA.

– (2002): World Development Indicators. Washington, DC, USA.

**Shenggen Fan**
International Food Policy Research Institute (IFPRI), 2033 K Street, NW, Washington, DC 20006, USA
phone: +(1)-202-862 56 77 fax: +(1)-202-467 44 39 email: s.fan@cgiar.org