& AGRICULTURAL DEVELOPMENT

POLICY ISSUES / RESEARCH PRIORITIES

IFPRI POLICY BRIEFS

IFPRI POLICY BRIEFS make available in capsule form recent research findings drawn from larger studies conducted by IFPRI and others that may not yet be accessible to the general public. Prior to publication the briefs are normally presented at an IFPRI policy seminar where they serve as a basis for an interchange of views between research analysts and decisionmakers on policy issues of immediate concern. Thus, the format is intended to be abbreviated and nontechnical in order to contribute to public understanding of complex issues on which systematic information is often lacking.

The briefs that follow deal with the role of rural infrastructure in agricultural development. Given that public expenditure is involved in infrastructure creation, development of this aspect of the rural sector is becoming an increasingly important policy issue for both national governments and foreign assistance agencies.

The effects of infrastructure development in fostering a greater division of labor in rural areas and in increasing the participation of low-income people in the process of economic growth are documented with particular attention to improvements in employment, income, and nutrition made possible by such growth. The briefs were presented at a meeting of IFPRI's Board of Trustees in Mexico City, January 1988.

INFRASTRUCTURE & AGRICULTURE

RAISUDDIN AHMED

DEFINITION OF INFRASTRUCTURE

The term "infrastructure" was evolved during the Second World War by military strategists to indicate wide-ranging elements of war logistics. Thereafter, development economists began to use the term interchangeably with "overhead capital." There is, however, no consensus in literature on a common definition of infrastructure.

But such a definition is essential for understanding and resolving issues related to research and public roles in development of infrastructure. The literature of the 1950s emphasized the process of industrialization in defining the elements to be included under infrastructure. Arthur Lewis includes public utilities, ports, water supplies, and electricity in his definition of infrastructure; Benjamin Higgins includes transport, public utilities, schools, and hospitals; and Albert Hirschman lists law and order, education, public health, transportation, communications, power, water supply, and flood control. With the increasing recognition of the role of agriculture in economic development of contemporary developing countries, the literature of the 1960s has extended the list to include agricultural research, extension services, financial institutions, irrigation, and drainage. This change in the way infrastructure is perceived clearly reflects the strategic roles those elements have played in the development of developing countries. It is therefore necessary to understand what makes infrastructure different from other economic structures and qualifies it for public action.

Albert Hirschman in *The Strategy of Economic Development* makes a distinction between "directly productive capital" and "social overhead capital." He sets out four conditions for distinguishing "social overhead capital."

- The services provided by the activity are necessary to facilitate, or are in some sense basic to, the carrying out of a wide variety of economic activities;
- The services are provided in almost all countries by public agencies or by private agencies subject to public control, and they are provided free of charge or at rates publicly regulated;
- The services cannot be imported; and
- The investment needed to provide the services is characterized by "lumpiness."

These conditions are similar to those that define public goods. Public goods are defined by their effect on external economies or diseconomies or attributes of natural monopoly. In this respect, Hirschman's conditions are more comprehensive than the criteria for defining public goods. For example, a lumpy investment may not qualify as a public good, but it may be the subject of public action under Hirschman's conditions. In developing countries, family-owned capital is generally limited, and underdevelopment of the financial market may cause even modest capital requirements for a project to be lumpy. After all, "lumpiness" is a relative term. A large irrigation project in a developing country may not qualify as a public good, but it may pass the test of Hirschman's conditions for government participation.

The holistic approach to the search for a common definition of infrastructure is important for conceptual clarity, but it is not pragmatic when research on infrastructural issues or resource allocation priorities is involved. Realizing this pragmatic necessity, Hirschman introduced the term "hardcore" and emphasized transport, communications, and power as the hardcore elements of infrastructure. In doing so, he emphasized the importance of the first condition on his list of four. Transport, communications, and power are indeed basic to numerous economic activities. Moreover, the constraints imposed by underdevelopment of many other infrastructural elements are mitigated, at least partially, as transport and communication systems develop. Thus, law and order improve; market imperfections and failures are reduced; and access to health, education, and electricity facilities is enhanced by development of transport and communication systems. In this sense transport and communications are the leading elements of infrastructural development.

There is some sense in pursuing this definitional discussion until a consensus on the infrastructural elements that IFPRI should include in its research agenda is reached. It seems logical that IFPRI should focus its research on the leading elements (transport and communications, particularly for the rural sector), with supplementary research linking education, electricity, product markets, credit markets, and marketing of modern agricultural inputs to the leading elements. The logic of this position lies in, first, the emphasis on the leading elements; second, the exploitation of the existing talent at IFPRI for research on education, market development, and service provision for rapid agricultural growth; third, IFPRI's emphasis on Africa, where these factors are believed to matter critically; and fourth, IFPRI's already existing placement of high priority on research on agricultural technology and irrigation.

DEMAND-SIDE BENEFITS FROM INFRASTRUCTURE

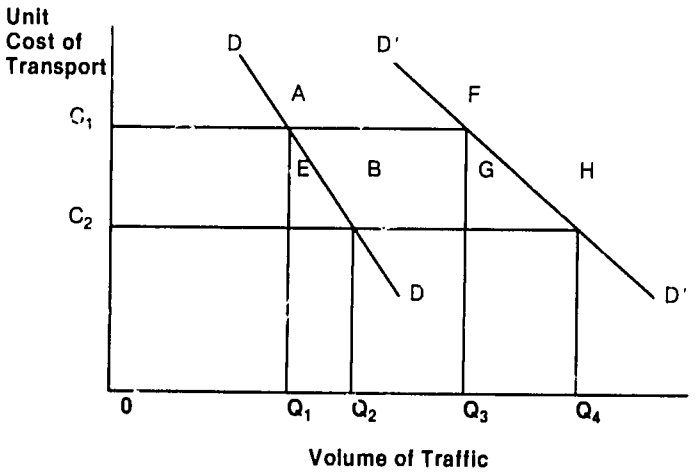
The benefits of infrastructural development are indirect and therefore not easily recognized. Potential users of infrastructure do not always state their preferences strongly in

guiding the supply of infrastructure because of this hazy recognition. Furthermore, many needs for infrastructural services are not expressed. In general, a government has to be perceptive to recognize the potential demand and to act accordingly as a supplier of infrastructural facilities. It is because of the vision and initiative of the Eisenhower administration in the United States that the road network is so well developed today.

Benefits Are Complex but Comprehensive

If a government has to perceive the potential demand for infrastructure in order to supply it, it is expedient that the mechanism that molds the formation of perception at the government level be examined. The economic factor that has conventionally been instrumental in the formation of views on the benefits from infrastructural investment at the policymaking level is the concept of "user cost savings" arising from investment relative to investment cost. Even though political forces have substantially influenced resource allocation decisions, this economic reasoning has continued to be the objective basis of most policy decisions. It is therefore appropriate to elaborate on this concept of benefit.

The approach of estimating user cost savings as a measure of benefits from a road project is shown in the diagram below. In the figure, DD is the demand curve for transport services, whereas the horizontal axis represents volume of traffic and the vertical axis represents the unit cost of transportation. When walking and headload were



the means of transportation (before the road project), the unit cost was OC_1 and the volume of traffic OQ_1. This cost is reduced to OC_2 when the road project is developed. This reduction also induces additional traffic ($OQ_2 - OQ_1$), which is solely determined by the demand elasticity of DD. Note that this additional traffic does not arise from any effect of structural change that may be caused by the road project. The total benefits from the development of the road are given by the area AC_1C_2B which consists of two components:

Cost savings on existing traffic = AC_1C_2E = $(OC_1 - OC_2)\ OQ_1$; and

Cost savings on generated traffic = $1/2\ (C_1C_2)\ (OQ_2 - OQ_1)$ = AEB.

This conventional approach is applicable in developed economies where resources are fully employed. In developing economies where resources are under- and unemployed and markets do not function perfectly, road development is expected to bring about substantial structural change. If this happens, the demand curve will shift to the right to D'D'. Under this new situation, the benefit from additional traffic generated will be ABHF, which is much larger than the benefit AEB from additional traffic under the static condition of demand (DD). It would, however, be a serious underestimation of development economists to assume that they have failed to see this simple logic and ignored the large benefit that arises from the shift of demand. The omission occurs largely as the result of the vacuum in factual information.

It is quite clear that the issue of how much structural change can be brought about by infrastructural development is critically important. Some studies show that, in fact, infrastructural development generates structural change. In order to place infrastructural development on a solid foundation, more studies of this nature are necessary.

It should be noted that the user cost savings approach to the measurement of infrastructural benefits takes into consideration only traded goods—goods that are transported from one location to the other. This approach does not take into account effects on goods and services that do not enter the market. Thus, a part of the incremental production induced by infrastructural development may be consumed at home rather than sold in the market. This benefit to the producer-consumer household will not be captured. The amount of this subsistence production in many developing countries is not small. Furthermore, nontraditional goods and most services are likely to be excluded from the benefit analysis unless the analyst is extraordinarily imaginative. A similar deficiency of the traditional method is an inability to reflect effects on employment. Perhaps because of the widespread implications of infrastructural development, Hirschman suggests overinvestment in "social overhead capital," particularly where demand is deficient and production costs are high, as is generally believed to be the case in Africa and many parts of Asia.

Interaction Among Infrastructural Elements Is Crucial

If a particular element is missing in an infrastructure package, then it may not be very effective in generating the full benefit that would be achievable if all complementary elements were present. For example, agricultural processing industries will not grow if electricity is not available, even if transport facilities are present. Similarly, growth of processing activities in areas with electricity but without transport facilities is generally weak. Some of these effects from the interaction of complementary elements of infrastructure, technology, and resource endowments deserve to be examined in detail.

1. Interaction between physical and institutional infrastructures is particularly important among the various types of interactions contemplated here. Physical infrastructure, such as a road provided at public cost, is intended to create a condition that will induce supplementary investment from private entrepreneurs (transportation vehicles, shops, industries, and so forth) in order to exploit the full potential of the physical infrastructure. Growth of these supplementary investments may be constrained by weaknesses in a number of institutional factors.

First, public policies must be conducive to private investment. Development of rural roads may not do much good if a country's trade policies prohibit import of transport vehicles that are not produced domestically, or if local insti-

tutions for registering and monitoring the vehicles do not exist.

Second, stimulation of market exchanges in areas where a new road has been built requires some public investment and formulation of rules of conduct. Public investment in building marketplaces at appropriate locations has been very productive This type of investment cost is the easiest to recover from users. Without this public investment, scattered roadside shops and periodic markets become a common feature. Gradually and over time, a market center may develop where a few rich traders can exact enormous rents because they own the land in a prime location. Irregular roadside markets are inefficient in exchanging market information. Public investment in development of marketplaces in the new areas covered by a road is therefore essential for orderly growth of marketplaces and exchange centers in rural areas. The knowledge of economic geographers is particularly relevant in locating these market developments. Formulation of rules for conduct of these marketplaces is not meant to constrain but to facilitate private trade. These rules ensure that there is no restriction on movement, no exploitative local taxes on traders by local powerful groups, and there is adjudication readily available to resolve trade disputes.

Third, development of financial institutions will be slow if left entirely to market forces. Literature on public initiative to provide credit to rural areas is quite rich and does not require a rerun here, but two points are particularly relevant. First, businessmen require credit to finance transport vehicles, industrial equipment, and working capital for trade, and to build shops. Second, most rural credit programs initiated by governments are designed for agricultural production. Therefore, rural credit programs are not meant for growth of the private investment in business, trade, and cottage industries that is essential to supplement public investment in physical infrastructure. Of course, diversion of agricultural credit to business purposes is a common feature. But it is often illegal and therefore has a transaction cost. What is necessary is the evolution of an organized rural credit market that can accommodate the diverse demand for credit by rural households.

Ideally, infrastructural development is supposed to provide an environment for the healthy growth of private entrepreneurship so that the public sector need not enter into direct production and marketing. However, there are occasions when the public sector may find it necessary to enter marketing directly. For example, in most developing countries fertilizer marketing is a public task, at least in the initial stage of diffusion. This is partly due to the lack of modern infrastructure and partly to high risk and marketing costs during the stage when demand is thin and scattered. Once a government enters into such a venture on the basis of an "infant industry" argument, it cannot easily get out, even when the baby is grown up. Public participation in foodgrain marketing is widespread, even in thick markets. Here market imperfection and concern for food security are offered as the reasons. In most cases backward infrastructure is the primary source of imperfect market behavior.

2. Interaction of infrastructure with technology has a number of facets. Improved infrastructure speeds up the pace of diffusion of technology. This happens because of improved mobility of extension workers, improved marketing facilities for modern inputs (for example, fertilizers, tubewells, and other equipment), and better access to institutional facilities. The impact on agricultural production of this interaction between infrastructure and technology will be substantial only if viable technology is available. The indirect effects of the technology-induced income and its expenditure further reinforce the effectiveness of infrastructure. The increased income is spent proportionately more on consumer goods and services, and availability of these goods and services is facilitated by infrastructure. Increased agricultural production and demand for consumer goods combine to increase the size of markets. A thin market becomes thick through the interaction of technology and infrastructure. The larger market, in turn, tends to reduce marketing costs, in addition to the general reduction in unit costs brought about by infrastructural development.

3. The effects of interaction between infrastructure and resource endowment are similar but not quite the same as those in the case of technology. Two aspects of resource endowments are important—population density and productive capacity of land, including mineral deposits. After all, infrastructure, particularly transport infrastructure, is meant to increase mobility of goods, knowledge, and people. In Africa, thin population density has frequently been used as an argument against giving priority to road development. Even with low population density, infrastructural development of this nature can be justified by the potential increase in production that opening up of land resources and enhancement of knowledge in Africa can bring about. Whether potential productivity of land and population should be considered in locating infrastructure is, however, an issue that has often been contested on grounds of equity. This issue will be discussed further in the section on regional priorities.

Infrastructural Development and Poverty Alleviation

Arguments pro and con the effects of infrastructural development on poverty are as follows. The antagonists argue that the distribution of benefits from infrastructural development is determined by the initial ownership of land and other assets, including liquid capital. Because infrastructural development generates its benefits through improvement in productivity of these assets, it is the rich who mainly benefit from infrastructural development. This is the standard argument advanced in the context of most development policies.

The protagonists argue their case from a number of angles. First, they argue that the poor may be short in land and capital but they have more labor to offer. Therefore, one must consider the effects on wage rates and employment as the result of infrastructural development. Wage income may rise faster than agricultural income and profit because, as mentioned earlier, infrastructural development leads to an increase in demand for hired labor as the result of diffusion of technology and the growth of nonfarm activities, as well as through the reduction in the supply of family labor of richer households, who may choose leisure over income. This is an empirical issue, however.

Second, a majority of the rural poor (small farmers and the landless) have *some* land and capital. This small amount of land and capital combined with abundant labor is an advantage in labor-intensive, small-scale livestock production, fishing, and vegetable growing in areas that have ready access to markets for these products. The absence of an immediate access to markets is a definite constraint in production of these perishable products. In-

frastructural development removes that constraint.

Third, public programs for the poor are more effective if the level of infrastructural development is higher. The ineffectiveness of famine prevention measures in areas of infrastructural underdevelopment is too well known to repeat. Finally, it is argued that if special care is taken in implementing programs for the poor (such as the Grameen Bank program in Bangladesh), credit can be extended to the poor so that they can avail themselves of the opportunities created by infrastructural development.

PUBLIC INVESTMENT IN INFRASTRUCTURE: SUPPLY-SIDE CONSIDERATIONS

By definition, infrastructural development is a government responsibility. It has to be treated from the perspective of a development strategy that a government may pursue for overall economic development. Once the strategic role of infrastructure is accepted, formulation of the program for infrastructural development should then reflect this strategic role in setting resource allocation priorities. Moreover, such a program should generally reflect resolutions of issues related to regional priority, cost-effectiveness, and organizational mechanisms for implementation and maintenance of infrastructural projects.

Development Strategy and Infrastructure

The development strategy of most developing countries emphasizes both growth and equity. Without growth, distribution of income primarily implies sharing of poverty; emphasis on growth alone may keep a majority of the people outside the mainstream of development and may even omit growth itself. A development strategy for growth and equity generally relies on agriculture and labor-intensive industrialization. The context for this is a mixed economy where the private sector conducts most of the production activities and the public sector provides a congenial environment in which private entrepreneurs can operate.

How this strategy is implemented and its consequences vary from country to country. Generation and diffusion of improved technology in agriculture through a comprehensive system of research, extension, credit, input marketing, and water control measures have been the principal instruments for accelerating the pace of agricultural production. But the pace of growth has remained slow in many countries. The missing link in this strategy of agricultural development is the failure to give sufficient priority to development of rural infrastructure.

In the case of industrialization, direct public production, subsidized credit, protective trade policies, and extension of advisory services have been the principal instruments. The experience with industrialization has been more frustrating than that with agriculture. This frustration has further reinforced the tendency for direct production by governments. It is the small-scale industries that are labor-intensive and consistent with the development strategy for growth and equity. Industrialization through small-scale industries involves a process of transition from commercial entrepreneurship of large farmers-cum-traders to industrial entrepreneurship of small-scale units. This transition can occur only when risk is relatively small, transaction costs are low, and marketing procedures are relatively easy. Infrastructural development critically influences all these factors. Domestic demand is an extremely effective conduit that reduces the market risk, and infrastructural development supports the demand for manufactured consumer goods. Once confidence is developed on the basis of the domestic market and efficiency is improved, the small-scale producer seeks international markets that further stimulate growth. It is easier to make the transformation from small-scale to large-scale and from domestic-demand-based to international-demand-based industrialization. Infrastructure is a critical element of this process.

Public Resource Allocation

Whether infrastructural development is accorded a key priority in a development strategy is generally reflected in the public budgetary allocations. IFPRI's analysis of public expenditures on roads and the transport sector, the central component of infrastructure, in 65 developing countries indicates that such countries allocate only about 7 to 20 percent of their public investment to this sector. Moreover, when urban-oriented infrastructural development approaches saturation and the task of developing rural infrastructure begins, the priority given to such development declines rapidly. This is clearly the case in Bangladesh, where an in-depth analysis was conducted. Allocations to the transport and communications sectors declined in Bangladesh from a share of about 20 percent in the late 1960s and early 1970s to about 8 percent in the early 1980s, even though about 25 percent of the villages in Bangladesh are still 10 miles or more away from a hard-surfaced road.

In many countries allocations to town development, urban housing, and subsidies to public industrial corporations amount to a large share of the budget. A 20 percent share of the public development budget, if maintained for 10–15 years, would give most such countries a highly developed transport sector. Recognition that priority should be given to infrastructural development is therefore a matter of budgetary allocations.

Regional Priority

Should the allocations to infrastructural development in various regions of a country be based on a strict productivity criterion, or should regional income disparity also be a factor? It is often argued that productivity is the cardinal criterion, and income disparity problems should be solved through mobility of labor and capital. But educational and ethnical problems could be insurmountable. It is also argued that the productivity criterion will always concentrate infrastructural development in areas that are already developed, because productivity of infrastructural development is itself a function of the existing level of infrastructural development. This is an issue that cannot have a generalized solution.

Techniques, Designs, and Cost Factors

Studies by the World Bank and the International Labour Organisation argue that the cost of rural roads can be reduced if they are designed using appropriate techniques. These design techniques relate to appropriate dimensions, materials, compaction methods, and specifications for culverts and bridges. Moreover, phasing of development with appropriate combinations of dirt and paved roads can reduce cost relative to benefits. These are important considerations that have received little attention in planning rural infrastructure.

External Assistance for Infrastructural Development

Infrastructural development in developing countries has historically been greatly influenced by foreign aid policies

of multinational donors. The World Bank's emphasis on high priority for infrastructural development was at its peak during the 1960s and then began to drop drastically. The transport sector's share of the World Bank's lending dropped from 35 percent in 1970–74 to 17 percent in 1980–84. Analysis of country cross-section data also shows the significant influence of foreign aid on allocations to transport, communications, and electricity. It seems likely that foreign aid policies of donors will continue to play important roles in infrastructural development in developing countries during the next decade.

Because wage goods constitute an important component in the cost of infrastructural development, food aid is a particularly important resource for development of rural infrastructure. However, the distinction between food aid to finance infrastructural development and infrastructural development as an outlet or basis for food aid is a subtle and significant difference that must be maintained to protect the image of infrastructural priority. Infrastructural projects must stand on their own merit, and food aid should be considered a resource like any other resource. Without this distinction, infrastructural development may become the secondary objective and food aid the primary one. Food aid could be a quite effective tool in containing inflation arising from increased public expenditure, particularly in chronic food-deficit countries.

Organizational Tasks in Construction and Maintenance

The pertinent points on organizational issues are as follows. First, construction and maintenance of rural infrastructure requires technically qualified persons posted at local levels. This is possible when local governments are an organized part of the political system of a country. Second, construction of a road in a rural area will do little good if the road is not kept in working condition. Maintenance of roads requires organization, skilled manpower, and financial resources. Most developing-country governments do not have an arrangement for sharing local revenues between the local and central governments. Moreover, revenue collection is often quite poor. Assigning responsibility to local governments for collection of revenue and giving the local government a share of that revenue would act as incentives for generating local resources. Third, new revenue collection opportunities arising from the kinds of activities generated by infrastructural development could help meet the financial costs of maintenance.

CONCLUSIONS

What issues deserve priority in IFPRI's research agenda? What country and regional priorities are desirable? What approaches are appropriate for research on infrastructural issues? In the light of the examination of conceptual issues presented here, the research issues that IFPRI might pursue in the future include the following:

1. The effects of infrastructural development on market development; agricultural production; household income, particularly from nonagricultural sources; employment; consumption patterns; savings and investment behavior; and poverty.
2. Interactions between physical infrastructure and institutional and technological development.
3. Public resource allocation, including the ordering of priorities between rural and urban infrastructures and between directly productive activities and social overhead capital, and determining the role of external assistance.
4. Organizational and institutional requirements for maintenance of infrastructure.

INFRASTRUCTURE & AGRICULTURE

RAISUDDIN AHMED

This note presents some selected results of a study to measure the effect of rural infrastructure conducted in 16 villages in Bangladesh in 1982. The effect of infrastructure was estimated from detailed data on villages with wide variations in infrastructure endowment. The sample was selected from a survey of 129 villages with comparable soil, agronomic factors, topography, and water regimes to neutralize any agroecological differences. In addition, the study employed appropriate econometric techniques to account for other socioeconomic factors unrelated to infrastructure.

INFRASTRUCTURE AND AGRICULTURAL PRODUCTION

The analysis of the agricultural production system was designed to measure the pure effects of infrastructure development through its effect on input prices and availability of inputs, including technology, response of production to inputs, and efficiency in the use of inputs. It shows that gross agricultural production increased by 35 percent due to infrastructure development. The diffusion of technology was found to be one of the most important factors influencing this result (Table 1).

Table 1
Effect of infrastructure on the use of inputs, 1982

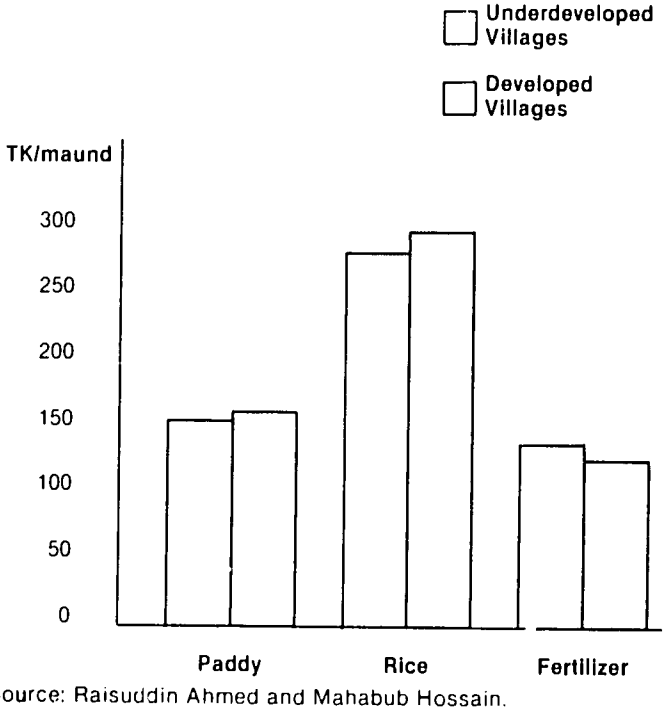
Input	Unit	Underdeveloped Infrastructure	Developed Infrastructure	Percent Difference
Irrigation	Percent of owned land	20.5	42.1	105
Area under HYVs	Percent of cropped area	24.5	42.0	71
Fertilizer	Kilograms of material per hectare of cropped land	78	150	92
Labor	Days per hectare of cropped land	115	119	4

Source: Raisuddin Ahmed and Mahabub Hossain.

In underdeveloped villages, 20.5 percent of owned land was irrigated, primarily by public projects providing surface water irrigation. Both surface water public projects and private sector tubewells accounted for the higher percentage of irrigated land in developed areas (42.1 percent). The latter was primarily associated with areas with infrastructural development. Similarly, the use of fertilizer and high-yielding varieties (HYVs) was more extensive in developed than underdeveloped areas.

Price effects are also associated with differences between developed and underdeveloped areas as shown in Figure 1. Paddy price did not differ greatly between the two groups of villages. Fertilizer prices were about 14 percent higher in the underdeveloped villages, and fertilizer use was 92 percent greater in developed than underdeveloped villages (Table 1). A decomposition analysis indicates that, of the 92 percent difference, about 64 percent can be attributed to the difference in the rate of adoption of HYVs, 12 percent to the difference in fertilizer prices, and the remaining 16 percent to the difference in availability of fertilizers.

Figure 1
Effect of infrastructure on agricultural prices, 1982



Source: Raisuddin Ahmed and Mahabub Hossain.

INFRASTRUCTURE AND RURAL EMPLOYMENT

Infrastructure affects the labor market basically through changes in the composition of employment as shown in Table 2. The development of infrastructure generates opportunities for nonfarm employment, where labor is less

Table 2
Effect of infrastructure on employment, 1982

Variables	Underdeveloped Infrastructure	Developed Infrastructure	Percent Difference	Statistical Significance
	(number of days/worker/year)			
Total supply	320	301	- 6	NS
Agriculture	212	187	-12	WS
Nonagriculture	108	124	15	WS
Self-employment	275	185	-33	S
Hired labor	45	116	157	S
Demand for farm labor	163	177	8.6	NS

Source: Raisuddin Ahmed and Mahabub Hossain.
Note: NS = Not significant; WS = Weakly significant; and S = Significant.

arduous and its productivity higher. So households that have necessary capital and skills substitute nonagricultural for agricultural labor, creating more opportunities for wage employment in agriculture for the remaining households. The shift of labor from agriculture increases the productivity of labor, while the shift from self-employment to wage employment increases duration of employment for the poor, who would have been forced otherwise to take up self-employment with very low productivity. The increase in the demand for hired labor puts an upward pressure on the wage rate and hence increases the wage earnings from the same amount of labor for the poor.

INFRASTRUCTURE AND HOUSEHOLD INCOME

The average incomes derived from various sources in developed and underdeveloped villages ranged from Tk 317 to Tk 5,012 (see Table 3). The data were further analyzed to measure econometrically the pure contribution of infrastructure. This analysis indicates that infrastructure development was associated with a 24 percent increase in income from crop production, a 78 percent increase from livestock and fishery production, and a 90 percent increase in wages. In the case of income from business and industries, an increase of household income of only 17 percent was attributed to infrastructure development.

Table 3
Average income from various sources in developed and underdeveloped villages, 1982

Sources	Developed Villages	Underdeveloped Villages	Difference
	(Tk)	(Tk)	(percent)
Agricultural income per acre	5,012	4,179	19.9
Field crops	4,098	3,405	20.4
Homestead and garden crops	914	774	18.1
Livestock and fisheries/household	1,782	1,205	47.9
Poultry	318	243	30.9
Milk	592	407	45.5
Fish	872	555	57.1
Business and industries/household	2,082	1,734	20.1
Business	1,464	1,330	10.1
Industries	618	404	53.0
Wage income per capita	596	317	88.1
From agriculture	190	122	55.7
From nonagriculture	407	195	108.3
Miscellaneous sources/household	3,625	4,013	-9.7

Source: Raisuddin Ahmed and Mahabub Hossain.

More significant than the increase in the level of household income is the distribution of incremental income arising from infrastructure. Income of landless and small owners increases proportionately more than for large owners for crop income, income from wages, and livestock and fisheries. This pattern is reversed for income from business and industries. Income from business is derived largely by richer households due to better access of such households to capital. Obviously, the importance of institutional development that is associated with providing credit to the poor combined with development of infrastructure is critical for enhancing the incomes of the poor through business and industries.

Quite a large amount of other empirical evidence is provided by the study on rural infrastructure in Bangladesh, including the effect of rural infrastructure on consumption patterns, savings and investment, and market and social development.

INFRASTRUCTURE & AGRICULTURE

SUDHIR WANMALI

Use of services, such as postal and transportation facilities; credit and banking institutions; facilities for distribution of seeds, fertilizers, pesticides and agricultural equipment; and market centers for agricultural products, is influenced by and influences the economic prosperity of a rural population. The degree of use of these services is a product of the level of development of agriculture. Details of the various characteristics of the use of services are provided below with examples from India and Zambia in an attempt to look at this pattern of use in the context of the nature of service provision in the two countries.

Household service use is governed by many factors. The two most relevant are availability of services and the economic status of households. These patterns of service use have several features related to access and rate of utilization that are common across the rural areas of India and Zambia but differ in their magnitudes. These differences reflect and are reflected by an ability to sustain a rural service infrastructure in the two countries.

PATTERNS OF SERVICE USE

In India between 40 and 70 percent of the total number of services used by the households were obtained from outside the sample villages in which the households are located. In Zambia, this figure ranges from 90 to 100 percent (Table 1).

Table 1
Degree of service availability among sample villages in India and Zambia

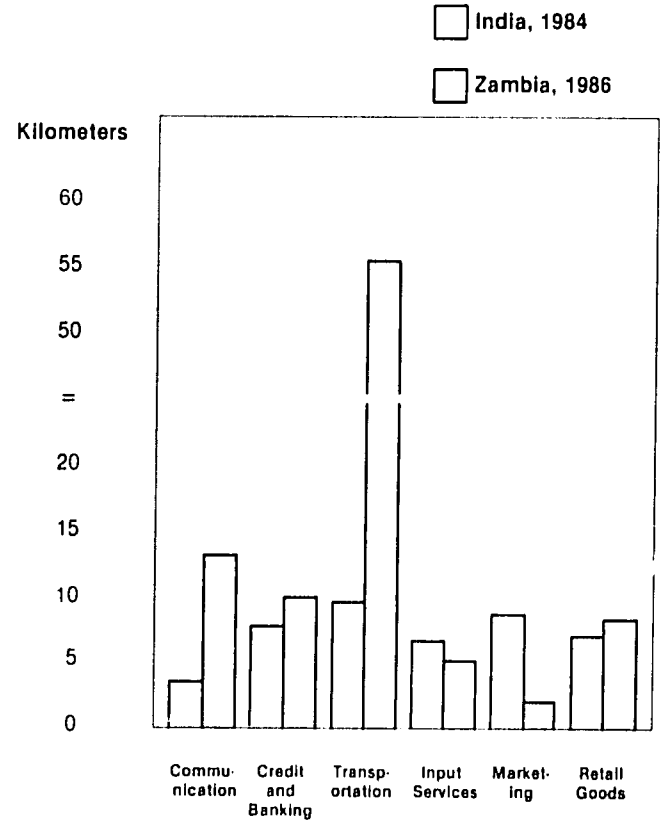
India, 1984		Zambia, 1986	
Village	Services Used from Outside of Village	Village	Services Used from Outside of Village
	(percent)		(percent)
Amudur	48	Mphata	100
Duli	68	Nkhoka	100
Kalpattu	45	Chaweya	93
Meppathurai	57	Kasendeka	99
Nesal	54	Mthanthela	100
Sirungathur	63	Matangila	100
Vayalur	66	Chipili	93
Veerasambanur	43	Sinda	99
Vegamangalam	56	Chiwizi	93
Vengodu	40	Kamwala	99
Vinayakapuram	60		

Source: Sudhir Wanmali.

Thus in India there is a better basis on which to provide services than in Zambia, which results in the Indian villages being more self-sufficient in agriculture-related service infrastructure. This also indicates that the households in India, as compared with those in Zambia, have a wider choice of services closer at hand.

As Figure 1 notes, this better access to agricultural services in India is related to the distances at which these are available. For all services except input distribution and marketing, the distances are shorter in India than Zambia. This better access in India, of course, results in greater use of services.

Figure 1
Patterns of access to services in India and Zambia



Source: Sudhir Wanmali.

The economic status of rural households also influences the pattern of use of services. Data indicate that richer households show a higher rate of utilization in both India

and Zambia, although the magnitude differs. A greater use of services is associated with larger landholdings (Table 2).

Table 2
Number of times services were used, by landholding size, India and Zambia

Services	India, 1984			Zambia, 1986	
	0 Acres	Less than 2 Acres	More than 2 Acres	Less than 2 Hectares	More than 2 Hectares
Communications	10.99	12.90	16.10	9.85	17.10
Credit and banking	1.32	10.48	18.23	16.06	25.66
Transportation	50.33	51.61	52.73	16.06	17.60
Input services	4.63	67.74	85.15	52.73	78.76
Marketing	4.63	73.18	85.55	52.85	79.66
Retail services	27.59	33.78	71.88	82.38	87.18

Source: Sudhir Wanmali.

A further categorization of households on the basis of their exposure to new agricultural technology indicates that those that are exposed to such technology also use more services than those that are not exposed to it. Also these technology-oriented households travel longer distances to obtain agricultural inputs as well as to purchase other consumer goods.

Analysis of household budget shares in India indicates that more than 60 percent of incremental incomes are spent on locally produced and distributed goods and services. This contributes to additional incomes and employment both in the farm and nonfarm sectors of the rural economy, thus strengthening the consumption linkages and multipliers. The analysis of the Zambia data along these lines is not yet complete, but it is apparent from a preliminary look at the data that such linkages and multipliers are weaker in Zambia than in India.

REGIONAL AVAILABILITY OF SERVICES

The actual use of services is governed not only by their availability in the villages in which the households are located but also by their availability in the region within which the sample villages are located. In India, for example, 17 subregional service centers, with 60 to 87 percent of the total of 134 services considered, provide rural service infrastructure to the region. In addition, as was seen above, almost all sample villages have at least 40 percent of the total services. In addition to the regional service center in Zambia, which has all 84 services, about 9 subregional service centers provide only up to 33 percent of total services, and only 3 of the sample villages provide about 7 percent of total services.

FACTORS INFLUENCING SERVICE PROVISION

The key factors influencing a better provision of services in India are the development of agriculture and the high population densities that are evenly distributed. The government policy of simultaneous provision of irrigation, electrification, roads, and rural service infrastructure greatly facilitated an accelerated agricultural development, which itself was helped by the availability of the new technological breakthrough. Further, the private sector also played a delayed but critical role in improving the level of service provision in India by complementing the efforts of the public sector.

Because of the low level of development of agriculture, low population densities with a scattered rural population, and a lack of complementarity of efforts between the public and the private sector, the overall provision of services in Zambia is very poor.

LESSONS FROM INDIA AND ZAMBIA

In rural India there is a strong orientation outside the village, after the introduction of the new agricultural technologies. Cultivators of high-yielding varieties of wheat and paddy, for example, require more inputs and services, which are typically purchased from outside their villages and in the nearby service and market centers. Similarly, with the increased incomes earned from the surplus agricultural production, the same cultivators demand other consumer goods and services, which are also purchased from the same service and market centers. This "outside-the-village" source of supply strengthens the link between not only the consumers and the traders but also between the rural and the urban sectors of the economy.

In rural Zambia, on the other hand, it would require simultaneous action by the government in agricultural research, technology diffusion, and development of rural service infrastructure to facilitate a faster development of smallholder agriculture and its incorporation, along the Indian lines, into the regional and national economy.

INFRASTRUCTURE & AGRICULTURE: EFFECTS ON NUTRITION

SHUBH K. KUMAR

LINKS BETWEEN INFRASTRUCTURE AND NUTRITION

Improvement of rural physical infrastructure may contribute in many ways to the improvement of nutrition in a community. Primarily, these include improvements in agricultural productivity and employment; increase in size of rural off-farm activities; better commodity markets; changes in the labor market; access and use of services that directly contribute to better nutrition, such as education and health; and the pattern of allocation of household resources brought about by all these changes.

The favorable effects of rural infrastructure, such as roads, on agricultural productivity and off-farm employment growth contribute to a higher rate of income growth for the lowest income groups than that which would occur without infrastructure. In addition, the easier access to and from markets increases the variety of foods available, reduces the effects of seasonality on availability of foods, as well as the prices at which food and nonfood items are available at most times of the year. Since off-farm employment usually requires more schooling, there is likely to be an increase in local demand for education. An increase in incomes may also be expected to increase use of health services. At the same time, the availability of physical infrastructure improves the accessibility of both these services. All of these changes are likely to improve the levels of nutritional status of the community.

There are other characteristics of rural areas with improved infrastructure that may, however, contribute to a higher prevalence of malnutrition. Areas that have irrigation infrastructure tend to be low-lying areas with relatively higher water tables than other areas. If water supply and sanitation conditions are poor, diarrhea and other waterborne diseases may be prevalent. These diseases are major contributors to malnutrition in young children.

Another factor that may contribute to a higher prevalence of malnutrition in areas with better infrastructure is migration. The increasing employment opportunities in these areas could result in migration from other rural areas. It is possible that if the households migrating into these rural growth centers are from the poorest groups, their inclusion in measurements of the prevalence of malnutrition may cause levels in the area to rise. This factor could complicate comparisons of areas (both in cross-section or time-series comparisons) that have varying levels of infrastructure development. It is also possible that problems related to settling in the new area may also contribute to a higher degree of malnutrition for these families in the short run.

Least well understood are possible changes in the patterns of allocation of resources—income and time—among and within households. Given the magnitude of changes taking place in employment, in the availability of goods and services, and possibly in the long-run opportunities for individual household members, it is likely that there will be shifts in the patterns of household and intrahousehold resource allocation. It is likely that most of these shifts could be explained by changes in incomes and prices, including shadow wage rates.

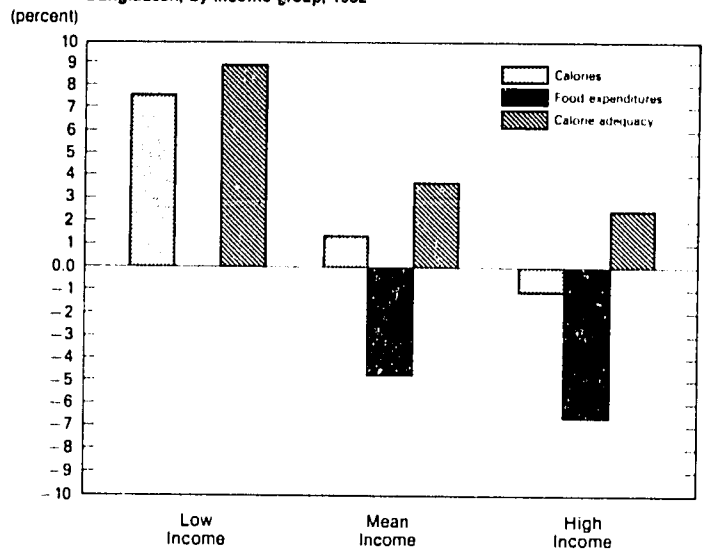
EVIDENCE FROM BANGLADESH

Current IFPRI work in Bangladesh indicates that when the effects on living conditions of varying levels of infrastructure development are examined, the emerging pattern is not entirely clear-cut. When the villages at the top and the bottom of the infrastructure development scale are contrasted, clear and significant differences emerge. Households in villages that are better endowed infrastructurally had, at all income deciles, significantly higher levels of total consumption expenditure and caloric intake and adequacy (this was especially pronounced for the lowest two quintiles), and slightly higher levels of protein adequacy. Protein adequacy, in contrast, was especially pronounced for the highest two income quintiles.

However, among the other villages where differences in the level of infrastructure were smaller, the same pattern did not emerge. Most of the differences between the two groups clearly stemmed from income gains in the infrastructurally advanced villages, and the absence of any clear-cut linear association between infrastructure development and rural income levels is also evident. Thus there are some poor villages with good access to infrastructure and some villages that are relatively well off but have poor access to infrastructure. Villages in the latter case invariably had more irrigation and water control infrastructure, which in Bangladesh is a major factor in raising agricultural productivity.

Multivariate analysis of household food intake shows that, while household income increments significantly increase dietary caloric intake, the degree of infrastructure development has an additional positive effect. This positive effect of infrastructure on caloric intake and adequacy is particularly important for the lowest income groups (Figure 1). Thus, at the 25th percentile of incomes, those who lived where infrastructure was above average had caloric intake 7.5 percent higher and caloric adequacy 8.9 percent higher than those who lived where infrastructure was less developed. For the upper income groups, intake of calories did not change, but the cost of food purchases declined by 6.6 percent, even with a slight improve-

Figure 1
Effects of above average physical infrastructure on calorie consumption, food expenditure, and calorie adequacy in Bangladesh, by income group, 1982



Source: Shubh Kumar.

ment in the level of protein intake. For households at the 25th percentile, on the other hand, food expenditure levels did not change much despite the significant increase in caloric intake. This suggests that in addition to the effect of infrastructure on income for the poor, there may be an additional effect reflecting an improved availability of essential food commodities with infrastructure development.

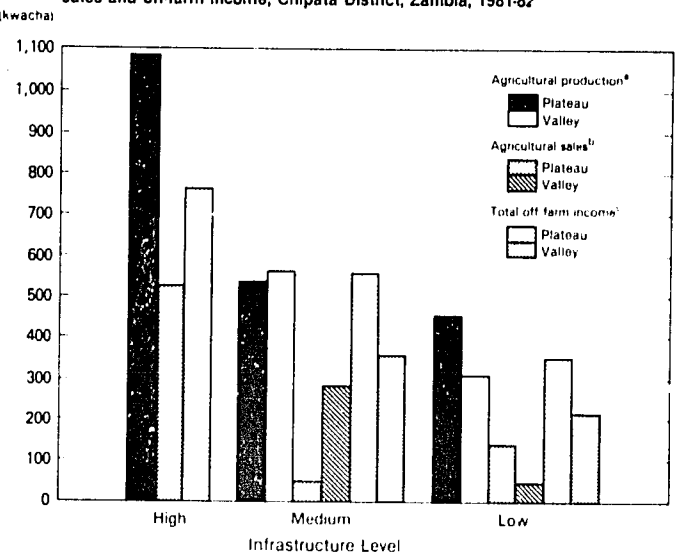
Expenditures for health and transportation were also higher in villages that were better endowed infrastructurally, reflecting a higher use of these services, because the cost of a single use is actually lower in these villages than in those with a poorer physical infrastructure. Child nutritional status was found to be significantly related to household income, caloric intake level for the household, and incidence and duration of disease in the child, all of which have been shown to be positively influenced by infrastructure development.

EVIDENCE FROM ZAMBIA

In general, rural infrastructure tends to be less developed in Africa than in Asia. In Zambia, which has very low population densities, rural infrastructure is less developed than in neighboring countries like Malawi and Zimbabwe. In the Eastern Province of Zambia, IFPRI studies have also found that in rural areas food consumption levels and adequacy indicate a high degree of seasonal fluctuation. While this is primarily a function of the unimodal rainfall pattern, it is likely that the lack of rural infrastructure also contributes to seasonal fluctuations in food intake. The seasonal price increases for cereals such as maize and rice were more pronounced in the more remote areas, especially when there was a net deficit in local production for the item. For example, in periurban areas the seasonal fluctuation in prices for these cereals was negligible.

Differences in the level and composition of income in rural areas with different degrees of access to services and infrastructure can also be identified. Of the two main ecological areas in Chipata District, the plateau sites are generally more accessible year-round than the valley sites. However, in terms of physical access to local centers of input supply and output marketing, as well as consumer products and services, there is substantial variation among sites. When the study sites were grouped according to access to agricultural infrastructure, some interesting patterns emerged (Figure 2). The plateau site with the best

Figure 2
Effect of agricultural infrastructure on agricultural production and sales and off-farm income, Chipata District, Zambia, 1981-82



Source: Shubh Kumar.

[a] Total value in kwacha per household
[b] Total value of postharvest sales per household in kwacha
[c] Gross kwacha per year, not including remittances

agricultural infrastructure also had the highest agricultural production income, the highest self-employment income (predominantly in the informal sector), and the highest cash income, both from agricultural sales and from off-farm sources. The reverse was the case for those plateau and valley sites with the poorest access to agricultural infrastructure. Even though household food intake and child nutritional status were found to be positively affected by overall household income, the association of these sites with cash and off-farm income components was relatively weak. This may partly be due to state marketing policies, which have contributed to the fragmentary nature of rural markets and other consumer-oriented institutions in rural areas, such as those for savings or credit. Without these institutions, the ability of households to translate improvements in cash income into dietary improvements at all times of the year may be limited.

Available evidence from both Bangladesh and Zambia suggests that improvements in rural infrastructure can improve household income from agriculture and nonagriculture, household food consumption, and the nutritional status of children. However, for growth in rural incomes to be translated into dietary and nutritional improvements, growth in other services, such as rural food markets and health and education services, also need to expand. In countries such as Zambia, where these services are primarily limited by the state activities, the favorable effects of the growth in cash incomes may be relatively limited.

INFRASTRUCTURE & AGRICULTURE

COMMERCIALIZATION

JOACHIM VON BRAUN

Integration of small farmers into the local, national, and international exchange economy opens up opportunities for specialization. Yet it has frequently been assumed that it is inappropriate to introduce into the small-farm sector technologically complex new export crops, and therefore small-farmer households should be viewed as providing only labor—not investment and entrepreneurship—in the commercialization process of agriculture. In Guatemala, for instance, this translates into policies that focus on large-scale export crop promotion (cotton, coffee, sugarcane, and beef) and on extreme concentration of land: 2 percent of the farmers hold 67 percent of the agricultural land. Historically, this has resulted in a wage-labor pool squeezed onto less productive soils in the Highlands, where most of the land is still sown with subsistence crops.

Collaborative survey work by the Institute for Nutrition in Central America and Panama (INCAP) and IFPRI shows that in a typical western Highland situation, 80 percent of the land is sown with maize and beans, 90 percent of which is consumed by the farm households who earn much of their cash income in the off-farm labor market.

CONCENTRATION OF INFRASTRUCTURE INVESTMENT

Public policy plays a key role in setting priorities for infrastructure investment. State policy on allocation of fiscal resources for infrastructure has promoted the concentration of the agricultural export sector. Public sector investments in transport, communication, and services were 3 to 10 times higher on a per-capita basis in areas where large-scale export farming is concentrated than in the small-farm regions of the Highlands during the period 1970-76.

Area	US$/Year/Capita
Small-farmer highland	
El Quiche	2.41
Huehuetenango	3.26
Sacatepequez	5.70
Large-farmer lowland	
Izabal	16.19
Santa Rosa	18.31
Escuintla	27.13

This approach reenforces the dual structures by neglecting investments in human capital such as education and training—literacy among small farmers is about 55 percent—and by concentrating capital investment in large-scale agriculture. As shown in the following example, improved infrastructure is instrumental to successful integration of the small-farm sector into the development process.

INFRASTRUCTURE AND NONTRADITIONAL EXPORT CROPS IN THE SMALLHOLDER SECTOR

In the mid-1970s, nontraditional export vegetables, such as cauliflower, broccoli, brussels sprouts, and snowpeas, were introduced in Guatemala. Because these crops are highly labor intensive, they give better returns when grown on smaller plots. The small-farm sector in the Highlands rapidly adopted the crops once market outlets were provided through contract growing and independent growers cooperatives.

IFPRI and INCAP made an in-depth study of the effects of nontraditional export crops on employment, income, consumption, and nutrition at the site of a small-farmer cooperative called Cuatro Pinos, which specializes in nontraditional export vegetables. The interaction between infrastructure and the labor-intensive new crops proved to be important to the success of the new crops.

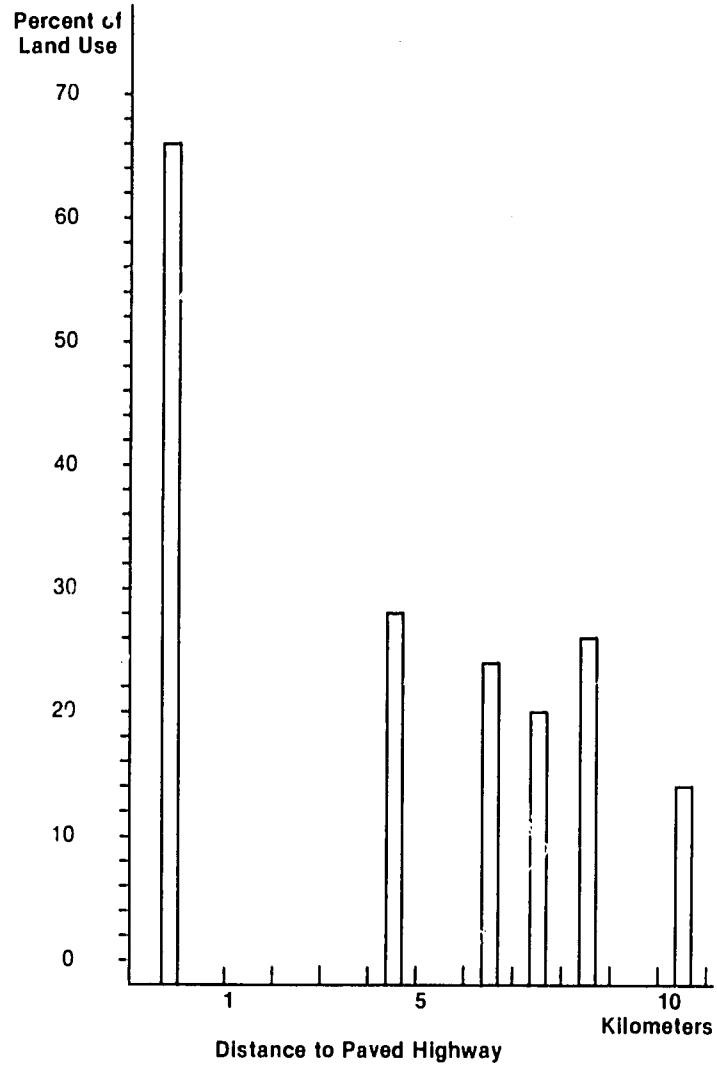
The nontraditional export vegetables create a lot of employment. Demand for field labor is about five times higher than that for maize. About half of the incremental labor is from family labor, largely drawn from off-farm work, and the other half is hired labor. Additional employment is created in transporting and processing the vegetables.

Most of the nontraditional export vegetables are grown in areas close to the Trans-American Highway, which provides a fast link to Guatemala City and the export outlets. Clearly, this well-kept road reduces marketing costs and eases access to markets, thus encouraging adoption of the new crops. Consequently, the rate of adoption of the new crops was significantly higher in villages located closer to the highway (Figure 1).

Certainly, the initial foundation of the export vegetable cooperative was facilitated by the geographical advantage of villages with "hard infrastructure"—good road access and electricity available for cool storage. Nevertheless, the actual foundation of the cooperative in 1979 and its rapid growth thereafter were the result of a complex institutional process. Expansion of local infrastructure and services followed the commercialization process and the institutional developments it induced. Some of the "soft infrastructure" stimulated by the introduction of export vegetables under a cooperative framework were

- Village farm input supply shops;
- Credit facilities;

Figure 1
Proximity to paved road and share of land used for export vegetables and other cash crops in six villages of the Cuatro Pinos Cooperative, 1985



Source: IFPRI/INCAP Survey, 1985.

- Output collection and packaging points and truck transport to and from villages (trucks not only carry the new crops but goods and passengers);
- Central facilities for processing and packing; and
- Social infrastructure, including health care services, nutrition and child care education for women, and adult literacy and accounting classes.

INFRASTRUCTURE, COMMERCIALIZATION, AND SUBSISTENCE PRODUCTION

There was concern that expansion of nontraditional export crops in the Western Highlands would further increase household food insecurity in an area where malnutrition is prevalent. Data show, however, that farm households that grow the new crops maintain a per capita supply of staple food from own production for food security similar to the stocks of other farmers of the same farm size and land quality. The export crop growers achieve this by increasing the intensity of use of labor and fertilizer per unit of land and by increasing the productivity of these inputs in maize production through better crop management. Thus, the loss in maize area to the new crops is compensated for by yield increases (Table 1).

Table 1
Land used for subsistence crops and per capita production of subsistence food in households growing and not growing export vegetables, 1985

	Land Used For Subsistence Crops		Availability of Subsistence Food (Maize) From Own Production	
Farm Size	Export Crop Farmers	Other Farmers	Export Crop Farmers	Other Farmers
(hectares)	(percent)		(kilograms/capita)	
<0.25	38.5	80.8	41	49
0.25-0.50	46.4	79.0	88	82
0.50-1.00	51.9	74.9	113	97
>1.00	54.1	66.8	137	138

Source: IFPRI/INCAP survey, 1985.
Note: The total sample was 400 households.

The hypothesis that the more efficient farmers—those with the higher yield statistics—were the first to join the export crop scheme is not supported by the analysis. However, more schooling was significantly associated with higher maize yields. Among export crop growers, each additional year of schooling of the head of household was found to increase yields by 7 percent, but education was not a significant factor among other farmers. It seems that once a farm enterprise becomes more complex, education increasingly pays off; enhanced education has to be part of a successful commercialization process.

Almost all farmers reserve a substantial share of their land for subsistence food, and they even make investments to maintain self-sufficiency in staple foods, even though the new crops yield about twice the return per labor day, and a shift of more land to nontraditional export vegetables is technically not limited. Farmers are cautious because of past experiences with market failures and high fluctuations, be it in the food or the labor markets. In theory, a more drastic shift into production for the market would be the "first best solution," if risks were not considered. Instead, farmers have adopted a "second best strategy"—increased productivity in subsistence production combined with expansion of more profitable nontraditional export crops—which is effective provided it is supported by rapid technological change in subsistence crops. In the long run, better rural infrastructure further reduces the probability of market failures and increases market integration, thus stimulating a move toward an economic "first best solution" of resource allocation in the small-farm sector.

INFRASTRUCTURE & AGRICULTURE

RICHARD H. SABOT

This note focuses on the possibility that investment in education may enhance the returns to investment in rural infrastructure and that, conversely, the returns to investment in education may be higher in rural areas with more highly developed infrastructure. This positive interaction may, in turn, reflect a more complex set of interactions between investments in education and infrastructure, on the one hand, and investment in directly productive rural activities, both agricultural and nonagricultural, on the other.

Many developing countries are at a watershed regarding the educational attainment of the rural labor force. Until recently parents in rural areas viewed investment in education as a means of gaining access for their children to the urban labor market. Rural-urban migration was highly selective of the educated: rates of urban migration increased sharply with educational level and, in the early stages of educational expansion, approached unity for primary as well post-primary school completers.

Despite substantial increases in educational opportunities in rural areas the rural labor force remained predominantly uneducated. The educational selectivity of rural-urban migration drained source areas of their best-endowed workers. It was likely, therefore, to have diminished the benefits of out-migration to those areas—higher per capita income in particular—predicted by neoclassical theory. The selectivity of migration also implied that activities in urban areas reaped the bulk of the productivity benefits of investments in education made by residents of rural areas. The income benefits yielded by education were likely to have been shared somewhat more evenly as a consequence of urban-rural remittances.

The pattern of migration and the incidence of the benefits of both migration and education have been changing quite rapidly in some countries. In the last two decades it has been common for the rate of growth of the educational system to outpace the growth of labor demand in the urban occupations in which the employment of educated workers was previously concentrated. The result has been a "filtering down" of successive cohorts of workers with a given level of education into lower-level occupations. Once the probability of any educational group obtaining urban employment begins to decline, further educational expansion and filtering down tend to decrease the rates of urban migration of the educated in rural areas and, consequently, to increase the educational attainment of rural populations.

Consider, for example, the change that has occurred in rural Pakistan. Table 1 shows the educational attainment of various age groups of the rural labor force in three regions. In the Punjab and Northwest Frontier Province the increase over time of educational attainment is quite striking: moving from older to younger groups, the proportion of workers with no education declines while the proportions with primary and secondary education rise sharply.

Table 1
Educational attainment of three age groups of males in three provinces in rural Pakistan, 1987

	Punjab						
Age Group	Uneducated	Primary	Middle	Secondary	or	More	Total
15-29	129	81	60	69		13	352
	(36)	(23)	(17)		(20)		(100)
30-44	101	25	26	42		15	209
	(48)	(12)	(12)		(27)		(100)
More than 44	226	38	25	16		4	309
	(73)	(12)	(8)		(7)		(100)
	Northwest Frontier Province						
Age Group	Uneducated	Primary	Middle	Secondary	or	More	Total
15-29	108	36	59	60		22	285
	(38)	(13)	(21)		(29)		(100)
30-44	99	21	13	39		29	201
	(49)	(10)	(7)		(34)		(100)
More than 44	165	25	7	14		5	216
	(76)	(12)	(3)		(9)		(100)
	The Sind						
Age Group	Uneducated	Primary	Middle	Secondary	or	More	Total
15-29	212	32	4	4		1	253
	(84)	(13)	(2)	(2)			(100)
30-44	143	28	8	5		3	187
	(77)	(15)	(4)	(3)		(2)	(100)
More than 44	157	18	5	2			182
	(86)	(10)	(3)	(1)			(100)

Source: Richard Sabot
Note: The numbers in parentheses are percentages. Totals may not add to 100 percent because of rounding.

The increase in educational attainment has two important implications. First, it confirms that 20 years ago in Pakistan it would not have been meaningful to consider whether the returns to investment in education vary with rural infrastructure endowments. Today, assessing the consequences and sources of variability of the large injection of human capital in rural areas is a feasible undertaking and an increasingly pressing issue.

Second, the increase in educational attainment of the rural labor force in Pakistan suggests a potentially serious error in the conventional method of conducting the cost-benefit analysis of education. Standard measures of rates of return are based on data generated by sample surveys of urban wage employees. The measures exist for more

than 40 countries and have had an important influence on the magnitude of government expenditure on education and on the priority given to the various levels of education.

But educational expansion and filtering down may make the performance of primary-completers who left school a decade or two earlier a hollow prospect for those just entering the urban labor market. In all but a few developing countries the majority of the marginal cohort of primary-school completers will not obtain urban employment. Rather they will enter employment in rural areas. In a smaller but growing number of countries the same will be true for the marginal cohort of secondary-school completers. The returns to primary and secondary education in these countries will thus crucially depend on the effects of education on productivity in agriculture and in rural nonagricultural activities.

Thus, a number of hypotheses regarding the interaction between investments in education and infrastructure are suggested:

1. The larger the stock of infrastructure in the locality, the greater the increase in agricultural productivity that results from a rise in the educational level of the agricultural labor force. Moreover, to realize the positive relationship between education and agricultural productivity, infrastructure may have to be in excess of a threshold level. Allocative efficiency and the tendency to innovate and apply lessons taught by agricultural extension programs may all increase as a consequence of a rise in the educational attainment of farmers, but only where the stock of infrastructure is sufficient to permit the commercialization of agriculture. Conversely, while investment in roads may increase opportunities for the commercialization of agriculture, the extent to which those opportunities are exploited may be a function of the educational level of farmers.

2. The larger the stock of rural infrastructure, the greater the increase in levels of production, employment, and labor productivity in nonagricultural rural activities resulting from a rise in the educational level of the rural population. As above, for the benefits of education to be reaped, it may be necessary to have a certain minimum stock of infrastructure.

Again, education may be thought of as enabling the rural population to take advantage of opportunities, in this case for diversification out of agriculture into rural services and manufacturing, provided by investments in infrastructure. Education may do this by fostering entrepreneurship. In addition the stimulus to rural economic activity provided by the increased supply of educated workers may reflect the greater (cognitive) skill intensity of labor demand in rural nonagricultural activities than in agriculture.

3. The greater the stock of infrastructure the greater will be the effect of a rise in rural educational levels on linkages between agriculture and nonagricultural rural activities and between rural and urban activities. The implication is that the greater the stock of infrastructure, the greater will be the effect of an increase in educational levels on the magnitude of multiplier effects resulting from an increase in demand originating in one sector or of a sector-specific cost-reducing innovation.

4. Investment in infrastructure in relatively isolated rural areas will increase the rate of return to investment in schooling by permitting economies of scale and low-cost improvements in school quality. In rural areas where the population is spatially dispersed and roads are poor the only way to achieve high enrollment rates is to have many small schools. Improvements in local transport will increase a school's catchment area and permit a larger average school size. This may permit savings in expenditures on overheads (including school books and other teaching materials).

Moreover, the reduction in the isolation of teachers may yield positive externalities. Improvements in the quality of education may also result from an increase in the ability to recruit more skilled teachers at the prevailing wage. One effect of reducing the isolation of rural areas is to increase their attractiveness to teachers as places to live. Improvements in the skill level of teachers that result from investment in infrastructure should reinforce those that result from the more general increase in the supply of educated workers in rural areas.

5. The greater is the stock of human capital, the larger the effect an increase in rural education levels will have on the nature of, and expected returns to, investment in services. If commercialization of agriculture and diversification into rural manufacturing proceeds at a more rapid pace because of the education-infrastructure interaction, it follows that there will be increased demand for commercial services.

Furthermore, increases in the education level of target populations will require changes in the teaching methods used by agricultural extension, nutrition, health, and family planning programs. The greater is the level of infrastructure, the easier it will be to upgrade the quality of these programs, for reasons similar to those that apply to the improvement in educational quality.

6. The hypotheses above have stressed positive interactions between returns to investment in education and in rural infrastructure. However, it should be noted that to the extent that rural infrastructure projects become make-work projects for school-leavers, the returns to both investment in education and investment in infrastructure will be depressed.

The rapid increase in the supply of educated workers, many of whose employment expectations have been disappointed, will undoubtedly give rise to political pressures for the public sector to employ more educated workers than is justified by the derived demand for labor. The potential productivity gains associated with the build-up of human capital in rural areas will not be realized if school-leavers are employed by public works bureaucracies at a negligible social marginal product. Moreover, the cost of infrastructure projects will then rise without a concomitant rise in returns.

INFRASTRUCTURE & AGRICULTURE

STEPHEN A. VOSTI

Policymakers are often concerned with the effects of government investments in infrastructure, especially the short-term and long-term distribution of benefits related to consumer welfare and increased agricultural productivity, and the lags between initial capital outlays for infrastructure improvement and the realization of productivity gains in agriculture. Understanding the overall effect of investments in infrastructure requires focusing on the short-term and long-term adjustments of rural households. Using data on rural electrification in Brazil, this note sketches the theoretical notions underlying short-term household adjustments following improvements in infrastructure and presents and statistically supports an intuitive mechanism that promotes subsequent investments in technologically advanced agricultural inputs.

HOUSEHOLD EFFECTS

Rural farm households tend to reap the short-term welfare benefits of improvements in infrastructure before exploiting the latent increases in agricultural productivity inherent in infrastructure. This trend is of particular concern to many policymakers in developing nations. There are valid reasons for this initial consumption-oriented reaction, as well as for subsequent investments in agriculturally productive inputs both directly and indirectly related to specific improvements in infrastructure.

First, the benefits derived from investments in consumer durables, many of which are made feasible by improvements in infrastructure, are often immediately available to all household members and may have spin-off benefits to neighbors as well. For example, once electric wires are strung, the information and entertainment provided by television and the improved storage capabilities offered by refrigeration are available at the flip of a switch. Conversely, investments in modern farming inputs generally show some return only after at least one crop cycle, thereby making equivalent investments relatively less attractive, especially to those with relatively high discount rates, limited access to capital markets, or both.

Second, the out-of-pocket and other marginal costs associated with capturing these short-term welfare benefits associated with infrastructure improvements are generally low. An electric shower apparatus, for example, is relatively inexpensive and easy to use, and greatly increases the satisfaction derived from bathing. Improved farming techniques, on the other hand, often require the purchase of a "package" of complementary inputs, as well as the potentially time-consuming and costly acquisition of new knowledge.

Third, reaping the benefits associated with increased agricultural output (often regardless of its origin) involves factors that are beyond the immediate control of farmers. Uncertainty generated by prices, access to complementary inputs and storage facilities, and the generally unknown demand elasticities for farm products all combine to decrease the expected returns to investments in agricultural technology.

Data collected from 1979-84 in Brazil's Zona da Mata in Minas Gerais by the University of Vicosa support these hypotheses regarding the access to and use of electricity available to rural households. The initial benefits derived from electricity were generally found within the home. In 1979, 81 percent of those with access to some type of electricity used it exclusively within the household, while only 17 percent made use of electrical power both inside the home and on the farm. Only 2 percent used electricity solely for farming purposes. Detailed 1981 data also indicate rural households' preferences for consumer durables, with 41 percent owning televisions; 78 percent, refrigerators; and 46 percent, radios.

Given that farm households are likely to invest initially in short-term welfare improvements, questions remain about whether subsequent investments in modern farming inputs will follow, and what the mechanism for generating these productivity improving investments will be. Intuitively, it can be assumed that the returns to short-term, welfare-improving investments will drop off quickly once some culturally determined level of "acceptable" comfort has been achieved. Subsequent investments in refrigerators and televisions would be viewed as redundant, time discount rates are likely to decrease, and the overall focus will shift from investments in consumer durables to increasing the longer-term productive potential of farms. Further, farms that have made initial investments in consumer durables will be more likely to invest in modern inputs due, in part, to their greater access to information. Empirical evidence supports these hypotheses. In 1979, only 21 percent of those farms with access to off-farm electricity used it for both farming and household purposes. That preparation increased to 33 percent in 1981 and further to 45 percent by 1984.

There is also statistical support for the increasingly important links between the existence of electricity on farms and the degree to which farmers employ other types of modern farm technology. Based on data collected in 1979, shortly after the integrated rural development project was initiated in the Zona da Mata of Minas Gerais, estimations of the influence of electricity on the use of chemical fertilizer on maize indicated no significant link. However, as time passed, the importance of electricity increased. It became statistically significant in 1984, indi-

cating that, controlling for other factors known to influence adoption rates, rural households with access to electricity were more likely to invest in other modern farm technology than households without electricity.

CONCLUSIONS

If the short-term welfare gains generated by improved infrastructure are preferred by rural households to the generally delayed productivity gains yielded by the same source, then it appears that the first-order effects of investments in infrastructure are likely to fuel household investments in consumer durables, and that increased use of modern farming inputs is a second-order effect. Data from Brazil's Zona da Mata confirm the initial concentration of benefits from electrification within the home and, more importantly, demonstrate a trend toward expanding its use to farming. Finally, over time, access to electricity is shown to be increasingly significant in determining the use of other types of modern farm technology in that specific socioeconomic and agricultural environment.

In closing, it should be noted that because the benefits to rural households of improved infrastructure are neither instantaneous nor distributed symmetrically across households, and because the farm-level adjustments required to make use of newly available (or less expensive) inputs are neither automatic nor immediate, measuring the effects of investments in infrastructure on household welfare and agricultural production requires detailed longitudinal data.

INFRASTRUCTURE & AGRICULTURE

RAFAEL CELIS

RECENT INFRASTRUCTURE DEVELOPMENT

Costa Rica is known for its impressive development as a political democracy, its low rate of illiteracy, and its fair income distribution. Another less well known but equally essential feature of the economy, however, is Costa Rica's steady improvement of basic and supplementary infrastructure during the last two decades.

Table 1 shows that by 1986 Costa Rica had 99 kilometers of paved roads per 1,000 square kilometers. For the sake of comparison, this figure is triple that of Bangladesh in 1980/81. When tar and gravel roads are included, Costa Rica has 278 kilometers of all-weather roads per 1,000 square kilometers; when dirt roads are included this figure rises to almost 700 kilometers for the dry season. The intensity of road use has steadily grown as illustrated by an increase in cargo and passenger transportation per kilometer of 8.9 percent and 6.9 percent per year respectively.

Table 1
Some indicators of infrastructure development in Costa Rica, 1966-86

Indicator	1966	1986	Annual Growth Rate %
Tar roads (kms/1000 kms²)[a]	n.a.	99	. . .
Gravel roads (kms/1000 kms²)[a]	n.a.	179	. . .
Dirt roads (kms/1000 kms²)[a]	n.a.	416	. . .
Number of motor vehicles (1000)	41.8	226.9[b]	9.3
Cargo transported by road (million tons per kilometer)	438[a]	2,875[b]	8.9
Passengers transported by road (millions per kilometer)	2,790[a]	12,080[b]	6.9
Electricity users (1000)	125.9	512.4	7.3
Sales of electricity (gigawatts)	548	2,697	8.3
Telephone lines (1000)	26	276.4	12.5
Number of public telephones	62	5,018	24.6
Coverage of water supply (% of population)			
Total	74[c]	82[d]	0.8
Rural	35[c]	62[d]	4.5
Coverage of sewage systems (% of population)			
Total	38[c]	91[d]	6.9
Rural	30[c]	87[d]	8.5

Sources: Costa Rica Ministerio de Obras Publicas y Transportes (MOPT); Instituto Costarricense de Electricidad (ICE); and Instituto Costarricense de Acueductos y Alcantarillados.

[a] Figures for 1963; [b] for 1985; [c] for 1967; [d] for 1980.

The number of users of electricity has increased at an average annual rate of 7.3 percent and sales of electricity by 8.3 percent per year. This resulted in an increase of electricity consumption per 1,000 users from 4.35 to 5.26 gigawatts over a span of 20 years. In 1986 two-thirds of electricity users were located in small towns and rural areas. Costa Rica has also exported electricity to Panama and Nicaragua since the early 1980s.

In Costa Rica today each and every community in rural areas has access to telephone service. Among the indicators presented in Table 1, the telephone system has shown the sharpest increase, especially the public telephone service with an annual growth rate close to 25 percent.

Water supply and sewerage services, key elements in public health, have experienced dramatic changes in Costa Rica, especially in rural areas. In the last 20 years, rural water supply coverage has doubled and the rate of construction of sewerage systems (sewage conduits, latrines, and septic tanks) is such that the proportion of rural population covered is now three times larger than two decades ago. These achievements even exceed the goals established by international health organizations.

There are other components of infrastructure, not included here, that have also played an important role in the social, political, and economic development of the country. Among them are hospitals and health centers, schools, community centers, storage facilities, seaports and airports, railroads, and permanent markets. An ambitious irrigation project is under way in the northwest part of the country, which will serve more than 56,000 hectares by the year 2000, approximately one-fifth of the country's area sown in annual crops.

CRITICISMS AND EXPECTATIONS OF INFRASTRUCTURAL DEVELOPMENT

Although Costa Ricans in general are proud of their system, the strategy of infrastructure development followed by successive governments has been severely criticized. These criticisms have come both from within the country and from international agencies. Among the various opinions, the following are worth noting:

- Infrastructure development has promoted the growth of an increasingly oversized public sector. This has impaired the efficiency of the economy as a whole and has imposed the burden of larger and larger fiscal deficits.
- Fixed capital investment has been biased toward basic infrastructure and that supporting social programs such

as schools and hospital buildings, both of which are not immediately productive. People who support this argument believe that Costa Rica has shared the pie before baking it.

- Costa Rica's huge external debt—one of the largest per capita in the world—has originated mainly from the need to finance the building of infrastructure with external borrowing. The feasibility of repaying the debt is remote, precisely because the type of infrastructure is not productive and because the services provided are highly subsidized.

On the other hand, many people, including the most severe critics, recognize that the infrastructural base the country has today is its most valuable asset for spurring economic growth. The possibilities for attaining equity goals at the same time are more tangible due to an even spread of infrastructure throughout the country.

PAST TRENDS AND FUTURE PROSPECTS

Verifying the validity of these criticisms is a complex task. But it is possible to look at some basic historical information and reflect on the issues raised (Table 2). To be consistent with major economic events, the information is broken down into three periods: 1966–80, a period of expansion of the economy; 1981–82, the years in which the most profound economic crisis of the last four decades was manifested; and 1983–85, when recovery from the crisis clearly took off.

During the 1966–80 period, GDP grew on average by a respectable 6 percent per year. Although agricultural production grew at a slower pace, exports of agricultural origin experienced an impressive increase that doubled the rate of growth of GDP. During the same period, fixed capital investment grew faster than GDP, and its components, construction and machinery, moved at about the same pace. Public investment grew more rapidly than private investment; this is also reflected in a larger growth rate of government expenditures and fiscal deficits. External debt became more than 20 times larger with most of the resources going to finance basic infrastructure, social programs (education, health, and housing), and balance-of-payments deficits. To a much lesser extent, the foreign debt also directly supported production activities.

Without implying a cause-effect relationship, one can say that during this first period infrastructure grew largely through borrowing from external sources. The size of the government also increased to cope with expanding development of infrastructure and social programs. It must be noted, however, that the private sector played an important role in capital accumulation.

During the crisis period of 1981–82, GDP, investment, total exports, and even government expenditure and fiscal deficits sharply declined. It is interesting to note, however, that agricultural exports continued to expand modestly overall, especially exports of processed agricultural products. External debt, on the other hand, reached unprecedented levels, presumably to compensate for the drop in production and investment.

Between 1983 and 1985 the economy, supported in part by capital inflows from abroad, grew again. Since emerging from the crisis, the economy has already shown interesting changes. First, the composition of investment, which in previous years was balanced between construction and machinery, now favors purchase of the latter.

Table 2
Growth of production, exports, fixed capital investment, external debt, and government expenditures in Costa Rica

Indicator	1966	1960	1982	1985	Average Annual Growth Rates 1966-80	1981-82	1983-85
GDP		(1966 ¢ millions)				(percent)	
Total	4,288.4	9,647.8	8,742.6	9,790.6	6.0	-4.8	3.8
Agriculture	994.1	1,736.1	1,738.8	1,933.4	4.1	0.1	3.6
Fixed capital investment							
Total	735.9	2,424.5	1,314.3	1,977.4	8.9	-26.4	14.4
New construction	388.5	1,212.6	712.4	928.0	8.5	-23.4	9.1
Machinery	347.4	1,211.9	601.9	1,049.4	9.3	-29.5	20.1
Private	527.0	1,653.5	983.0	1,573.5	8.5	-22.9	16.8
Public	208.9	771.0	331.3	403.9	9.8	-34.4	6.8
Exports		(US$ millions)					
Total	135.7	1,000.9	869.8	933.5	15.3	-6.8	2.4
Agriculture	108.1	570.4	596.8	669.7	12.6	2.3	3.9
Nonprocessed	93.9	480.8	491.9	549.6	12.4	1.1	3.7
Processed	14.2	89.6	104.9	120.1	14.1	8.2	4.6
External public debt		(US$ millions)					
Total	160.8	1,734.5	2,962.0	3,694.0	18.5	30.7	7.6
Allocation to Productive sectors	44.4	390.6	n.a.	n.a.	16.8	...	...
Basic infrastructure	65.3	849.9	n.a.	n.a.	20.1	...	...
Social sectors	9.2	224.0	n.a.	n.a.	25.6	...	...
Balance of payments	28.2	182.9	n.a.	n.a.	14.3	...	...
Other	13.7	87.1	n.a.	n.a.	14.1	...	...
		(1966 ¢ millions)					
Government expenditure	694.5	2,044.6	1,094.9	1,796.3	8.0	-26.8	17.7
Government deficit	172.8	854.0	224.8	378.0	12.1	-48.7	18.7

Sources: Banco Central de Costa Rica; MIDEPLAN; IMF.

Second, investment from the private sector was more than double the growth rate of public-sector investment. Third, agricultural exports continue to be the most dynamic ones.

Based on these observations, the following conclusions can be drawn:

- Democratic values, such as freedom of speech and political pluralism, would not have been put into practice if a good educational system had not been developed. The latter's success was a direct result of improved health, communication systems, and job opportunities, all of which infrastructure helped to develop.
- An oversized infrastructural base may be a burden during normal times, but it becomes a key element for recovery after a crisis.
- Public-sector intervention is key in infrastructural development, but private-sector participation is essential as well. The role of the private sector appears to be facilitated by the public sector's initial role.
- Infrastructure that is not directly productive might be a burden on the economy in certain periods. There is a point, however, at which the economy can rapidly absorb investment in directly productive capital thanks to the existence of a large infrastructural base.
- Infrastructural development can produce the best results in terms of growth and equity only when it is complemented with policies that facilitate its utilization. Macro policies and institutional setting are extremely important in this regard.