1994

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The Journal of Developing Areas 28 (July 1994) 469–486

The Impact of Infrastructure on Pakistan's Agricultural Sector

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Agriculture is the largest of the sectors contributing to economic activity in Pakistan; it provides over 25 percent of the country's Gross Domestic Product (GDP), employs over 50 percent of the labor force, and sustains 75 percent of the population. The sector directly accounts for over 25 percent of total exports, with cotton textiles and other agro-based manufactured exports accounting for an additional 35 to 40 percent of total exports. In FY 1989/90 the sector accounted for over 15.3 percent of the public sector development plan (including the fertilizer subsidy), 18.5 percent of private fixed investment, and 11 percent of total fixed investment.[1]

Because of its importance, Pakistan's agricultural sector has been examined at length.[2] While not denying the significance of factors such as pricing policies, subsidized inputs, the Green Revolution, farm size distribution and yields, land reform efforts, and the impact of research and extension on crop yields, the purpose of this paper is to examine a relatively neglected area likely to be critical to the sector's long-run viability—infrastructural development.[3] In particular, it seeks to determine what role infrastructure has played in the sector's growth. Has infrastructure initiated growth, or passively responded in order to alleviate bottlenecks created by growth? Have deficiencies in infrastructure been a major constraint on the sector's expansion? If so, what areas of infrastructure appear most productive for expanding future agricultural output?

Trends in Agricultural Output

Pakistan's agricultural sector has alternated periods of vigorous output growth with years of stagnation or productivity decline. In the 1950s low output growth

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was due to the disruptive effects of partition from India, water shortages resulting from a water dispute with India, and bad weather (drought in 1950/51 and 1951/52, and floods in 1954/55 and 1955/56).[4] The Green Revolution spurred recovery in the early 1960s. Growth became more intense in the late 1960s, and agricultural output grew at an average annual rate of 5.6 percent for a decade.

In the early 1970s agricultural growth slowed owing to unfavorable weather (floods in 1972/73 and 1973/74, and drought in 1974/75),[5] and because the Green Revolution's gains (new varieties of wheat, grown with controlled water, fertilizers, and pesticides) leveled off. The resumption of rapid growth in agriculture coincided with the launching of Pakistan's Fifth Five Year Plan (FY 1979/83) in FY 1978/79. Average annual growth in agricultural value added was greater than 4 percent during the plan period, nearly twice the 2.3 percent per annum rate of the preceding five years.

The Sixth Plan (FY 1984/88) focused on attaining greater self-sufficiency in agriculture. The major components of this strategy were diversification of crops, strengthening the institutional framework, structural adjustments in the pattern of production and distribution, adoption of better agronomic practices, modernization of agriculture, and increasing productivity (especially of small farmers) in order to create exportable surpluses.[6]

The average annual growth rate of the agricultural sector during the Sixth Plan period was 3.8 percent as against a target of 4.9 percent. Cotton production increased substantially owing to the use of high-yielding varieties of seed, higher fertilizer application rates, and improved plant protection measures. The production of sugarcane, rice, and wheat, however, were below the targets set in the plan.

The decline in sugarcane production may be attributed *inter alia* to the failure of research institutes to develop high-yielding varieties for general cultivation at attractive support prices for sugarcane from 1981 to 1986, and the lack of cooperation between sugar mills and cane producers. In the case of rice, a shortage of water at the transplanting stage, low rainfall, pest attacks, the lack of a high-yielding variety of rice, and monopoly procurement of rice at low prices resulted in decreased production. Finally, wheat production was affected by adverse weather in 1986/87 and 1987/88. The overall performance of the livestock subsector was close to 6 percent per year as envisaged in the plan.[7]

Over the past decade, the agriculture sector has undergone major technological and policy transformations. By introducing technical changes offering production incentives, and increasing the availability of fertilizer, water, and credit, Pakistan has increased its exportable surplus of cotton and is close to self-sufficiency in wheat. For the 1980–88 period the corresponding figure was 4.3 percent, up from 3.3 over the 1965–80 period (table 1). Since then overall growth has been maintained at similar levels (table 2). As in most semiarid developing countries, however, considerable variations exist in annual and seasonal production owing to adverse weather, pest incidence, and uncertain irrigation supply.[8]

Pakistan's agriculture is also characterized by regional disparities: Sindh and Punjab are the granary of Pakistan, whereas North West Frontier Province (NWFP) and Balochistan are the food-deficit regions. Average wheat yields in

Balochistan and NWFP are about 25 percent lower than in Sindh and Punjab. Low fertilizer applications, traditional farming practices, limited extension services, mountainous terrain, and a smaller share of irrigated land explain the slower pace of agricultural development in these two provinces.[9]

TABLE 1
GROWTH OF AGRICULTURAL PRODUCTION
(Average Annual Percentage Increase in Value Added)

Country	1965–80	1980–88
Low-income countries	2.6	4.4
South Asia		
Pakistan	3.3	4.3
India	2.5	2.3
Bangladesh	1.5	2.1
Sri Lanka	2.7	2.7
Nepal	1.1	4.4
East Asia		
China	2.8	6.8
Indonesia	4.3	3.1
Thailand	4.6	3.7
Malaysia	—	3.7
Middle East		
Egypt	2.7	2.6
Syria	4.8	0.5
Jordan	—	6.0
Turkey	3.2	3.6

SOURCE: World Bank, *World Development Report 1990* (New York: Oxford University Press, 1990), pp. 180–81.

TABLE 2
PAKISTAN: GROWTH OF AGRICULTURAL PRODUCTION
(Average Annual Percentage Change in Value Added)

Crop	1988/89	1989/90	1983/90	1989/90 % Share of Value Added
Wheat	13.8	–0.9	3.0	31.0
Rice	– 1.3	0.8	– 0.7	13.0
Cotton	– 5.9	3.0	12.6	31.0[a]
Sugarcane	12.0	–2.1	1.5	14.0
Oilseed	– 3.2	2.0	10.6[a]	—
Value added in agriculture	6.9	2.7	4.0	100.0

SOURCE: Government of Pakistan, *Economic Survey 1989/90* (Islamabad: Finance Division, Economic Adviser's Wing, 1990).
[a]The major oil seed is cotton, which is reflected in value added of unginned cotton. Rape and mustard seed constitute another 1 percent of value added.

Sources of Agricultural Growth

The early phase of agricultural growth in Pakistan was characterized as one of expanding the land under cultivation, that is, expanding the *extensive margin.* From 1950 to 1970, the total cultivated area expanded 26 percent while the cropped area increased by 30 percent.[10] Large-scale water projects and tubewell irrigation brought more land into production and made the Green Revolution possible in the 1960s. Area expansion accounted for the entire increase in sugarcane output in the 1950s and for 30 to 50 percent of all major crops' output during the 1960s, when the Green Revolution began to dramatically increase yields.

The limits of the extensive margin were reached by the early 1970s since the best arable lands in Pakistan had already been brought into cultivation. Although the irrigated area continues to increase, further additions to tillable land would have to come from decreasing the "cultivable waste" (areas around waterworks and areas on each river bank usually uncultivated as a precaution against flood damage), and the land "not available for cultivation" (arid zones, brush land, and hilly terrain). Neither offers much scope for area expansion; hence future increases in agricultural output will have to come from the *intensive margin*—increasing yields and/or labor productivity.

Constraints to Agricultural Output

Given the difficulties of increasing the cultivated area, the extent to which raising yields and labor productivity can contribute to future output growth will be critical determinants of the country's food situation. The potential for productivity increases is limited by several major constraints—inadequate input management and institutional support, labor-supply bottlenecks, environmental degradation, and the supply of water. Of these, the supply of water is probably the most severe.

Water is a binding constraint to land extension for agriculture. The limited expansion in area cultivated despite continued increases in water availability is an indication that additions to irrigation water at the extensive margin have come increasingly at greater cost.

The greatest scope for further important increments in irrigation water supply is likely to lie at the intensive margin of agriculture and will come through better operating policies for the irrigation system, an increasing water conveyance efficiency, and better on-farm management. Currently conveyance losses from river to distributary canal amounts to an estimated 25 percent, and from the distributary canal outlet to farmers' field to another 40 percent.[11] Studies modeling the Indus Basin have demonstrated that better operating policies for the irrigation system can bring about major improvements in operating efficiencies, and hence reduce crop losses.[12]

In addition to the problem of water availability, deficient use and management of inputs is an important constraint to agricultural growth. Pakistani agriculture still ranks low in input use relative to other developing countries despite progress over the last several decades. Greater use of inputs may increase yields if they are

managed properly. Although fertilizer use grew rapidly from 1970 to 1980 (14 percent per annum and close to 9 percent since 1980), crop yields did not. Limited water availability and inappropriate nutrient balance are often cited as reasons for this lack of yield response.[13]

Considerable effort has been made to incorporate the various supply constraints just noted into a comprehensive forecast of future food supplies (and demand balance). Of these, the most comprehensive is the Revised Indus Basin Model (RIBM).[14] According to RIBM demand and output projections made in May 1987, some minor shortfalls could emerge by 1992/93, but with adequate rainfall exportable surpluses of traditional export crops—cotton and rice—would remain large. Wheat production would fall only 3 percent short of demand, but sugarcane, maize, pulses, and meat would fall more than 50 percent short. The modest wheat shortfall is largely the result of low water availability during the Rabi (winter) season, but other constraints would contribute. In particular, family labor has been identified as a constraint in 6 out of the 9 agro-climatic zones covered by the RIBM. Unfortunately, drought in the last several years has severely reduced actual output.

The RIBM projections indicate that with appropriate investments in agriculture and water, and moderate increases in yields, large surpluses of cotton and rice would continue to be available for export. The value of rice exports would rise as an increasing proportion of these exports would consist of Basmati rice. Again, poor weather in 1993 resulted in lower than anticipated levels of production.

Despite these rather optimistic forecasts the fact remains that the prospects for sustaining this level of growth are becoming increasingly limited unless several recurring problems are successfully addressed. These include poor crop yields and productivity, inadequately funded and poorly managed support services and institutions, serious water resource management issues, long-standing land tenure problems, and inappropriate sector pricing policies.

Problems in the agricultural sector also prompted the country's National Commission on Agriculture to recommend, among other things,[15] that

1. the agricultural sector be modernized with special emphasis on raising output of sugar, pulses, and edible oil;
2. productivity increase be effected through vertical expansion in view of limited supplies of fertile land and water for irrigation;
3. rapid growth of animal husbandry and noncereal food cultivation be ensured for augmenting the availability of high food value products;
4. the existing rural infrastructure be strengthened such that employment potential and living conditions in the sector improve; and
5. an integrated program be evolved to arrest environmental degradation to conserve and improve the country's natural resources.

Infrastructure and Agricultural Output

A major implication of RIBM exercises and the analysis of the National Agricultural Commission is that agricultural output is likely to be increasingly

constrained. That is, at the extensive margin, increments to land and water for cultivation are becoming more expensive. Unfortunately the trend in investment in the sector has been downward (table 3). Agriculture accounted for about 25 percent of total private investment in the late 1970s (table 4). By the late 1980s, however, this figure had fallen rather sharply to around 18 percent. In part this shift in capital reflects an increasing tendency for the private sector to return to longer-term commitments to manufacturing under the Zia regime.

TABLE 3
PAKISTAN: AVERAGE ANNUAL GROWTH IN INVESTMENT, 1972–1990

	PRIVATE INVESTMENT					
		Manufacturing		Transportation/		
YEARS	Agriculture	Large	Small	Communication	Services	Total
1972/90	6.1	8.7	6.9	3.8	5.0	6.0
1972/80	6.7	− 3.0	4.0	2.9	5.1	3.1
1980/90	5.7	19.0	9.3	4.5	5.0	8.3
1985/90	5.9	18.2	11.8	8.6	9.5	10.4
	PUBLIC INVESTMENT					
				Large-scale		
YEARS	Rural Works	Indus Basin	Energy	Manufacturing	Railway	Total
1972/90	12.5	−18.5	14.3	10.7	− 2.7	8.4
1972/80	6.1	−15.1	9.5	49.3	7.5	14.4
1980/90	17.9	−21.1	18.3	−12.9	−10.1	3.7
1985/90	− 2.7	−16.0	18.2	− 8.7	−19.8	5.8

SOURCE: Compiled from data in World Bank, "Pakistan: Current Economic Situation and Prospects—Report No. 9283-PAK" (World Bank, Washington, DC, 22 March 1991); World Bank, *Pakistan: Review of the Sixth Five Year Plan* (Washington, DC: World Bank, 1983).

The public sector's investment in agriculture has varied considerably over the years (table 5). In the early 1970s rural works and the Indus Basin accounted for 20 to 30 percent of the public sector's investment. Nationalization of industries and a shift in development priorities toward large-scale industries under the Bhutto regime caused a dramatic decline in capital formation in Indus Basin projects.

The 1980s have seen a slight increase in public investment in rural works, following a decline in the mid-1970s. These programs along with the Indus Basin program have not fared well compared to allocations for energy.

Indus Basin investment is particularly critical because irrigated land produces 90 percent of total farm output. The Indus Basin irrigation system, which covers two-thirds of the country's cropped area, is the largest contiguous irrigation system in the world, including 22 dams and barrages, 57,000 km of canals, and about 107,000 watercourses.

As early as 1983, the decline in Indus Basin investment led the World Bank to note:

> While substantial past investments in irrigation infrastructure have given Pakistan the physical capacity to harness its surface water supplies to expand irrigated areas, there is substantial scope for improving the management of the irrigation system to better meet crop water requirements. The

TABLE 4
PAKISTAN: COMPOSITION OF PRIVATE INVESTMENT, 1972–1990
(Percentage of Total Private Investment)

YEAR	AGRICULTURE	MANUFACTURING		TRANSPORTATION/ COMMUNICATION	SERVICES	OTHER
		Large	Small			
1972	18.1	20.7	4.3	11.8	8.5	36.5
1973	19.4	14.9	4.7	17.9	8.8	34.2
1974	22.8	13.3	5.9	18.0	10.0	30.0
1975	19.3	13.7	5.9	13.4	9.5	38.1
1976	24.7	14.6	5.4	11.4	9.2	34.6
1977	24.6	14.3	5.2	10.4	11.4	34.2
1978	26.5	12.7	5.0	9.7	10.2	35.9
1979	25.7	11.9	5.2	10.0	10.4	36.7
1980	23.7	12.8	4.5	11.7	10.0	37.3
1981	21.6	16.1	4.9	8.6	9.4	39.4
1982	21.0	18.4	5.7	7.6	9.4	38.6
1983	22.3	20.5	5.0	7.2	8.5	36.5
1984	23.4	22.5	4.8	7.6	8.0	33.7
1985	22.8	23.3	4.6	8.8	7.6	32.9
1986	20.4	25.8	4.9	9.2	7.8	32.0
1987	20.4	25.8	4.8	9.9	7.8	31.4
1988	19.5	26.9	5.0	10.0	8.0	30.5
1989	18.3	31.2	5.0	9.9	7.6	27.9
1990	18.5	32.7	5.0	8.1	7.3	28.4
	Average Annual Growth of Share					
1972/90	0.1	2.6	0.8	–2.1	–0.8	–1.4
1972/80	3.4	–5.8	0.6	–0.1	2.1	0.3
1980/90	–2.4	9.8	1.1	–3.6	–3.1	–2.7
1985/90	–4.1	7.0	1.7	–1.6	–0.8	–2.9

SOURCE: Compiled from data in World Bank, "Pakistan: Current Economic Situation and Prospects"; World Bank, *Pakistan: Review of the Sixth Five Year Plan.*

reliability and efficiency of the overall system is still low. Owing to the deterioration of canals and water course commands, more than one half of the gross inflow of the water system is being lost, primarily through seepage, percolation and on-farm losses. About 15–40% of the country's canal command area is severely waterlogged during various periods of the year, having a depth-to-watertable of less than 5 feet—a depth at which crop yields begin to decline markedly.[16]

The revised agricultural sector strategy that the government announced at the beginning of the 1980s emphasized the need to promote irrigation rehabilitation rather than new investments, bring input and output prices closer to world market levels, reduce public expenditure, and enhance the role of the private sector. These objectives were to be achieved by (1) reorienting public investment priorities to focus on rehabilitating irrigation infrastructure, upgrading on-farm water management, and enhancing agricultural resources and extension capacity; (2) aligning input and output prices with resource costs, with reference to international prices, and gradually removing subsidies; and (3) providing incentives to the private sector to actively participate in input and output marketing and distribution, the processing of grain and the exploitation of fresh groundwater.

These revised sector objectives were confirmed in the Ministry of Food and Agriculture's Policy Framework Paper (PFP) issued in 1988. The PFP stressed

TABLE 5
PAKISTAN: COMPOSITION OF PUBLIC INVESTMENT, 1970–1990
(Percentage of Total Public Investment)

Year	Rural Works	Indus Basin	Energy	Railway	Large-scale Manufacturing
1970	3.1	31.0	4.7	6.6	5.4
1971	1.1	28.0	16.4	6.6	1.9
1972	1.2	30.0	12.6	3.5	3.0
1973	2.1	18.3	9.8	2.7	2.8
1974	1.3	10.8	10.4	1.7	5.5
1975	1.3	9.5	21.8	5.4	9.6
1976	1.0	9.1	19.6	3.9	19.4
1977	0.5	3.1	13.5	4.2	24.1
1978	0.3	4.2	13.7	3.7	30.3
1979	0.6	1.9	13.8	3.5	30.4
1980	0.6	2.7	8.8	3.4	24.9
1981	2.0	3.4	13.0	4.2	18.5
1982	2.6	2.8	12.5	4.5	15.0
1983	3.8	2.8	17.7	3.9	14.6
1984	3.6	1.5	16.2	2.6	15.0
1985	3.4	0.6	18.9	3.2	9.1
1986	3.7	0.6	17.6	3.7	9.6
1987	3.3	0.6	21.9	3.1	5.7
1988	3.7	0.4	22.2	2.3	5.1
1989	2.6	0.2	32.5	0.3	3.7
1990	2.2	0.2	32.8	0.8	4.3
			Average Annual Growth of Share		
1972/90	3.4	–24.3	5.4	– 7.9	2.0
1972/80	– 8.3	–26.0	– 4.4	– 0.4	30.3
1980/90	13.9	–22.9	14.1	–13.5	–16.1
1985/90	– 8.3	–19.7	11.7	–24.2	–13.9

SOURCE: Compiled from data in World Bank, "Pakistan: Current Economic Situation and Prospects"; World Bank, *Pakistan: Review of the Sixth Five Year Plan.*

the importance of enhancing productivity through adequate funding of investment and appropriate price incentives to farmers. Priority was to be given to accelerating privatization of tubewells in fresh groundwater areas, adjusting support prices, promoting private sector participation in rice and cotton exports, removing the fertilizer subsidy as well as all distribution controls, and ensuring full recovery of operations and maintenance costs for irrigation and draining systems.[17]

Good progress has been achieved in carrying out a number of key elements in the government's program, especially in terms of reducing input subsidies, aligning output prices toward international trend prices, and opening up the sector to private sector participation. Much less progress has been made in improving the efficiency and management of the irrigation and draining subsector, and in enhancing the effectiveness of research and extension.[18] These developments led the World Bank in 1991 to note:

> Pakistan continues to confront serious water sector issues, both in terms of extremely slow progress in carrying out urgently needed maintenance and rehabilitation of irrigation infrastructure, as well as in terms of ensuring a fair and efficient distribution of water resources on the basis of actual crop

water requirements, rather than historical water rights. To address these issues will require much stronger efforts to collect adequate water charges to fully cover operations and maintenance, as well as actions to accelerate implementation of on-going investments in the irrigation subsector. There is also urgent need to address underlying institutional issues which make it difficult to effectively coordinate agricultural support services with planning and management of the irrigation/drainage subsector.[19]

Impact of Infrastructure

The patterns just noted suggest that a situation of deteriorating rural infrastructure currently exists in Pakistan. They do not, however, tell us much about the relative effectiveness of different types of infrastructure in stimulating output in the agricultural sector or private investment directed toward increased food production. More important, they provide no insights as to the direction of causation—has infrastructural development through lowering costs of production stimulated output and/or investment in the rural sector? or instead, has infrastructure been a chronic bottleneck to output? That is, has the government responded with increased provision of infrastructure only after infrastructure deficiencies have severely constrained output and the flow of private capital into the sector?

A major issue in the analysis of the role of infrastructure in Pakistan's post-1971 agricultural development therefore centers around the direction of causation: has infrastructure initiated growth in agricultural output or has it simply responded to the needs created by that output?

Among economists there is a broad spectrum of viewpoints, some of them diametrically opposed to one another, concerning the role of infrastructure in the development process.[20] There is consensus, however, as to the need for a certain level of basic infrastructure facilities in potential agricultural areas, since ultimately infrastructure must be a limiting factor without which no development process could take place even if other development-inducing factors were present. However, opinions as to infrastructure's precise role in the growth process beyond this point differ greatly.

Some economists such as Donald R. Glover and Julian L. Simon[21] and Peter C. Frederiksen[22] take the view that the role of infrastructure is simply to relieve "tensions" generated by supply and demand patterns as well as bottleneck pressures. Another (smaller) group of economists led by Fritz Voigh[23] maintains that increases in infrastructure exert a follow-on influence on investment and growth.

The majority of economists seems to take a middle position between these two more-or-less diametrically opposed views.[24] Some of them consider infrastructure to be a function of the level of development; in other words, the more economically and socially backward a potential development area, the stronger the impulses emanating from improvements in the stock of infrastructure. Others feel that the reciprocal relationship between changes in infrastructure and socioeconomic developments is such that the problem of cause and effect is not open to solution.

Most economists agree, however, that if infrastructure investments, labor market planning, and educational planning are uncoordinated, they are likely to yield conflicting results or, at any rate, outcomes that could eventually lead to undesirable solutions. Much of the confusion as to the role of infrastructure in

industrial development occurs because infrastructure itself is not homogeneous. In addition, it is quite likely that the contribution to output from infrastructure investment will be dependent on the stock of supporting factors—the composition and level of which are likely to vary somewhat over time.

Complicating the issue is the fact that for many years economists were reluctant to discuss the issue of causality from a statistical perspective. In recent years, however, several statistical tests are gaining wider acceptance in addressing issues of this type. The original and most widely used causality test was developed by C. W. J. Granger.[25] Applied to the situation at hand, infrastructure causes (in the Granger sense) growth in agriculture, if agricultural growth can be predicted more accurately by past values of infrastructure investment than by past values of its own growth. To be certain that causality runs from infrastructure to agricultural growth, past values of infrastructure investment must also be more accurate than past values of growth at predicting infrastructure expenditures.

More formally, four cases are possible: *(a)* infrastructure causes growth when the prediction error for growth decreases when infrastructure investment is included in the growth (agriculture) equation; in addition, when growth is added to the infrastructure equation, the final prediction error should increase; *(b)* growth causes infrastructure when the prediction error for growth increases when infrastructure is added to the regression equation for growth, and is reduced when growth is added to the regression equation for infrastructure; *(c)* feedback occurs when the final prediction error decreases when infrastructure is added to the growth equation, and the final prediction error decreases when growth is added to the infrastructure equation; and *(d)* no relationship exists when the final prediction error increases both when infrastructure is added to the growth equation and when growth is added to the infrastructure equation.

These patterns also imply something about the extent to which inadequate stocks of infrastructure may constrain agricultural output and/or inhibit private sector investment. Extending the original ideas of A. O. Hirschman, infrastructure development can initiate growth through subsidizing agriculture by lowering the costs for certain inputs used in production.[26] This is the process referred to by Hirschman as development via excess capacity (of social overhead capital). Conversely, lagging infrastructure may increase costs of producing and result in slowing output and investment. In this situation the authorities are under pressure to expand infrastructure to "catch up" with the stock of directly productive capital. This route is often referred to by development economists such as Benjamin Higgins as development via shortage (of social overhead capital).[27] As Higgins notes:

> Either method of unbalanced growth yields an "extra dividend" of "induced, easy-to-take or compelled decisions resulting in additional investment and output." Balanced growth (of social overhead capital and directly productive activity) is not only unattainable in most underdeveloped countries, it may not even be desirable. The rate of growth is likely to be faster with chronic imbalance, precisely because of the "incentives and pressures" it sets up.[28]

From the preceding it follows that at least four possible situations characterize the relationship between infrastructure investment and agricultural output in Pakistan:

1. *Infrastructure Causes Growth.* This pattern is likely to reflect a situation where infrastructure is in excess (or nonconstraining)—the lower costs stemming from its provision result in follow-on investment and agricultural output. In this situation, infrastructure could be expected to have a high degree of linkage with productive factors and thus produce a strong output/investment response.
2. *Growth Causes Infrastructure.* Here infrastructure is lagging and responds to the needs created by previous agricultural growth. In this situation, infrastructure is likely to be a constraint on that output. This may have occurred in Pakistan, particularly during periods (such as the 1980s) when agricultural output increased rapidly. Although infrastructure expanded during this period, it may still (given the needs) have been insufficient to produce a substantial stimulus to output.
3. *A Feedback Relationship Exists between Growth and Infrastructure.* Growth and infrastructure become interdependent, perhaps reflecting a situation where infrastructure is likely to be a binding constraint on growth. Once increased, infrastructure is adequate (relative to needs) to provide a positive stimulus to investment and/or further output.
4. *No Relationship Exists between Growth and Infrastructure.* Infrastructure is not a constraint on agricultural growth, nor does it possess or create the type of linkages needed to induce increases in output or investment in the sector.

Points 2 and 3 imply that some threshold level of infrastructure may be necessary before positive economic results can be obtained from expanding this type of capital.

Operational Procedures

The Pakistani government does not publish data on the stock of and increments to the country's infrastructure. By following the procedure of Mario I. Blejer and Mohsin S. Khan, however, it is possible to approximate increments to the nation's infrastructural base.[29] The basic assumption underlying these proxies is that infrastructure investment is an ongoing process that moves slowly over time and cannot be changed very rapidly.

The first of the two approaches takes the trend level of real public sector investment as representing the long-term or infrastructural component. In the discussion that follows, this measure is referred to as "estimated infrastructure." In computing this measure of infrastructure we have used a linear trend. Deviations of real public sector investment from the trend are assumed to correspond to noninfrastructural investment.

A second approach is to make the distinction between types of public investment on the basis of whether the investment is expected or not. Again, it is assumed that expected, or anticipated, public investment is closer to the long-term or infrastructural component. If deterioration is occurring in the country's stock of infrastructure, this measure may be a more accurate proxy than that obtained by using the trend method. It was the one used in the computations that follow.

All variables were deflated by the GDP deflator and are in constant 1985 prices.[30] For best statistical results, the variables were transformed into their logarithmic values.[31]

A major conceptual problem in a study of this type is that public infrastructure is usually not specifically directed toward one particular sector. Energy, for example, might be used by a number of sectors, some of which, perhaps, were not even considered in the original feasibility studies. Because of this a number of different measures of infrastructure (and investment) were used. As purely a basis of comparison, several measures of private investment (total private and private in agriculture) were also included in the study.

Relationships between infrastructure expenditures and the economy were considered valid if they were statistically significant at the 95 percent level of confidence. That is, if 95 percent of the time we could conclude that they had not occurred by pure chance, we considered them statistically significant.[32]

There is no theoretical reason to believe that infrastructure and the economy have a set lag relationship—that is, they impact on one another over a fixed time period. The period could be rather short run, involving largely the spin-off from construction, or longer term, as either term expands from the stimulus provided by the other. To find the optimal adjustment period of impact, lag structures of up to six years were estimated. The lag structure with the highest level of statistical significance was the one chosen as best depicting the relationship under consideration (the optimal lag reported in tables 6 and 7).

Results

The tests for causality between infrastructure (and investment) and agricultural output produced several interesting patterns (table 6):

1. The public sector rural works infrastructure has largely been one of response to growth in agricultural output. That is, expended rural works programs have not stimulated growth in agricultural production. The same also appears to be the case with regard to local government investment and infrastructure.
2. Interestingly enough, Indus Basin investment (and infrastructure) were not statistically significant in affecting agricultural production.
3. The strongest linkages between public infrastructure and the agricultural sector originated from total government investment. A moderate stimulus was obtained from expanded government investments in semipublic activities. These included energy (together with Indus Basin and rural works). Apparently, therefore, Indus Basin and rural works have the

TABLE 6
PAKISTAN: INTERACTION OF PUBLIC INVESTMENT, INFRASTRUCTURE, AND AGRICULTURAL OUTPUT, 1972–1990

	CAUSATION PATTERNS				
	A	B	C	D	DOMINANT PATTERN
Total public investment	1 (0.27E-2)	2 (0.19E-2)	2 (0.82E-2)	4 (0.53E-2)	Feedback (+m,+w)
Total public infrastructure	1 (0.27E-2)	4 (0.11E-2)	2 (0.67E-2)	1 (0.44E-2)	Feedback (+s,+w)
Total private investment	1 (0.27E-2)	1 (0.19E-2)	3 (0.26E-2)	1 (0.29E-2)	Investment—>Output (+m)
Rural works investment	1 (0.27E-2)	1 (0.28E-2)	4 (0.64E-0)	4 (0.15E-0)	Output—>Investment (+w)
Rural works infrastructure	1 (0.27E-2)	1 (0.28E-2)	4 (0.29E-1)	1 (0.22E-1)	Output—>Infrastructure (+w)
Private investment agriculture	1 (0.27E-2)	1 (0.22E-2)	4 (0.84E-2)	4 (0.44E-2)	Feedback (+w,+w)
Semipublic investment	1 (0.27E-2)	2 (0.20E-2)	2 (0.17E-1)	4 (0.14E-1)	Feedback (+m,+w)
Semipublic infrastructure	1 (0.27E-2)	2 (0.22E-2)	1 (0.15E-1)	4 (0.14E-1)	Feedback (+w,+w)
General govt. investment	1 (0.27E-2)	3 (0.28E-2)	1 (0.10E-1)	2 (0.63E-2)	Output—>Investment (+w)
General govt. infrastructure	1 (0.27E-2)	2 (0.24E-2)	1 (0.77E-2)	1 (0.52E-1)	Feedback (+w,+m)
Federal govt. investment	1 (0.27E-2)	3 (0.25E-2)	1 (0.19E-1)	3 (0.17E-1)	Feedback (+w,+w)
Federal govt. infrastructure	1 (0.27E-2)	2 (0.21E-2)	1 (0.13E-1)	2 (0.88E-2)	Feedback (+w,+w)
Provincial govt. investment	1 (0.27E-2)	1 (0.29E-2)	2 (0.13E-1)	2 (0.80E-2)	Output—>Investment (+w)
Provincial govt. infrastructure	1 (0.27E-2)	2 (0.25E-2)	2 (0.96E-2)	3 (0.76E-2)	Feedback (+w,+w)
Local govt. investment	1 (0.27E-2)	1 (0.30E-2)	1 (0.33E-1)	1 (0.21E-1)	Output—>Investment (+m)
Local govt. infrastructure	1 (0.27E-2)	1 (0.28E-2)	1 (0.37E-1)	2 (0.27E-1)	Output—>Infrastructure (+w)

NOTES: Summary of results obtained from Granger Causality Tests. A Hsaio Procedure was incorporated to determine the optimal lag. All variables were deflated by the GDP deflator (1985 = 100) and were estimated in their logarithmic form. Regression Patterns: A = private on private; B = public on private; C = public on public; D = private on public. The dominant pattern is that with the lowest final prediction error, given in parentheses under columns A, B, C, and D. The signs (+, –) represent the direction of impact. In the case of feedback the two signs represent the lowest final prediction error of relationships B and D. Each of the variables was regressed with 1, 2, 3, and 4 year lags, and the optimal lag in years is indicated by 1, 2, 3, or 4 in columns A, B, C, and D. Strength assessment (s = strong; m = moderate; w = weak) is based on the size of the standardized regression coefficient and *t* test of statistical significance.

potential to increase agricultural output, but only when they are undertaken in conjunction with other types of investment.
4. In all cases investment had as great or greater a stimulus than infrastructure on agricultural production. This finding suggests that demand factors may be as important (or more so) than the supply-enhancing linkages associated with government programs.
5. Private investment in agricultural was the only type of investment that was characterized as increasing agricultural output without a feedback linkage occurring.

With regard to private investment in the agricultural sector (table 7), we find the following:

1. In general, there were considerably more statistically significant results involving infrastructure (investment) and private investment than infrastructure and output. Again, in contrast to agricultural output there were a number of negative relationships involving public sector programs and private investment in agriculture.
2. With regard to the two specific public programs directed toward the agricultural sector, rural works has had a weak (albeit positive) impact on private investment in agriculture. In turn, private investment in the sector has stimulated further investment (and infrastructure) in rural capital formation. On the other hand, Indus Basin investment has had a negative effect on private investment in the agricultural sector. In addition, private investment has had an even stronger negative effect on Indus Basin investment. Indus Basin infrastructure has not stimulated private investment in agriculture. Again, private investment in agriculture has reduced further increments to Indus Basin infrastructure.
3. Energy investment has provided a modest stimulus to private investment in agriculture. Also important in this regard were general public investment (and infrastructure) and local government infrastructure.
4. The strongest inducement to private investment in agriculture was provided by provincial government infrastructure.
5. In addition to the Indus Basin investment, negative relationships between government programs and private investment were associated public enterprise infrastructure and investment.

Conclusions

In their review of the literature, Will Martin and Peter G. Warr note that declines in the relative importance of the agricultural sector to economic growth in developing countries are usually attributed to three broad groups of potential causes: declining relative prices of agricultural products, differential rates of technical change, and changes in relative factor endowments.[33] By all measures this literature has stressed the effects of relative prices, with technology usually assumed to be stagnant. Unfortunately, the factor accumulation effects have received minimal attention.

TABLE 7
PAKISTAN: INTERACTION OF PUBLIC INVESTMENT, INFRASTRUCTURE, AND PRIVATE INVESTMENT IN AGRICULTURE, 1972–1990

	CAUSATION PATTERNS				
	A	B	C	D	DOMINANT PATTERN
Total public investment	4 (0.84E-2)	2 (0.76E-2)	2 (0.82E-2)	2 (0.365-2)	Feedback (+w,+w)
Total public infrastructure	4 (0.84E-2)	4 (0.65E-2)	2 (0.67E-2)	3 (0.49E-2)	Feedback (+w,+w)
Rural works investment	4 (0.84E-2)	2 (0.73E-2)	4 (0.64E-0)	3 (0.15E-0)	Feedback (+w,+m)
Rural works infrastructure	4 (0.84E-2)	1 (0.62E-2)	4 (0.29E-1)	3 (0.94-2)	Feedback (+w,+w)
Public enterprises investment	4 (0.84E-2)	2 (0.61E-2)	2 (0.17E-1)	2 (0.16E-1)	Feedback (–w,+w)
Public enterprises infrastructure	4 (0.84E-2)	2 (0.61E-2)	1 (0.14E-1)	2 (0.15E-1)	Public—>Private (–w)
Public investment energy	4 (0.84E-2)	1 (0.45E-2)	4 (0.89E-1)	3 (0.72E-1)	Feedback (+m,+w)
Public infrastructure energy	4 (0.84E-2)	1 (0.69E-2)	4 (0.81E-1)	4 (0.76E-1)	Feedback (+w,+w)
Railroad investment	4 (0.84E-2)	1 (0.73E-2)	1 (0.39E-0)	1 (0.44E-0)	Public—>Private (–w)
Railroad infrastructure	4 (0.84-2)	1 (0.97E-2)	4 (0.58E-1)	2 (0.47E-1)	Private—>Public (+w)
General public investment	4 (0.84E-2)	3 (0.33E-2)	1 (0.10E-1)	3 (0.71E-2)	Feedback (+m,+m)
General public infrastructure	4 (0.84E-2)	4 (0.25E-1)	1 (0.77E-2)	4 (0.71E-2)	Feedback (+m,+w)
Federal investment	4 (0.84E-2)	2 (0.70E-2)	1 (0.19E-1)	1 (0.71E-2)	Feedback (+w,+w)
Federal infrastructure	4 (0.84E-2)	1 (0.70E-2)	1 (0.13E-2)	2 (0.12E-1)	Public—>Private (+w)
Public investment in Indus Basin	4 (0.84E-2)	1 (0.61E-2)	1 (0.23E-0)	2 (0.13E-0)	Feedback (–w,–m)
Public infrastructure in Indus Basin	4 (0.84E-2)	1 (0.95E-2)	1 (0.12E-0)	4 (0.49E-1)	Private—>Public (–m)
Provincial govt. investment	4 (0.84E-2)	2 (0.39E-2)	2 (0.13E-1)	3 (0.83E-2)	Feedback (+w,+m)
Provincial govt. infrastructure	4 (0.84E-2)	1 (0.33E-2)	2 (0.96E-2)	4 (0.80E-2)	Feedback (+s,+w)
Local government investment	4 (0.84E-2)	3 (0.48E-2)	1 (0.34E-1)	3 (0.18E-1)	Feedback (+w,+m)
Local government infrastructure	4 (0.84E-2)	2 (0.43E-2)	1 (0.37E-1)	4 (0.20E-1)	Feedback (+m,+m)

NOTES: See table 6.

Martin and Warr found that in the case of Indonesian agriculture the process of capital accumulation may be extremely important in determining the economic process by which the share of this sector declines with economic growth. Their results suggest that further accumulation of capital in relation to labor should have significant effects on that sector's share of GDP.[34]

While not directly examining the role of factor prices and technological change in agriculture, the results of the causation tests presented earlier are consistent with Martin and Warr's analysis. They suggest, however, that the source of capital may be critical in determining the manner in which the agricultural sector will grow over time. Specifically, the most effective way of increasing agricultural output in Pakistan is to encourage more private investment in the sector. While some types of government infrastructure stimulate increased levels of food production, they tend not to be the ones directed toward that sector—that is, rural works, Indus Basin. In fact, there is evidence that the Indus Basin competes with the private sector for funds (or at least discourages private investment in the sector). On the other hand, deficiencies in several types of infrastructure may be a moderate constraint on agricultural production. These include total public investment (and infrastructure), energy, and several types of general government infrastructure. What is suggested here is that a better coordination of government programs in which an effort is made to alleviate conflicts between individual projects may be more productive than government programs directly oriented toward the sector.

The results presented here are consistent with the idea that agricultural development in Pakistan must now rely on intensive rather than extensive types of inputs. That is, rather than allocating funds toward bringing more land under cultivation (and irrigation), the government should strive to encourage activities that increase output per acre. This would include incentives to the private sector to increase mechanization together with other-yield increasing types of inputs.

NOTES

1. World Bank, "Pakistan: Current Economic Situation and Prospects—Report No. 9283-PAK" (World Bank, Washington, DC, 22 March 1991), p. 18.

2. See for example, Faiz Mohammad, "The Performance of Pakistan's Agricultural Markets in the Green Revolution Perspective," *Pakistan Development Review* 23 (Summer–Autumn 1984): 287–304; M. Ghaffar Chaudhry and Zafar Iqbal, "Regional Distribution of Agricultural Incomes in Pakistan: An Intertemporal Analysis," *Pakistan Development Review* 27 (Winter 1988): 537–46; Eshya M. Mukhtar and Hanid Mukhtar, "Input Use and Productivity across Farm Sizes: A Comparison of the Two Punjabs," *Pakistan Development Review* 27 (Winter 1988): 595–604; Faiz Mohammad and Sayyid Tahir, "Agricultural Prices in Pakistan: A Multimarket Analysis," *Pakistan Development Review* 27 (Winter 1988): 577–92; M. Ghaffar Chaudhry, "Technological Change and Distribution of Agricultural Land: The Case of Pakistan," *Pakistan Development Review* 28 (Winter 1989): 617–25; Joseph Nagy, "The Overall Rate of Return to Agricultural Research and Extension Investments in Pakistan," *Pakistan Journal of Applied Economics* 4 (Summer 1985): 17–28; Shahid N. Zahid and Syed S. Hyder, "Pakistan's Terms of Trade 1973–74 to 1983–84," *Pakistan Journal of Applied Economics* 5 (Winter 1986): 91–142; M. Ghaffar Chaudhry, "Mechanization and Agricultural Development in Pakistan," *Pakistan Development Review* 25 (Winter 1986): 431–45; Nasir M. Khilji, "Optimum Resource Utilization in Pakistan's Agriculture," *Pakistan Development Review* 25 (Winter 1986): 469–85; M. Ghaffar Chaudhry, Manzoor A. Gill, and Ghulam Mustafa Chaudhry,

"Size—Productivity Relationship in Pakistan's Agriculture in the Seventies," *Pakistan Development Review* 25 (Winter 1986): 349–59; Carl H. Gotsch, "Linear Programming and Agricultural Policy: Micro Studies of the Pakistan Punjab," *Food Research Institute Studies* 12, no. 1 (1975): 3–105; Hiromitsu Kaneda, "Economic Implications of the 'Green Revolution' and the Strategy of Agricultural Development in West Pakistan," in *Growth and Inequality in Pakistan*, by Keith Griffin and Azizur Rahman Khan (London: Macmillan, 1972), pp. 94–122; and Syed Nawab Haider Naqvi, Mahmood M. Khan, and M. Ghaffar Chaudhry, *Structural Change in Pakistan's Agriculture* (Islamabad: Pakistan Institute of Development Economics, 1989).

3. The only other study to examine these issues—John Antle, "Infrastructure and Aggregate Agricultural Productivity: International Evidence," *Economic Development and Cultural Change* 31 (April 1983): 609–20—does not include Pakistan; Tariq Husain, "Potential for Irrigated Agricultural Development," in *Pakistan's Development Priorities: Choices for the Future*, ed. Shahid Javed Burki and Robert LaPorte (Karachi: Oxford University Press, 1986), pp. 45–83.

4. Omar Noman, *Pakistan: Political and Economic History since 1947* (London: Kegan Paul International, 1990), pp. 16–17.

5. Noman, *Pakistan*, chapter 2.

6. Government of Pakistan, *Seventh Five Year Plan 1988–93 and Perspective Plan 1988–2003* (Islamabad: Planning Commission, 1988), p. 161.

7. Government of Pakistan, *Seventh Five Year Plan*, p. 161.

8. World Bank, "Pakistan: Current Economic Situation and Prospects," p. 18.

9. World Bank, "Pakistan: Current Economic Situation and Prospects," p. 18.

10. The following section draws on data presented in World Bank, "Pakistan: Rapid Population Growth in Pakistan: Concerns and Consequences—Report No. 7522-PAK" (World Bank, Washington, DC, 17 March 1989), chapter 6.

11. Government of Pakistan, Ministry of Food and Agriculture, *Report of the National Commission on Agriculture* (Islamabad: Ministry of Food and Agriculture, 1988), chapter 17.

12. World Bank, "Pakistan: Rapid Population Growth," p. 112.

13. World Bank, "Pakistan: Rapid Population Growth," p. 114.

14. For the detailed forecasts see G. P. Kutcher to the Ministry of Food and Agriculture, Islamabad, memorandum, May 1987, "Policy Planning in a Resources-Constrained Environment: Pakistani Agriculture in the 1990s."

15. United Nations Economic and Social Commission for Asia and the Pacific, *Economic and Social Survey of Asia and the Pacific, 1988* (Bangkok: United Nations, 1989), pp. 31–32.

16. World Bank, *Pakistan: Review of the Sixth Five-Year Plan* (Washington, DC: World Bank, 1983), p. 46.

17. World Bank, "Pakistan: Current Economic Situation and Prospects," p. 22.

18. World Bank, "Pakistan: Current Economic Situation and Prospects," p. 22.

19. Ibid., pp. 21–22.

20. The following draws on Robert E. Looney and Peter C. Frederiksen, "The Regional Impact of Infrastructure Investment in Mexico," *Regional Studies* 15, no. 4 (1981): 285–96.

21. Donald R. Glover and Julian L. Simon, "The Effect of Population Density on Infrastructure: The Case of Road Building," *Economic Development and Cultural Change* 24 (April 1975): 453–68.

22. Peter C. Frederiksen, "Further Evidence on the Relationship between Population Density and Infrastructure: The Philippines and Electrification," *Economic Development and Cultural Change* 29 (July 1981): 749–58.

23. Fritz Voigh, "The Tasks of Modern Transport Science," *International Journal of Transport Economics* 2 (December 1974): 255–62.

24. See, for example, Neils Hansen, "Unbalanced Growth and Regional Development," *Western Economic Journal* 5 (1965): 150–62; and the essays contained in *Transport Investment and Economic Development*, ed. Gary Fromm (Washington, DC: Brookings Institution, 1965).

25. C. W. J. Granger, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica* 44, no. 4 (1969): 424–38.

26. A. O. Hirschman, *The Strategy of Economic Development* (New Haven, CT: Yale University Press, 1958), especially chapters 3–5.

27. Benjamin Higgins, *Economic Development* (New York: W. W. Norton, 1959), p. 405.

28. Ibid.

29. Mario I. Blejer and Mohsin S. Khan, "Public Investment and Crowding Out in the Caribbean Basin Countries," in *The Economics of the Caribbean Basin*, by Michael Connolly and John McDermott (New York: Praeger, 1985), pp. 219–36.

30. The data for investment upon which the infrastructure expenditures were calculated were derived from figures in World Bank, "Pakistan: Current Economic Situation and Prospects"; and World Bank, *Pakistan: Review of the Sixth Five Year Plan*. GDP and the GDP price deflator are from various annual issues of the International Monetary Fund (IMF), *International Financial Statistics Yearbook* (Washington, DC: IMF, 1972–93).

31. The underlying reasons involve the assumption of stationary conditions. See C. Hsiao, "Autoregressive Modeling and Money-Income Causality Detection," *Journal of Monetary Economics* 12, no. 1 (1981): 85–106; and Wayne Joerding, "Economic Growth and Defense Spending: Granger Causality," *Journal of Development Economics* 22 (April 1986): 35–40.

32. A detailed description of the statistical methods is given in Robert Looney, "Defense Expenditures and Economic Performance in South Asia: Tests of Causality and Interdependence," *Conflict Management and Peace Science* 11 (Spring 1991): 37–68.

33. Will Martin and Peter G. Warr, "Explaining the Relative Decline of Agriculture: A Supply-Side Analysis for Indonesia," *World Bank Economic Review* 7, no. 3 (1993): 398.

34. Martin and Warr, "Explaining the Relative Decline of Agriculture," p. 398.