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Effects of Irrigation on Rice Productivity and Commercial, Educational and Overall Infrastructure on Farm-Household Decisions in Central Punjab, 1992

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EFFECTS OF IRRIGATION ON RICE PRODUCTIVITY AND COMMERCIAL, EDUCATIONAL AND OVERALL INFRASTRUCTURE ON FARM-HOUSEHOLD DECISIONS IN CENTRAL PUNJAB, 1992

By

Memoona Rauf Khan

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ABSTRACT

EFFECTS OF IRRIGATION ON RICE PRODUCTIVITY AND COMMERCIAL, EDUCATIONAL AND OVERALL INFRASTRUCTURE ON FARM-HOUSEHOLD DECISIONS IN CENTRAL PUNJAB, 1992

By

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To offset declining productivity and incomes in the current cropping systems in Pakistan, the Government invested substantially in rural infrastructure during 1986-92. Analysis of variance (ANOVA) examines whether higher levels of rural infrastructure have actually affected farm-level choice of on-farm and off-farm labor employment, crop mix and educational investments in the rice-wheat production system. Dummy variable Cobb-Douglas production models measure the effect of irrigation infrastructure and commercial labor markets on rice productivity.

Cluster analysis demonstrates that the majority of sample villages have good access (measured by distance) to most infrastructural services. ANOVA results indicate that increased access to industrial town or overall infrastructure are associated with greater off-farm employment by rural farm-households. High industrial town and overall access is associated with half of farmland grown to summer horticultural crops compared to low access areas where one-tenth of farmland is planted to such crops. Better overall and market town access is associated with farmers' increasing diversification of their farmland to livestock crops, and away from winter wheat.

Higher overall and educational infrastructural access are identified with increased male and female literacy, but their effect on male literacy is much higher. Adult males benefit from past formal or informal educational investments. One-third of off-farm employment include professional and government jobs or skilled trades.

Irrigation water systems for 113 rice farmers are defined by canal water, private and government tubewells and their combinations. Canal water is used by four-fifths, tubewells by three-fifths and government tubewells by two-fifths of such farmers primarily in combination with one or more of the other irrigation sources. Canal water was the single-most efficient irrigation source while private tubewells were intermediate in efficiency between canal water and government tubewells. Canal water in combination with private tubewells was found to be the most efficient irrigation combination and yielded the highest total factor productivity. Farmers with irrigation systems consisting of government tubewells combined with any one or both of the other sources had the lowest efficiency. Closer access to the market town also increased rice productivity.

DEDICATION

This dissertation is dedicated to my loving and understanding parents who gave me the courage and support to succeed

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CHAPTER 1: INTRODUCTION

1.1 Background

Development of infrastructure stimulates agricultural development and economic growth within developing countries in several ways. Mellor (1988) and Mellor and Ahmed (1989) argue that within agriculture infrastructure contributes to the dissemination of technology, increased trade, mobility and division of labor. Reardon and Vosti (1995) also argue that infrastructure creates incentives for farmers to diversify their agricultural output, followed by intensification to one or more crops, in order to enhance system or total factor productivity on their farms. Infrastructural improvements transform the economy of villages and towns from subsistence-level to commercialized economies by creating and expanding production and consumption linkages between agriculture and other sectors of the economy. In developing countries such as Pakistan labor released from agriculture often works in service and industry sectors related to agriculture. Hence increased agricultural productivity leads to enhanced off-farm productivity through production linkages such as fertilizer factories, input (seed, fertilizer and pesticide) procurement centers, light engineering workshops, development of indigenous transport modes as well as consumption linkages operating through increased incomes and purchasing power.

Two key categories of physical infrastructure, irrigation and roads, have played a catalytic role in the agricultural growth path of Pakistan since the 1960's and 1970s. Extensive public infrastructural investment in tubewell and canal irrigation facilitated the rapid adoption of Green Revolution high-yielding seed and fertilizer (Naseem 1981; Khan 1981, 1975). The resulting increase in agricultural productivity generated spin-off effects. During the period 1963-1973 per capita agricultural incomes rose from $200 to

$300[1] (Pakistan Economic Survey, 1986), a growth rate of 10% per annum. Infrastructure together with technology was instrumental in causing a structural transformation within Pakistani agriculture. Initially farmers diversified their crops to include one or more cash crops. Eventually they intensified the production of their major cash crops giving rise to new cropping systems identified with high-yielding varieties of Basmati and IRRI rice, Mexi-Pak and American cotton and maize varieties, as well as the country's staple wheat (Naseem 1981; Khan 1981,1975). Total system and factor productivity on farms increased, leading to a rise in rural incomes which stimulated the demand for manufactured goods, and released labor to the small and large industries manufacturing sector.

As the agricultural economy grew, government reinvested in the expansion of physical infrastructure. As a result, road networks around urban, market and district centers were enhanced and new irrigation projects were constructed, including projects that diverted rivers from their natural flow through permanent headworks at strategic points[2]. The expansion of roads enabled farmers to gain access to existing and evolving commercial market networks, while enhancing their potential agricultural productivity through increased water availability. Hence, farmers benefited from the multiplier effects of increased productivity.

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[1] In Pakistan, agricultural production contributes to 38% of GNP and 60% of exports as well as providing food and fibre to a population of 120 million people, (increasing at the rate of 2.9% per annum). Hence 57 percent of the population derive their livelihood directly or indirectly from agriculture.

[2] These dams which include Mangla, Tarbela and Guddu Barrage are very extensive in size. For example, Tarbela Dam is the world's largest earth-filled dam.

1.2 Problem Statement

These developments contributed to rapid growth in agricultural output for two decades. However, since the late 1970's, population pressure on existing land and water resources has increased dramatically causing declining land, labor and total factor productivity in the current cropping systems (Byerlee 1987). The quantity of land and water resources have deteriorated as farmers' overuse of tubewell water has caused severe salinization of soils, while flooding along the canal water-courses has led to waterlogging. The flow of water along the water-courses has also declined, mainly due to dwindling water levels in the northern rivers.

In order to offset this decline in productivity, the Government made a major second-round infusion of road infrastructure during the period 1986-92, with the goal of increasing household incomes. Improvements in rural infrastructure have again been directed at increasing farmers' opportunities to avail themselves of profit-generating activities. However, recent major investments in roads has not been accompanied by investment in irrigation.

1.3 Research Justification

While the general role of infrastructure on agricultural development is widely acknowledged, policy-makers require information on the impacts of specific types of infrastructure in order to guide future investment decisions. To date, data on infrastructure in Pakistan has been gathered and analyzed primarily at the aggregate level. Measures used have consisted of estimates of the proportional share of GNP spent on roads or irrigation or the relevant type of infrastructure (e.g communications, transport etc). Jimenez (1993) has criticized such measures pointing out that it is hard

to attribute causality between such aggregate infrastructural measures and development outcomes.

Hamid and Hussein (1974) have analyzed the collective effect of a number of types of infrastructure at a more disaggregated (district) level. Other researchers have selectively examined issues of individual types of infrastructure such as health and education. Some disaggregated infrastructural data has been gathered by research agencies, such as the International Food and Research Policy Research Institute, (under the Pakistani Food Security project 1988-1994), but the individual and simultaneous impact of various types of infrastructure on agricultural development has only been examined cursorily. Policy debate and research often focuses on one stage or one sector and does not explicitly account for linkages which may arise due to the feedback or secondary effects of important agricultural decisions and outcomes.

The value of these linkages lies in the fact that they may meet more than one development objective at a time. But often policy-makers and economists have little understanding of the impact that simultaneous interaction of all types of village-level infrastructure have upon agricultural development and upon affected groups, such as farmers. The effect that access to one type of infrastructure (e.g irrigation) may have upon farmer behavior may be very different from the effect that access to another type of infrastructure may have (off-farm labor markets). Hence, this study, designed to fill the existing information gap and focuses on analyzing the effect of recent infrastructural investments at a disaggregated (village) level — the level that most directly affects farmers.

In this study, a village is defined as a rural population unit, normally consisting of a number of contiguous households, which may or may not be engaged in farming.

All villages in the study area are agriculturally-based, with most of the land belonging to the farm households contiguous to the village. These villages are well-served by commercial and marketing agents, who take advantage of the high population density of the village to extend infrastructural services to individual households. In addition, the Government typically provides infrastructural services such as tax collection, Government tubewells and security services (police posts) at the village level. Thus information regarding the various types and categories of infrastructural services and their empirical measures of access has been collected at the village level[3].

Infrastructure affects farmers' decision-making jointly, both at the farm and the household level. For most developing countries (including Pakistan), the farm and the farm-household is the same entity. The literature on economic development (Deaton 1994, 1980, Strauss 1986, Barnum and Squire, 1979; and Lau and Yotopoulous 1974 etc) defines a farm household[4] as a socio-economic entity that has the multiple nature of an economic firm producing agricultural output and providing labor supply, as well as being a consumption unit. Such farm-households constitute the main unit of agricultural decision-making and form over 50% of farm-production firms and consumption units within Pakistan[5]. Thus the impact of different types of infrastructure on economic decisions made at the household level need to be analyzed.

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[3] Farmers within the same village are implicitly assumed to face homogeneous levels of infrastructural services.

[4] A household is generally defined to be a group of people who are living in the same house or block of contiguous, jointly-owned houses. The inhabitants are often related to one another and eat from the same pot.

[5] Pakistan Economic Survey, 1994.

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Among summer cash crops, rice is the major crop grown by farmers in the rice-wheat cropping system in the Punjab. Water is an essential input for rice. Thus, irrigation infrastructure affects rice revenues directly through increased water availability, and indirectly through its effect on inputs with which (irrigation) water is complementary. Other types of infrastructure may also affect rice productivity through their indirect effect on inputs.

1.3.1 General Objectives

A major objective of this research is to accumulate and examine evidence on the impact (or lack thereof) of recent Pakistani investments in the different types of rural infrastructure on the rice-wheat production system of Central Punjab, in order to:

1) Measure farmers' access to physical, transport, commercial, telecommunications, institutional, administrative and social infrastructural services in the rice-wheat production system.

2) Examine the impact of these various types of infrastructure on farm-household decisions regarding the choice of crop mix, on-farm and off-farm labor employment and educational investments as well as the linkages between them.

3) Examine the direct impact of different kinds and combinations of irrigation infrastructure upon the productivity of the major crop (rice) in the rice-wheat productivity system.

4) Examine the impact of the quantity of farm resources (inputs) and of marketing infrastructure on the productivity of inputs through an increase in the efficiency of resource use within the rice production function.

5) Examine the effect of commercial infrastructure on rice productivity by way of an increase in the expected price of rice and decreases in expected input prices.

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1.3.2 Specific Objectives and Hypotheses

The focus of the study is to measure the impact of infrastructure on household decisions, as well as total farm productivity. Thus, two types of questions are studied. The first set of objectives and related hypotheses are broader in scope and assess the impact of various types of infrastructure on (1) crop choice, (2) off-farm employment and (3) education and the linkages among them within the farm household. The second series of questions focus more on the productivity on the rice crop enterprise on farms. These questions are designed to assess the (1) direct effect of the different kinds and combinations of irrigation infrastructure on the rice production function; (2) the effect of the quantity of farm resources (inputs), as well as the efficiency of their usage on rice productivity; (3) the direct effect which closer access to marketing infrastructure (represented by market towns) has on increasing the efficiency of resource use within the rice enterprise and (4) the effect of commercial infrastructure represented by the nearness to industrial and market towns on the prices increasing revenues of rice and costs of inputs (decreasing costs).

1.4 Infrastructural Impacts on Farm-household Decisions

As Deaton (1994) has pointed out, the objective of most (farm) households is to maximize their utility, which is generally approximated by real income from all sources. Rural households have different endowments of land, labor, (physical assets including transport, capital goods etc) and human capital skills. In accordance with Reardon and Vosti's decision-making tree (1995), the household makes decisions regarding its allocation of time in a series of steps (Fig 1.1). First household members decide on the allocation of their time between farm and off-farm activities. The amount and type of off-farm employment may be contingent upon their level of human capital

endowment, as well as their access to infrastructure. The household also simultaneously decides whether children or young adults will forego working on the farm, in order to get expected higher returns from future higher-paying work through investment in education. Finally, the farm household decides upon its subsectoral choice regarding its allocation of land for animals, crops and trees. Also it decides between its allocation of land among rice or wheat grains, vegetables, fruits and fodder crops, allocation of land to fallow, and the intensity of cropping within individual crops.

Distinct types of infrastructure affect the various decisions made by the rural farm household along the decision-making tree to varying degrees (Fig 1.1). Sections 1.4.1 through 1.4.3 focuses on the effect of diverse types of infrastructure on three important farm-household choices namely (1) crop choice, (2) off-farm employment and (3) education.

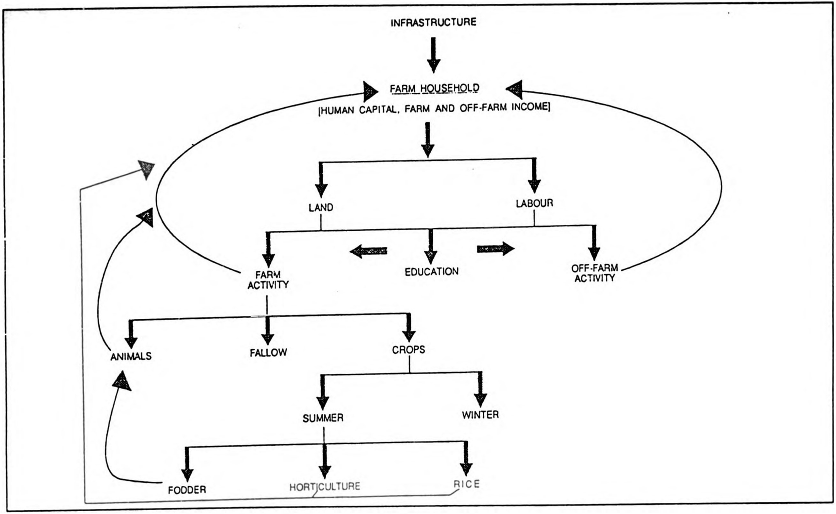

Figure 1.1: The Effect of Infrastructure on Farm-Household Decisions

1.4.1 Crop Choice

By increasing access to the market and urban centers, infrastructure expands the potential size of the market for many agricultural products, e.g bulky perishable fruits and vegetables and other specialty crops demanded by urban consumers. The increased demand for these goods leads farmers to expect that they can obtain higher prices for them in these marketing centers. Thus, the expected prices of high-value perishable and specialty crops may rise, relative to the prices of food and subsistence crops. This creates an incentive for farmers to diversify their crop composition towards these high-value crops, leading to a rise in total farm value. An increase in output multiplied by higher prices generates enhanced crop revenues and family income. At the same time, the costs of producing both the existing and new crop-mix of enterprises is also cheaper, due to lower transport, marketing and other transaction costs. This leads to an increase in short-term profits (defined as revenues less costs)[6].

Easier access to roads (or physical infrastructure) decreases the transport costs, while greater access to trading services or commercial infrastructure decreases the cost of marketing output, enabling formerly bulky and perishable non-tradable goods such as fruit, vegetables and fodder to be marketed. The transport and transactions cost of purchasing fixed and variable inputs such as seeds, fertilizer, herbicides, and machinery and tubewell equipment also fall.

In Pakistan, the effect of infrastructure on the crop-mix within farms may differ with regard to summer and winter crops. In general, opportunities for crop-

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[6] In the short-run even if demand is 'fixed' infrastructure will increase these profits. It may also be noted that implicit rent on owned land is not included in this type of short-run profit.

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diversification within both the summer and winter seasons are conditioned by the availability of irrigation water, rain and land endowment, as well as agro-climatic suitability of the land for growing the various crops. Reliability of water in both seasons, in particular, may induce farmers to diversify to perennial crops such as fruits.

1.4.1.A Summer Cropping

Diversification and specialization opportunities for summer crops are conditioned by a number of important factors. System conflicts in the management of rice and wheat[7] or loss of soil fertility due to water-logging and salinity may induce farmers to diversify production of their crops. Availability of water opens up two routes to farmers: they may diversify their cash crops to include sugar-cane, vegetables (chillies, potatoes, peas), and various fruits (water-melons). Alternatively, farmers with better land resources or management capabilities may choose to specialize more intensely in the production of rice, or another single cash crop, such as tobacco.

But a lack of irrigation water in summer makes farmers totally dependent on monsoon rains, and greatly increases the risk of crop failure. Thus farmers may choose to produce lower-value and less risky green fodder crops (such as maize, millet or sorghum) or utilize the land for grazing. Such farmers may diversify into livestock farming, using fodder as an input in milk production within an integrated farming system. Alternatively, the land may be left fallow to increase soil fertility, thus obtaining no immediate output or return from it.

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[7] One such conflict involves quick turn-around time between harvesting of basmati rice and planting of the wheat crop. Hence while clay soil is most suitable for the production of rice, this time constraint prevents such soil from being drained and dry in time for the sowing of the wheat crop.

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This discussion gives rise to the following research objective and related research question (hypothesis):

Objective

To measure the degree that farmers have shifted their cropped area from summer rice to specialty crops.

Hypothesis

Farmers in more infrastructurally-accessible areas with sufficient irrigation infrastructure have diversified their summer crop to include high-value horticultural crops (fruits and vegetables) and maize, in addition to rice. Such crops are contingent upon having sufficient irrigation water.

1.4.1.B Winter Cropping

Good access to irrigation infrastructure and increased availability of water enables farmers to diversify towards the production of high-value (perennial) fruits and vegetables in the winter season. Better access to large commercial markets representing increased marketing opportunities for their crops, may act as a further impetus for this diversification.

Compared to the summer, more diversification opportunities exist during the winter season for farmers who have access to commercial infrastructure, but no access to irrigation infrastructure. This is because wheat and winter fodder can be grown on residual moisture from the monsoon rains. With ready access to the market, farmers are induced to forgo their risk-averse criteria for growing summer wheat and lower-value fodder crops (for household food security), in order to diversify to specialty-fodder crops. They may sell these specialty-fodder crops directly in the market by u

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market, or utilize them as an input in milk production within an integrated crop-livestock activity.

The following objective and associated hypothesis are derived from this discussion:

Objective

To measure the shift of cropped area from winter wheat to high-value specialty crops such as higher-value fodder (i.e berseem), fruits and vegetables.

Hypothesis

Two specific questions or hypotheses will be examined and analyzed:

1 In the winter season, farmers in infrastructurally-accessible areas have decreased the amount of farm area sown to wheat and lower-value fodder crops, and diversified to specialty crops including berseem.

2 Availability of irrigation infrastructure has further enabled such farmers to shift to the production of high-value horticultural crops.

1.4.2 Off-farm Employment

According to the literature (Deaton 1994, Deaton and Muellbauer, 1980; Gronau 1983 etc), members of the farm-household allocate their time between on-farm and off-farm labor activities. In Pakistan, there is normally gender-division of labor, so that men work primarily outside the home and women primarily undertake the tasks of child-rearing and home-making.

Although on-farm income may be their major source of income, household adults (primarily males) may want to take additional advantage of their household resources (in terms of labor and human capital stock) and get higher-paying off-farm activities to generate additional household income. Accessibility to infrastructure, such as off-farm ab

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as off-farm labor markets increases off-farm labor opportunities, and enables farmers and male members to either work off the farm in wage employment, or migrate seasonally to the cities, in order to secure labor, construction and hotel jobs there during the slack agricultural periods. Close access to off-farm labor markets is expected to decrease the costs of relocation and increase the benefits accruing to such off-farm labor employment. Good overall access to infrastructural facilities is also expected to enhance farmers' awareness of off-farm economic opportunities, and encourage the mobility of labor from the village. Such off-farm employment generates cash income for farmers, and acts as a conduit to relax their liquidity constraint. The increased cash income enables farmers to purchase variable inputs, such as fertilizer, certified seed, and rent the services of hired machinery etc. Farmers may also be able to save money and increase their capacity to purchase physical capital goods to increase farm productivity.

This discussion gives rise to the following research questions:

Objective

To measure the impact of access to commercial and overall levels of infrastructure on the amount of off-farm labor activity engaged in by the household.

Hypothesis

Improved access to commercial infrastructure, as represented by off-farm employment opportunities, enables farmers to increase off-farm labor employment, thereby increasing their cash earnings.

1.4.3 Education

The farm-household makes another potential investment choice viz: that of investment in human capital. As Schultz (1994), Timmer (1988) and Johnston and

Kilby (1975) have pointed out, the return to investment in human capital increases during the structural transformation of agriculture.

Increased access to primary schools[8] may induce parents to educate their children, even if they need their help on the farm. Close access to both primary and secondary schools is very important for children, as most parents will not and often cannot afford to send their children to the nearest town or city for education. Furthermore, access to secondary schools may be particularly important for such children to obtain a good education.

Studies conducted by the International Food and Policy Research Institute (IFPRI) in Pakistan (Sabot et al, 1990; Alderman and Chishti, 1989; Rizvi and Chaudhry, 1988 etc) indicate that the return to higher education is particularly high, even in the rural areas. Male household-members can invest in human capital resources in order to take advantage of stable and higher-paying off-farm labor opportunities, such as in teaching or in Government jobs, jobs in the formal Government sector, or more highly-skilled blue-collar jobs such as skilled factory work, carpentry, woodwork or professional jobs such as typing, etc. Thus many farmers may find it more profitable to give up full time farming activities in order to work in the city or nearby town in a professional, Government or technical job, and become a part-time farmer. But in order to be able to avail of these opportunities, they need to obtain at least a high school degree or a technical diploma.

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[8] In an effort to remedy low literacy rates among rural males and females respectively, the Government has undertaken large investments in human infrastructure (primary and secondary schools). Literacy among males is 35.1% and 47.3% compared to 16% and 22.3% among females, according to the Agricultural Censuses of 1961 and 1981 respectively.

In contrast, within agrarian farm-households in this traditional Muslim society, education is generally not perceived to be necessary for rural women[9]. However, societal preferences for female primary and higher education are changing, even in rural areas. Farmers' preference to have educated wives is increasing because educated wives are better able to cope with household and farm-management, enabling husbands to diversify into off-farm activity.

Proximity to schooling plays an especially important role regarding female education, as parents generally do not feel secure in sending their daughters to a school some distance away from the village, due to socio-cultural constraints on girls' freedom of movement and fear for their security. The availability of methods of transport to the school may also be important in determining actual utilization of schooling services by girls. Also access to secondary school education and teaching certification generally allows women the opportunity to take up professional jobs in teaching[10].

This discussion gives rise to the following research objective and hypothesis:

Objective

To measure the impact of social infrastructure on farmers' investment choices with regard to human capital.

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[9] Extremely low literacy levels of 8% among rural women (Pakistan Economic Survey 1993-94) are a major problem, with nearly prohibitive socio-cultural constraints for female education even at the primary level.

[10] While agricultural women often work in the fields and take care of farm animals, work opportunities outside the house for rural women are often limited to teaching.

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1.5.1

Hypothesis

Increased access to overall infrastructure and men and women's education infrastructure in particular, affect the level of male and female literacy, respectively.

1.5 Impacts of Infrastructure and Other Determinants on Rice Profitability

The second series of research questions are more narrow in scope than the previous sequence because they concentrate only upon assessing farm productivity and the efficiency of resource use within the farm. Increased availability of public irrigation originally led farmers (during the 1960s and 1970s) to substitute away from growing subsistence crops and growing this high-value grain and cash crop to such an extent that it is currently the most widespread high-value cash crop grown within this farming system (Figure 1.2). Thus irrigation infrastructure is the most important type of infrastructure to impact upon farm profitability in this system because it provides water for growing high-value cash crops, including rice (as well as fruits and vegetables). The impact of irrigation and production inputs on rice profitability are discussed in sections 1.5.1 and 1.5.2, while the impact of other types of infrastructure on rice productivity are discussed in Sections 1.5.3 and 1.5.4.

1.5.1 Impacts of Irrigation Infrastructure:

Irrigation infrastructure is different from other types of physical infrastructure such as roads because it often represents a direct input within the production of rice. Roads increase access to larger market or industrial towns which generally have an indirect impact on total farm productivity (Figure 1.2). At the farm-household level, irrigation infrastructure consists of all the available water-related investments, including farmers' private irrigation, as well as public irrigation investments in tubewells and canals.

Irrigation infrastructure enables farmers to increase their range of production possibilities by decreasing land under fallow and increasing production through specialization in a single crop or diversification to other crops (already discussed in section 1.4.1). Farmers in this system have already specialized to rice, further specialization in the rice crop which enables them to generate a greater volume of marketable surplus, and benefit from economies of scale in transportation and purchase of inputs. As sustained levels of water availability are essential for growing rice, access to increased levels of irrigation and water, increases the total revenue obtained from rice. In Figure 1.2 this causality is depicted by means of an arrow leading from irrigation water to rice revenues denoting a feedback effect from increased investments in water levels and vice versa.

Within the rice activity, farmers may make selections between higher-yielding IRRI rice varieties or lower-yielding Basmati rice varieties. However, total revenues will increase, regardless of which variety is used, because the price of IRRI rice is lower than that of Basmati (by approximately 40%), while its yield is higher than that of Basmati rice (by approximately 40%). Hence, the lower output of Basmati rice is compensated by its higher price, while the higher output of IRRI compensates for its lower price.

As the total output of rice is not homogeneous it had to be expressed as total revenue which is the monetary equivalent of physical product. But in order to distinguish it from the revenue function in the literature as well as for ease in interpretation, it will be normally interpreted as physical output. Hence total productivity (TP) within the rice activity is obtained by dividing the total revenue by the sum of the weighted average of the major inputs. Average productivity (AP) with

regard to a single input denotes the total revenue divided by the quantity of the input. A commonly-used measure of single factor output (AP) is output per unit of land (i.e yield). Partial factor productivity (or marginal productivity: MP) with regard to a single input is the change in rice revenues due to the application of an additional unit of the input.

Rice farmers are all expected to be able to have access to one or more sources of irrigation because this crop cannot be grown without continued availability of water. Increased irrigation water availability is expected to shift the production function outward and contribute to increased productivity and revenues. In general, areas with better irrigation infrastructure are expected to obtain higher rice revenues compared to areas having worse irrigation infrastructure. However, this impact may be differentially divided according to the different sources of irrigation. Total factor productivity across farm-level irrigation systems may thus be different, depending upon the efficacy of the individual water sources, as well as the levels of the water sources. However, some farmers may have access to more than one water source and different combinations of irrigation sources, as well as varying levels of availability of water within individual sources. These combinations and indexes or classes of combinations may form and in fact define different irrigation systems. Total factor productivity across these different irrigation systems may be differentially distributed, depending upon the efficiency with which different sources combine, as well as the ranks or classes of individual irrigation sources within the combined systems.

Canal water appears to be the public irrigation investment most widely available to farmers. Access to canal water varies depending upon whether the village and farms within the village are located at the head, middle or tail-end of the water-course. Amo

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The Government originally invested in a great number of tubewells all over the Punjab. However, since the 1970s little investment in tubewells has been made. Currently the irrigation department is responsible only for the maintenance of these tubewells. Due to the scattered nature of the Government tubewells they are expected to have only a supplemental effect on rice productivity unless they are the sole source of irrigation for the farmer.

[11] These actions occur although all farmers pay the same level of water tax for canal water.

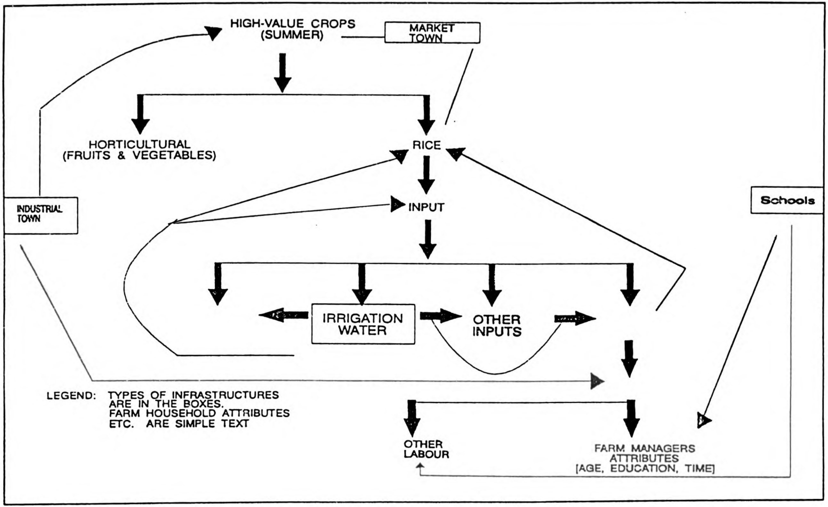

Figure 1.2: Impacts of Infrastructure on Rice Profitability

It may be noted that public irrigation is available to sample farmers, only due to each farm's spatial location; whether the village (in which the farm is situated in), has a public tubewell, and/or whether the farm and village are located next to the water-course. However, investment in private tubewells is necessarily farmer-specific (or individual-specific) rather than location-specific. Many farmers appear to have made up the deficiency in their required level of water availability for the rice crop by investing in their own tubewells. Others have invested a share in a tubewell with neighboring farmers or relatives. In particular, those farmers who do not have access to canal water are expected to have invested in their own private tubewell(s).

The previous discussion gives rise to the following research objective and related hypotheses:

Objective

To measure the sources and levels of irrigation infrastructure available to farmers, and measure the effect of different types of irrigation infrastructure on total farm productivity proxied by rice productivity.

Hypothesis

Generally farmers with higher quantities and quality of irrigation generally have higher rice profitability.

1 Farmers who have higher access to higher levels of canal water irrigation are expected to derive higher productivity from rice, compared to farmers who have no access to canal-water.

2 Farmers who have access to water from tubewells, either through sole or joint ownership of one or more tubewells or through being able to buy water, are expected

to derive higher productivity from rice, compared to farmers who do not have any access to tubewells.

3 Government tubewells are not expected to exert a positive effect on rice profitability except when they are the only source of irrigation.

1.5.2 Impact of Production Inputs

As farming is an art rather than a science, profitability across farms is expected to vary in accordance with the different amounts of inputs that farmers apply to the rice crop. The effect of these inputs are discussed next.

Factors of production such as land and labor play an important role in the production of rice. As population pressure on the land is intense in the sampled area (particularly in Gujranwala district), land resources are intensively used. Hence, rice yields are expected to be positive. The output elasticity of land defined as the change in output due to a unit change in inputs is also expected to be positive.

Water is applied to the rice crop at varying times and intensities throughout the rice crop's growth cycle. The application of irrigation water requires a constant stream of labor from the household's labor stock. As rice is a labor-intensive crop, a large stock of labor is required to produce (the crop), including labor provided by family members, namely: females and children. The total cost of labor (or any other single input) employed in the rice activity is equal to the unit price of the input, multiplied by its quantity. If total revenues rise (i.e via higher yields) and prices of inputs and outputs are constant (or they rise at a lesser rate), the share of income to labor also rises.

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1.5.3 Impact of Market Town

Closer access to the market town is expected to impact rice productivity through two effects. The first effect is similar to that obtained through enhancement in human capital and information-processing skills of farmers which increases their chances of adopting new crops/technology. The second effect operates through changes in expected prices.

Farmers travel to markets regularly to sell their output and buy inputs. They know the commission agent and input supplier quite well. Hence they often exchange information on the raising and management of production systems with other farmers, input procurement and commission agents. Often they adopt technology only after someone they know has used it. Access to the market thus serves as a proxy for access to information, through which farmers learn new techniques. Farmers learn to use a given bundle of resources more efficiently in rice production, which increase total farm productivity.

As indicated previously, closer access to the industrial town and the market town are expected to increase the percentage of farmland devoted to specialty crops. In similar fashion, close access to the market town is also expected to affect rice productivity, through increases in the price which rice is expected to fetch in the market. Increased prices for rice may be anticipated to increase the expected revenues which farmers will obtain from their rice crop. This indirect causality is depicted by an arrow running from roads to all higher-value cash crops as well as to rice. Hence closer access to markets is expected to increase total revenues.

1.5.4 Impact of Industrial Town

Close access to the industrial town is expected to exert two types of effects. Closer access to off-farm labor markets (embodied by the industrial town) and resulting higher expected wages are expected to induce labor to leave the farm, and obtain better off-farm jobs. This difference in the land-labor proportion is expected to be captured by variable proportions in inputs estimated in the production function. Accordingly the effect of the industrial town is included in the production function to validate the hypothesis that access to the industrial town does not have any impact upon the efficiency of resource use within the rice crop. Alternatively, the demand-pull effect of the industrial town increases the revenue-generated productivity measure obtained from growing high-value labor-intensive cash crops including rice. This effect will reinforce the price effect exerted by close access to the market town.

1.6 Concept of Infrastructure

Definitions

While infrastructure is defined as consisting of the underlying foundation (or basic framework) of an organization or a system, it has been defined differently in the various social science disciplines such as urban studies, community development, geography, psychology and economics. Practitioners within each of these fields tend to focus on those features of infrastructure that are shaped by their disciplinary view of the system and what constitutes its underlying framework.

Within the economic growth literature, Hirschman (1958) initially defined overhead capital to consist of "non-importable, durable goods, basic to, or facilitating the carrying out of a wide variety of economic activities". His definition emphasizes two salient points viz: the durable aspect of infrastructure, as well as the heterogeneity

of the economic activities. Infrastructure shares the quality of durability with capital goods[12]. Thus, both infrastructure and capital generate a flow of services from a given stock.

An activity is defined to be an undertaking with one or more clearly defined outputs. For a capital good such as a tractor, which is used for plowing, the final output are crops or similar types of outputs. On the other hand, physical infrastructure such as a road, is used to transport people going about their business (or for leisure) activities, animals, and durable and producer goods, such as seed, tractors, threshers, etc. This movement of people, machinery, goods and services constitute the production and consumption linkage activities through which the economic development of that area is taking place.

Hirschman (1958) also distinguished between social overhead infrastructure[13] and private capital goods. Normally, when two or more farmers have access to an infrastructural service which is jointly owned and/or consumed and may or may not be provided by the government, it is known as a social overhead (or capital) good. Different types of irrigation infrastructure constitute social overhead goods. In Pakistan, a great deal of irrigation water is provided by the Government, in the form of tubewell water and irrigation canals[14].

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[12] Capital goods are intermediate goods used as an input into the production of another good.

[13] Public goods include infrastructure owned by the Government.

[14] Canal water is an example of a common pool resource. Farmers located upstream have differential access to it compared to farmers located downstream. It is also a public good, because exclusion costs arise, as farmers located close to the canal extract water from it, or even block the canal, whether or not they pay for it.

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The above discussion should not be interpreted to mean that infrastructure consists only of what Wanmali (1988, 1987) and Diewert (1984) term as "hard infrastructure" or durable goods such as roads, irrigation and electrification. Rather, the term infrastructure has evolved within the literature, to reflect all infrastructural services which are necessary for the development of agriculture. Therefore, the concept of infrastructure incorporates a broad range of services including transport (bus and truck), finance (credit and banking), animal husbandry etc or "soft infrastructure". The pattern of accessibility to these services have "strong economic and spatial features which can improve, or hinder access to the rural population and the prospects for agricultural development (Wanmali 1987)". The sub-division of infrastructure into different types as described in Chapter three, has been done in keeping with this broad definition.

1.7 Social Versus Physical Access

While physical access denotes how near the infrastructural service is to the user, this concept is subject to interpretation. While it is comparatively easy to measure the physical access to an administrative infrastructural service such as a police station, it is much more difficult to measure the level of 'social or political' access which villagers have to that service. Thus, certain villagers may not actually use the service, even if they can reach it. Hence, social access often determines whether villagers actually use a given service.

Social access varies among villagers and/or farmers, according to whether or not they have social and political power or are associated with people enjoying social and political power. For example, access to certain institutional or Government services in Pakistan, (particularly credit, police and extension agencies) are subject to ranging from

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varying forms of 'social access'. Theoretically, each police station, extension agent or credit office, services the needs of a number of villages, based on the relevant Government agency or bank's rules. However, Government services often target larger farmers, the headmen in the village, namely: farmers with favorable income and social standing, either by accident or design. And because it is more expensive to lend to smaller farmers or farmers owning fewer assets, even subsidized credit schemes for smaller farmers are subverted by larger farmers[15]. Similarly, extension agents often contact those farmers whom they perceive as being able to be risk-takers (generally larger and more wealthy farmers).

On the other hand, social access appears to be much less important in getting access to commercial services. Agents operating such services (e.g commission agents) often live in the same villages as their neighbors and are intimately acquainted with the needs and requirements of their clientele including farmers. Thus they are able to simplify their operating procedures to suit farmers.

1.8 Chapter Summary

Physical access is used to measure the ability of an individual to utilize the services generated by infrastructure. Infrastructure is defined as social overhead capital which contributes to the economic development of an area. Infrastructure is important because it complements institutions and technology in the growth strategy

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[15] Banks' transactions costs regarding smaller farmers is generally higher than for larger farmers for reasons documented elsewhere in the literature (inadequate collateral, difficulty with paper-work due to illiteracy and unfamiliarity with official documents etc).

Subsidized credit schemes for smaller farmers create excess demand for credit on the part of larger farmers, whose lower transactions costs, and political power, enables them to obtain the loans.

of a country. During the 1960s, investment in roads and irrigation infrastructure facilitated the adoption of Green Revolution technology and increased agricultural productivity in Pakistan. In contrast, the impact of a more recent infusion of road infrastructure has not been examined, a gap which this study hopes to remedy.

This study addresses two types of questions as indicated in Sections 1.3.1 and 1.3.2. Firstly, it measures the impact of various types of infrastructure on three farm-household decisions viz: (1) crop choice, (2) off-farm employment and (3) education. Infrastructure, operating through its impact on increases in market opportunities and prices is expected to lead to diversification from food to horticultural crops. Also, increases in access to educational opportunities are expected to be associated with enhanced literacy levels while increased access to off-farm labor markets are associated with increased off-farm employment.

The second set of questions which are addressed concern the effect of infrastructure on the (major) rice activity. The study focuses on this crop enterprise because it is the major cash crop within the system, as well as for its dependency on irrigation water (and hence infrastructure). Questions examined include (1) whether the sources, combinations of sources and their levels of irrigation water availability as well as (2) farm resources (inputs); affect rice profitability directly;
(3) the impact of closer access to marketing infrastructure on the efficiency of resource use within the rice activity; and (4) the effect of commercial infrastructure (industrial and market towns) on the (expected) prices of rice and costs of inputs.

1.9 Organization of the Thesis

The research is presented in eight chapters. The first chapter introduces the research. Chapter two reviews the literature, which presents how other researchers have represented the concepts and empirical measures of infrastructure in order to measure its impacts on agricultural productivity, investments and growth. The empirical measures collected in the survey are described with reference to the conceptual issues involved in measuring access within any one infrastructural service.

Chapter three describes the sampling design used for selecting the sample of villages and farmers in the study area, as well as the main socio-economic characteristics of the sample farmers. Survey instruments used are presented in the appendix to this Chapter.

Chapter four presents the results of two kinds of analyses conducted on village-level infrastructure. First infrastructure is divided into individual types or categories considered important to the target group of farmers. These categories are then matched with the 30 infrastructural services on which empirical information has been collected. Through correlation analysis, a parsimonious set of 13 key infrastructural indicators is obtained. An overall infrastructural index is also constructed from the individual measures. Secondly, the results of cluster analysis are presented, whereby the subset of 13 key indicators is used in order to divide the village sample into more and less infrastructurally developed areas. The method of cluster analysis is also described, whereby the best access measure(s) is (are) selected and the most suitable clustering algorithm is selected. Village summaries are presented in the appendix to this chapter.

Chapter five presents the major hypotheses regarding the effect of certain categories of infrastructure on three farm-household choices namely: crop choice in farmland, the choice between on-farm and off-farm employment and education. These hypotheses are formally tested for, by means of the two-way analysis of variance.

Results derived from testing one set of hypotheses are linked to results derived from other hypotheses.

Chapter six presents and specifies the theoretical production model and describes in detail the derivation and aggregation of variables used to estimate the farm-household revenue (production) function. These variables include the choice of output(s) and inputs used as well as two types of infrastructure; the market and the industrial town. The theoretical and empirical considerations considered with respect to the choice of functional form are also described.

Chapter seven describes and analyzes the sources, combinations and ranking or classes among irrigation sources. Two different methods of measuring the available irrigation information are utilized to construct two different regression models, which are then used to test the hypotheses regarding total factor productivity, and the effect of industrial and market town on rice production.

The last chapter consists of the conclusions. Summary findings are presented by stating each hypothesis and presenting the major finding(s) with regard to it. The policy implication(s) of each hypothesis as well as linkages among the hypotheses and recommendation(s) for further research are also discussed.

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CHAPTER 2: LITERATURE REVIEW; MEASURES AND IMPACTS OF INFRASTRUCTURE

2.1 Introduction

Various empirical measures have been used to capture the concept of access to infrastructure, which itself consists of a variety of services, as it is a multi-dimensional concept. But the purpose of measuring access to infrastructure and its various component services is often to measure the effects that such access has on the extent and type of agricultural development. Agricultural productivity is often a yardstick which is used to measure this development.

Hence the literature review is divided into two parts: initially it examines how infrastructure has been measured empirically in the literature, and then how these measures have been applied in order to address various issues of concern within agricultural development. Section 2.2 presents the conceptual and empirical representation of access to infrastructure within the literature. Section 2.3 reviews the results of the various studies regarding the effect of infrastructure on agricultural growth, investment and productivity within agriculture.

2.2 Concepts and Empirical Measures of Accessibility

Various measures of accessibility to infrastructure have been reported in the literature. Infrastructure was initially studied at an aggregate level using measures derived from national income accounting techniques during the 1950 and 1960s (Jimenez, 1993). While access to infrastructure has often been represented by distance, physical infrastructure including roads and irrigation were often the major infrastructural components of interest. Hence Antle (1983), in his cross-sectional study of 47 countries, considered distance to be the most important dimension for measuring infras

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measuring infrastructure, and represented it by expenditure on the transportation and communications industries in the national accounts as a good measure of infrastructure. Antle (1983) used Gross Domestic Product of transportation and communications industries but deflated these figures by square kilometer land area in order to convey information regarding the population which this land area served. Binswanger (1987), in a cross-country study of 58 countries, included a road density variable, similar to Antle's infrastructural measure, as part of public sector endowments. He also incorporated the quality of physical infrastructure by including the percentage of paved roads.

In their analysis of district-wise panel-data study on Indian village-level data from 108 villages (1966-1980), Binswanger and Barnum (1986) expanded both the measures and categories of infrastructure they studied to include the percentage of the rural areas electrified, measures of water availability to measure irrigation, as well as distance to measure various infrastructural services such as markets, banks and grain mills. In a cross-section and time-series study of 85 districts in India, (1960/61 through 1981/82), Binswanger et al (1989) measured infrastructure using Government infrastructure variables such as primary schools, canal irrigation, rural electrification, regulated rural markets and total road length.

Recent studies have become more decentralized and use a greater variety of measures both to capture the comprehensiveness or breadth of infrastructural services considered. Wanmali and He (1989) emphasize the importance of a number of distinct types of infrastructural services, which when taken as a whole, contributed to economic development in a certain area. They divided groups of infrastructural services according to the major types of socio-economic activities which these services fo

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services fulfil for the target population of farmers. By doing so they were able to explain and compare patterns of spatial economic development in two geographically dissimilar regions in Zambia and India (1988, 1986). Hence in their disaggregated household cross-sectional study, Ahmed and Hossein (1990) also used various types of rural infrastructure, including means of transport, communications, education and markets to measure the different aspects of agricultural development.

Measures used to capture different aspects of accessibility have also expanded. In an effort to obtain a more refined measure to incorporate the various considerations which may arise in getting access to a particular service, Ahmed and Hossein (1990) and Ahmed (1990) constructed an infrastructural index for 16 villages by combining information regarding distance, time taken and fare to obtain cost per mile of travel to the concerned infrastructural services.

Access to various economic indicators has been most commonly measured by means of distance; Ahmed and Hossein 1990, Binswanger et al, 1989 and Antle 1983 etc. However, literature from World Bank publications, Wanmali (1987 onwards), Ahmed (1990) and Krueger (1989) regarding the role of rural infrastructure draws on practical intuition in postulating that access should be measured in terms of both pecuniary and non-pecuniary costs.

Krueger (1989) and studies sponsored by the World Bank (Carapatis et al, 1992; Riverson et al, 1991; Riverson and Carapatis, 1991;) have emphasized the measurement of physical accessibility in terms of accounting for non-pecuniary costs that take into account the difficulty or timeliness of a 'typical' journey. For example, particular attention is paid to issues of whether or not the roads are paved, unpaved or a combination thereof, and whether or not the methods of transport are adapted to

the roads which they traverse. They compare the modes of transport both in Asia and African and conclude that indigenous transport modes, dependent on animal power consisting of donkeys, bullock-carts and horse-carriages, and adapted for the rougher roads in Asia, have led to much lower costs of transport in Asia compared to Africa, which is dependent on motorized forms of transport for transport of goods.

The inherent nature of the infrastructural category and service itself has often indicated the appropriate type of measure to be used. Thus irrigation is normally measured in terms of volume (such as cubic centimeters) of water. In the absence of such measures indices have proved to be useful in measuring access to various infrastructural services.

As indicated previously researchers have sometimes made spatial adjustments for the area covered by infrastructural services, researchers have mostly represented infrastructure by the presence of certain services, rather than by the density or actual usage of these services, i.e the population that these services provide for, and to what extent they actually used these services. Within locational studies, the effects of dense accumulations of infrastructure are known as agglomeration. However, recent studies on infrastructure's effects by Wanmali and He (1989) and Krueger (1989) attempt to measure access both in terms of the distance and the density of these services. Wanmali (1989) used a more decentralized framework to question respondents regarding the frequency with which they used certain infrastructural services, the time that they incurred in travel and the duration of trips made etc, in order to gauge the level of use of these services. At a more aggregate level Krueger (1989) calculated that density of transport services were much higher in India than in Zambia.

In summary, most researchers have focussed on certain types of infrastructure which they hypothesize will impact the activity that they want to measure. This is both true for both the aggregate and the more disaggregated level studies. However, in more aggregated studies, researchers tend to use less detailed information in constructing measures to encompass accessibility across various infrastructural services. Distance is the measure commonly used although it has been adjusted for population density and spatial characteristics. More disaggregated level studies have availed of the opportunity to gain more detailed insight into actual usage or probable usage of services.

2.3 Measuring the Impacts of Infrastructural Access

2.3.1 Aggregate Level Studies

Infrastructure strengthens linkages between the village and urban economies and helps in the transformation of agriculture from a subsistence level economy to a commercialized economy. Antle (1983) found that the effect of access to infrastructural services measured by aggregate road density per country, were highly significant in explaining higher agricultural productivity in more developed versus less developed countries. Binswanger (1989) who estimated agricultural supply and input demand functions for cross-country analyses, as well as within-country time series analyses for India, found both irrigation and roads to have a strong positive effect on agricultural output and agricultural development in the area over a sustained period of time. Impetus for the adoption of technology for diversifying from low-input subsistence crops to higher-value cash crops was provided by better irrigation and road facilities, as well as credit availability. A 1% increase in physical measures of infrastructure and paved roads and road density (together) contribute to a 1.62% and

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0.38% increase in agricultural productivity. However, Donovan and Ahmed's (1992) critique of Binswanger's results point out that the two variables may have captured other country attributes as well. Finally Queirioz (1992) found that the extent of paved road networks were also significant in explaining differences in GDP per capita across countries.

2.3.2 Decentralized Studies

At a more decentralized level, recent studies conducted by the International Food and Policy Research Institute (IFPRI) in Bangladesh, Zambia and India (Ahmad & Hossein 1990, Wanmali & He 1989 & Wanmali 1988,1987), as well as district-wise studies in India by Barnes and Binswanger (1986) and Binswanger et al (1989) respectively, indicate that farmers who have access to infrastructural services readily avail themselves of such opportunities. For example, Binswanger and Barnum (1986) analyzed Indian village-level data obtained for 108 villages from 1966 to 1980, using principal component and regression analyses. Results from this district-wise panel-data study, designed to determine the impacts of rural electrification and infrastructure on agricultural productivity and input use, found that irrigation variables were negatively related with distance to transport and positively related with the presence of markets. The location of banks were influenced by the presence of infrastructure, which in turn had a significant impact on the number of grain mills. Schooling variables were positively associated with agricultural innovations and grain mills, indicating a positive relationship between an educated labor force and improved agricultural production. However, the relevant coefficients were reported as unstandardized coefficients, rather than in elasticity form, hindering comparison with other stud

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In a cross-section and time-series study of 85 districts in India (1960/61 through 1981/82), Binswanger et al (1989) sought to understand the response of agricultural investment and output to the actions of farmers, government agencies and banks. Government infrastructure variables incorporated in the study included access to primary schools, canal irrigation, rural electrification, regulated rural markets and total road length. The model was constructed using fixed effects methods and exogenously given agro-climatic variables, thus incorporating the simultaneity problem of banks, infrastructure, and private agricultural investment. Binswanger et al found that while the effect of irrigation infrastructure was significant, the combined simultaneous effect of banks and other infrastructural variables they used had 250% higher agricultural productivity than that of irrigation alone.

Finally Ahmed (1990), analyzed the effect of getting access to village-level infrastructure on various farm-household activities and decisions, in Bangladesh (in terms of cost per mile. He found that villages with more developed infrastructure in Bangladesh had 32% higher crop and household income than villages with lesser developed infrastructure, with the benefits extending to large and small farmers alike.

2.3.3 Studies for Pakistan

In Pakistan, little evidence on the impacts of recent infrastructural investments is currently available. Earlier studies such as Hamid and Hussein (1974) attempted to measure socio-economic indicators of well-being by using district-level data. Such studies supplemented the normal gross measures of sectoral spending (on roads, public irrigation etc) obtained from national income accounts (Jimenez, 1993). A more

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recent study by IFPRI (as part of its Food Security Project in Pakistan (1988-1994) obtained several measures of village-level infrastructure. However their sample of villages was purposely chosen from among the most poor villages in such a way that one village was chosen from each Province. Hence, because the village were too scattered and too few in number (five to ten villages for the whole of Pakistan), there was little heterogeneity regarding access to village-level infrastructure across households within villages. Productivity of the farming systems were computed. However, little analysis was done to assess the effect of infrastructure on productivity.

2.4 Application to Current Study

The literature review was used as a guide to collect the different types of information required to measure physical access to the various infrastructural services. While it appeared to be too time-consuming to collect information regarding actual usage at the farm-level, information was collected at the village-level with the explicit assumption made that all farmers in the same village had equal access to the village and thus an equally likely probability of obtaining services from it.

In order to be able to choose the best measure of accessibility, collecting information only on measures of physical access such as distance were considered to be limiting. Distance alone does not capture the difference in monetary fares, time and convenience and other costs associated with different modes of transport, such as walking, travelling by bullock-cart, donkey, mule, horse-drawn carriage, rickshaw, tractor, bus or train. Hence the empirical data which has been collected consists of the most common mode of transport or combination of modes of transport used to reach an infrastructural service as well as the distance and cost incurred involved in such journeys. Information regarding non-pecuniary measures such as the time taken to reach

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to reach a service and the duration of transport and frequency at which the sole or secondary mode of transport plies its route were also collected. Taken as a whole, this composite of different variables captures the differences which arise in getting access to a particular location. A comprehensive list of the types of infrastructural services which were important for farmers were also made, in order to obtain a richer and more comprehensive data set to measure infrastructure.

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CHAPTER 3: SAMPLING DESIGN AND CHARACTERISTICS OF SAMPLE FARMS

3.1 Introduction

The physical and economic characteristics of the rice-wheat production system are initially described in Section 3.2. Section 3.3 reports the different stages of the sampling strategy employed. The two rounds of survey implementation are described in detail. The methods of identification of 28 villages are described as well as the area-wise sampling method used to select farm-households from within each of these villages. Section 3.4 analyzes and presents the socio-economic characteristics of the sample farms.

3.2 Study Area

The irrigated plains of Pakistan, consisting of 16 million ha, include 80% of the cultivated area of Pakistan. Of the three major irrigated cropping systems in the country, the rice-wheat production system has the second highest total area, as seen in Figure 3.1[1] (Amir and Aslam, 1989). Rice and wheat are grown in rotation on the west bank of the Indus River in the two provinces of Sind and Punjab. The study area was selected to represent the rice-wheat agricultural production system of the Punjab. It consists of the districts of Sheikhupura, Gujranwala, Sialkot, Lahore and southern Gujrat and covers 1.1 million hectares of irrigated land.

3.2.1 Physical Characteristics

The study area comprises the flood plains and bar uplands of the Central Punjab, lying between the Sutlej and Jhelum rivers. The area has a semi-arid steppe sub-tropical type of climate. The rainfall varies from 800mm in Sialkot to 425mm per

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[1] The other two cropping systems consist of the cotton-wheat and sugarcane-maize systems.

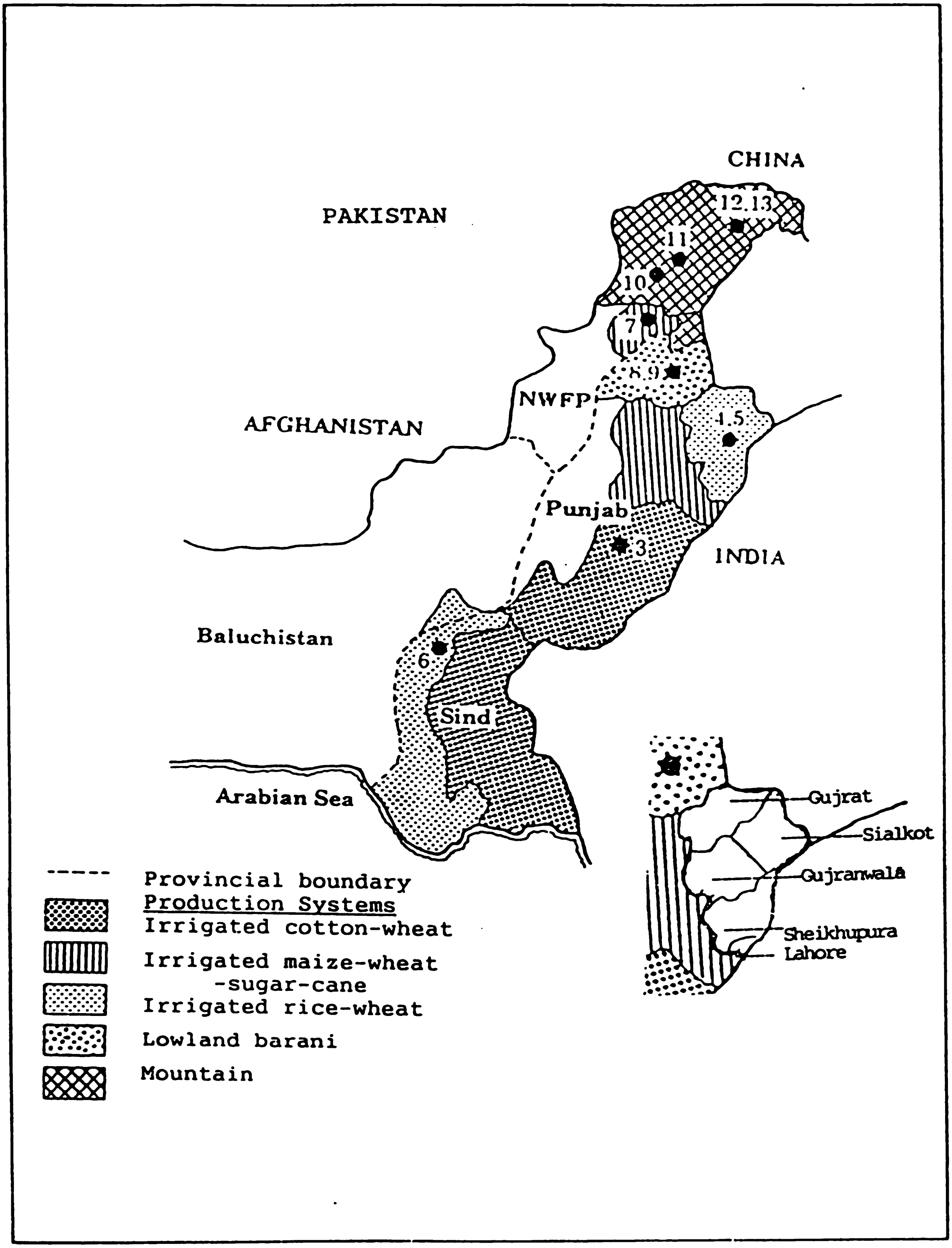

Figure 3.1: Map of Pakistan 1989

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annum in Sheikhupura. The mean monthly summer rainfall is 108mm in July, August and September, but winter rainfall is only 14 to 22 mm.

3.2.2 Economic Characteristics

The study area consists of small densely-populated villages, surrounded by semi-commercial livestock-cropping farms, which are well integrated into rural factor and product markets. The area has a well-integrated marketing structure, with various secondary markets or mandis forming the epicenter for a number of primary markets.

3.3 Survey Methods

The main source of data used in this study was a micro-level survey conducted in two rounds. During the first round of the survey, a sample of 28 villages was selected for detailed investigation from among the population of villages in the study area. In the second round, five households were selected from each of these 28 villages.

3.3.1 Sampling Design

The dominant cropping system, (the rice-wheat production system) was selected as the sampling universe in order to hold agro-ecological factors constant. This sampling strategy, introduced and articulated by Farming Systems researchers (BHW, 1982, CIMMYT 1980), has also been used by Ahmed and Hossein (1990) in Bangladesh. Time and logistical constraints prevented including in the sample all five districts in the dominant cropping system in the study area. Hence, the study utilized a three-stage sampling process. The three stages of the sample design are illustrated by means of an organizational tree (Figure 3.2).

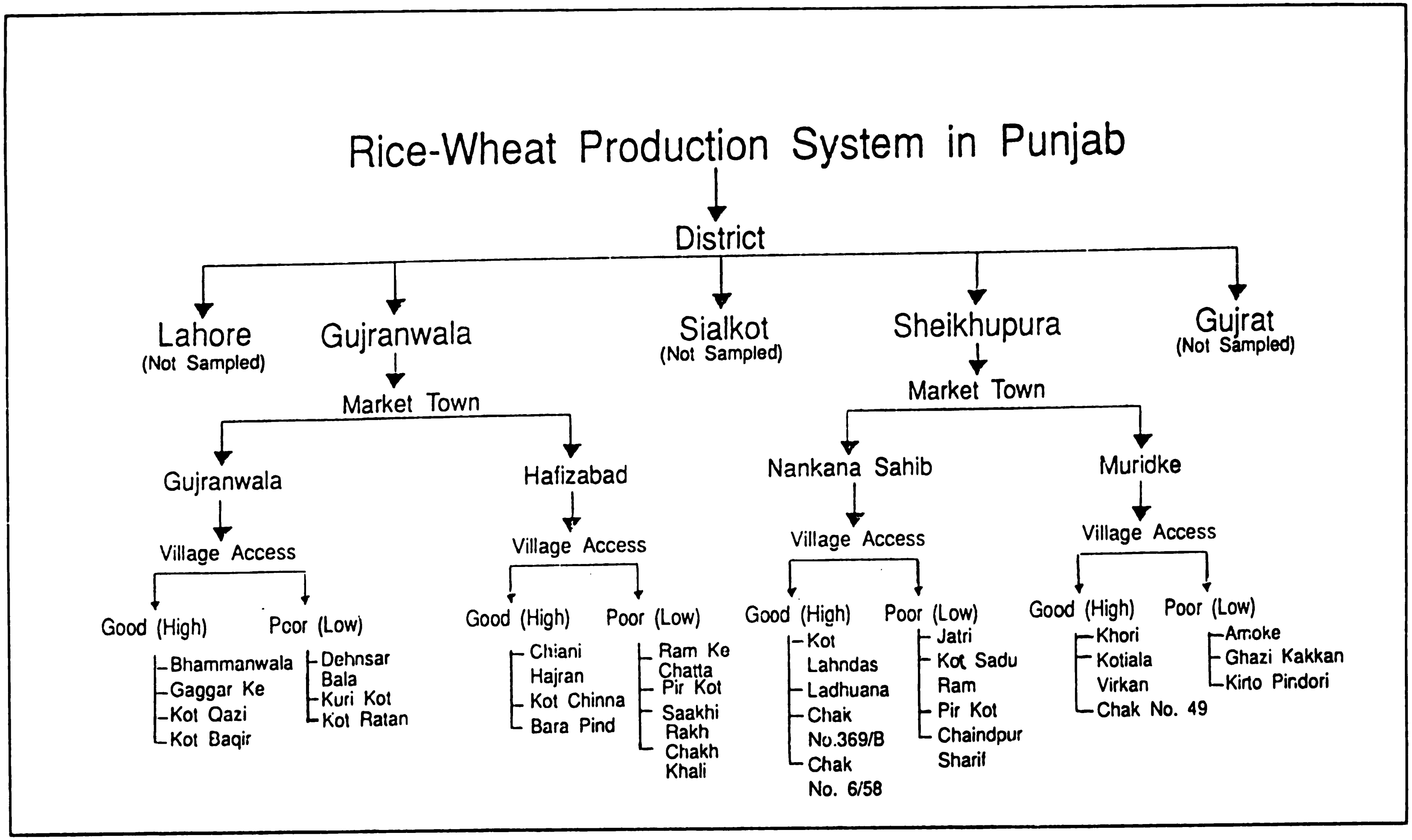

Figure 3.2: Sampling Design for 28 Villages & 140 Farm-Households, C. Punjab 1992.

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At the first stage, two out of five rice-wheat production districts in the Punjab were selected (Figure 3.1; inset). The districts of Sheikhupura and Gujranwala were chosen because they are the geographic and economic focus of the rice-wheat production system in Pakistan. This sub-sample area consists of 45% of Punjab's population and is the largest contiguous area planted to rice and wheat, although each of these two districts have both more and less-developed areas within them.

The source of this differential development arises from varying access to urban-based areas with infrastructurally-dense services. For example, within Gujranwala district, urban-based development has arisen from the presence of two large industrial cities viz: Gujranwala (with a population of over 2,000,000) and Kamoke (having a population of over 500,000). Similarly, Sheikhupura district contains the industrial centers of Muridke and Sheikhupura and the market town of Nankana Sahib. These cities are well-endowed with infrastructural services and are commercially developed. Thus, they generate a large demand for agricultural goods and labor. Also these areas are well-endowed with agro-ecological factors (fertile soil, plentiful water and irrigation), which contribute to higher potential agricultural productivity.

The objective of the second stage of sampling was to capture the inter-village variability within the two districts by selecting a random number of villages containing a cross-sectional mix of both more and less accessible villages. Since simple random sampling of villages would not capture the differential (agro-ecological and infrastructural) sources of variability within the area, an attempt was made to stratify the sample of villages by approximating accessibility to villages, by type and kind of road. However, this proved to be impossible because the available district maps, indicating the main, district and smaller linkage roads had been printed 15 years ago. Thus, the available information was out-of-date, as many new roads had been built up, linkage roads had been upgraded to district roads, and other roads had deteriorated. On the other hand, the information regarding the main highways and district roads was more current and easily verifiable by direct observation. A two-way stratification, with respect to the available economic and geographic information, was implemented for the second and third stages of sampling, due to the above-mentioned constraints. At the second stage of the sample design, accessibility was measured by the distance from the market town. Two major market towns were selected from each of the two districts. Gujranwala City and Hafizabad were chosen from Gujranwala district while Nankana Sahib and Muridke were chosen from Sheikhupura district. These market towns are spatially dispersed and capture geographical randomness within both districts. Gujranwala is located at the north end of the quadrant, with Muridke located due south, Nankana Sahib to the west and Hafizabad to the north-west. The two northern towns of Hafizabad and Gujranwala belong to Gujranwala district while the two southern towns of Muridke and Nankana Sahib belong to Sheikhupura district. Thus, each district is represented equally in the sample of selected villages. Within their respective districts, the westerly and northwesterly market towns of Nankana Sahib and Hafizabad are both large market towns, but are less developed than the Muridke and Gujranwala industrial centers. The implementation of the sampling design is illustrated with respect to Sheikhupura district (Figure 3.3).

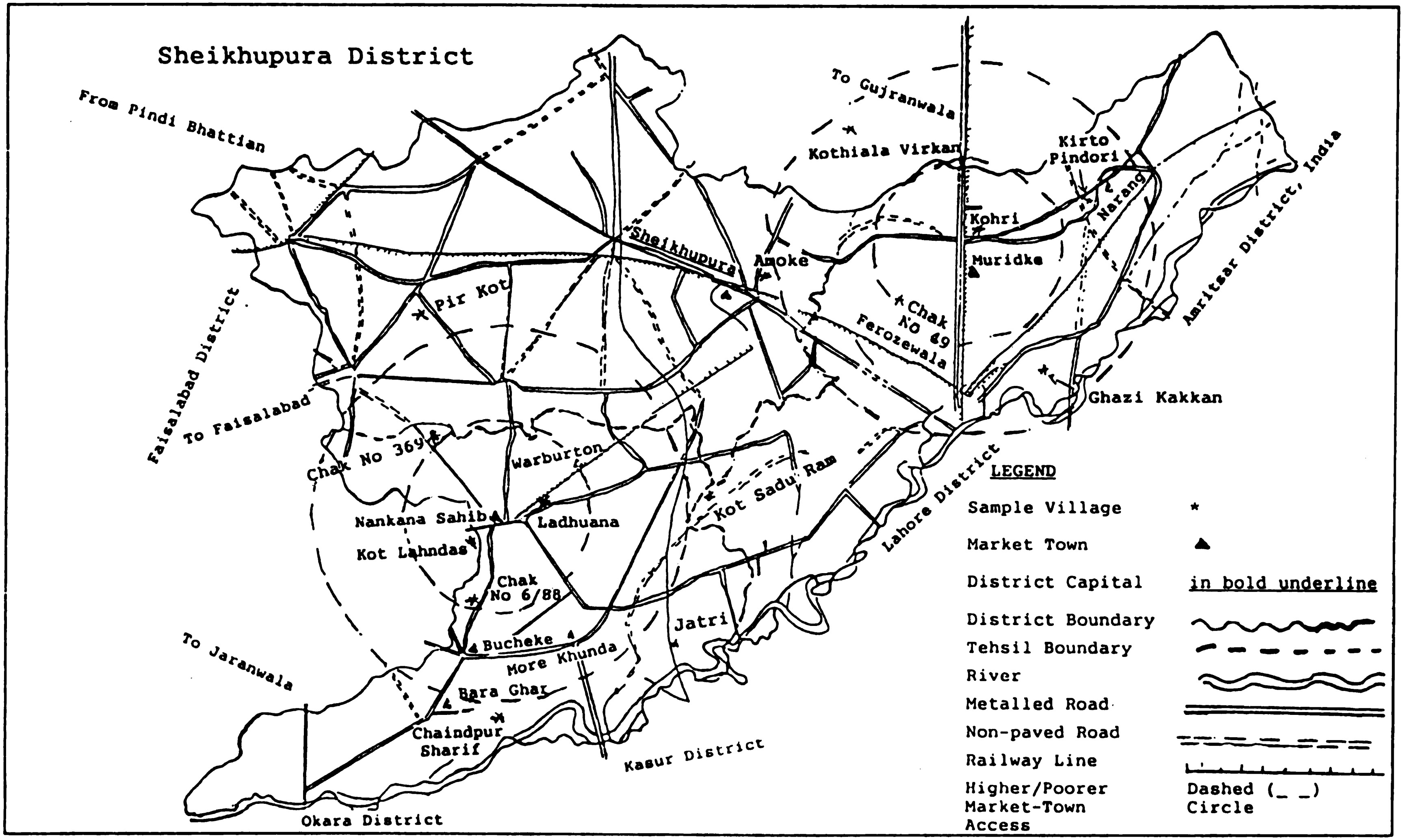

Figure 3.3: Selection of Villages in Sheikhupura District: Central Punjab, 1992

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The third stage in the sampling design consisted of drawing two concentric circles around each of the market towns. The inner circle was drawn at a diameter of 11 kms distant from the respective town, which served to represent the more accessible areas; while the outer circle was drawn 22 kms from the center and represented less accessible areas. Although both 11 kms and 22 kms do not appear to represent great distances, routes leading from the market town to the village are often circuitous, due to varying land topography and land use. Thus, villages are often much further from the market towns than they first appear. In addition an effort was were made to choose four villages, which were spatially distributed and located equidistant from each other, from within the inner circle and between the inner and outer circle[2]. This method was implemented with expert assistance from the field staff of the Crop Reporting Service. In the sample of villages, four less and four more accessible villages were selected from around the market towns of Nankana Sahib and Gujranwala City while three more accessible villages and four less accessible villages were selected from the remaining market towns of Muridke and Hafizabad. The exact location of the villages chosen within Sheikhupura district (whose names are shown in Figure 3.2) are shown in the detailed map of the district (Figure 3.3).

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[2] In a few instances, it was impossible to implement this strategy because it was necessary to eliminate very large villages (which approximated small towns) from the sample. Secondly, within Sheikhupura district, since the circle crossed the district boundary to the west, sampling could not be done in that direction. Also, the industrial town of Sheikhupura was located to the north-east of Nankana Sahib, so that villages further away from Nankana Sahib (but within the outer circle) were 'contaminated' by being closer to Sheikhupura (Fig 3). Hence only one village (Amoke) was sampled in that direction.

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3.3.1.A Village Survey

The above described procedure identified a total sample of 28 villages. In each of these villages, one knowledgeable farmer was chosen as a suitable respondent for the village survey, which was conducted during the first round of survey implementation. This respondent was generally the headman or revenue agent of the village, who was also a farm operator. He was asked detailed questions regarding village-access to 30 different infrastructural services. Six kinds of empirical information, with respect to how to gain access to these services, was also obtained. In addition, detailed information regarding village-level of technology, prices, and marketing information was collected. The village survey (or profile) and guidelines provided to the enumerators for its correct implementation used is in its implementation are presented in Appendices I.A and I.B.

3.3.1.B Farm-Household Survey

In addition, a second household survey was conducted to determine the productivity of the rice crop. The farm-household survey used and a glossary of terms used are presented in Appendices I.C and I.D. In Pakistan, most villages have an agrarian base, with most of the land belonging to the farmer households located near the villages. Thus, the household was the focal point of this inquiry. Five respondents were randomly chosen from each village, including four small farmers and one large farmer[3]. Farmers were screened by means of a few questions, and only farmers who managed and operated a farm were interviewed. According to this criteria, people who

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[3] Larger farmers operate more than 12.5 acres, the minimum acreage required for an average family of six persons to derive a commercially-viable living (Ministry of Food and Agriculture, Pakistan Government). However, the amount of acreage defining a large farm can vary. It is 25 acres in Hafizabad district.

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owned a farm but did not operate it, were not interviewed[4]. Also, potential respondents who were related to each other were excluded from the potential sample because there was a strong possibility that related farmers might live in the same household.

Ideally, in order to get unbiased estimates of the population parameters, households must be selected randomly from a complete population listing of village households. This method could not be followed for two reasons. Firstly, in Pakistan population sampling frames are extremely difficult to obtain. Secondly, because farmers leave their houses at dawn and returned at dusk during rice harvesting during the season in which the survey was conducted, they could not be contacted in their households during the day.

Hence, an area sampling frame was used. Firstly, the village- designated revenue-collector (or numberdar: literally, the numbers man) was approached. With his help, the enumerators from the Crop Reporting Service drew a map of the village and the surrounding land. They also located the lands belonging to the large farmers. Then the enumerators located the locus of the distribution of land around the village. Starting from this central point, they contacted a farmer approximately every 500 meters in a north, south, east and west direction. If a farmer was unable to pass the screening questions, the farmer in the next plot of land was approached and so forth. After interviewing the fourth respondent, the enumerators compared notes to see if they had obtained a larger farmer. If they had not done so, they purposely selected one of the larger farmers and interviewed him. But if they had already interviewed a larger farmer, they would draw lots to decided which direction to go to find other

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[4] For example, this excluded farm owners who did not operate their own farm.

owned a farm but did not operate it, were not interviewed[4]. Also, potential respondents who were related to each other were excluded from the potential sample because there was a strong possibility that related farmers might live in the same household.

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farmers to interview. In some villages, because there were very few large farmers, none were interviewed.

In retrospect, this sampling strategy resulted in the inclusion of a greater share of large farmers in the sample, than existed in the population. While larger farmers generally account for less than 10% of the farmers, and as few as 1% to 5% in many villages, the study sample included about 20% larger farmers. In spite of this problem, it appears that the sample farms represent the population of small and large farms in the predominantly rice-wheat production system in the Gujranwala and Sheikhupura districts.

3.4 Socio-Economic Characteristics of Sample Farms

Socio-economic data in addition to information regarding the farming system was collected through the above described farm-household survey. Descriptive statistics regarding their socio-economic characteristics of the sample farms are presented in sections 3.4.1 through 3.4.3.

3.4.1 Demographics

Generally, sample farm-households are larger than a singe family, due to the prevalence of extended families or closely related multiple families[5]. The mean farm household family consisted of 10.8 people, but ranged from 2 to 30 members (Figure 3.1). On average, these households were made up of 3.2 males, 2.82 females, 2.46 male children and 2.35 female children, respectively[6].

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[5] Deaton has described the agricultural farm-household in terms of space and social structure, as a group of people living and eating from the same 'pot'.

[6]These figures are consistent with empirical findings by Strauss and Thomas (1994) which indicate that higher morbidity rates and illnesses for female children in Pakistan (and other South Asian countries) led to an adverse female-male gender imbalance.

Table 3.1: D

Demographic Variable
Family Size
Total
Male adults:
Total
Educated
Female adults
Total
Educated
Male children
Total
Schooling
Female children
Total
School
Farm labor (
Full-time [b]
Part-time [c]
Farm Manager
Age (years)
Education (

Notes:

[a] T

[b] 132

[c] 77

Table 3.1: Demographic, Labor and Management Attributes of 140 Sample Farm Families, Central Punjab, 1992

Demographic Variable	Mean	Standard Deviation	Minimum	Maximum	Median	Mode
<u>Family Size</u>						
Total	10.79	5.63	2.0	30.0	10	5.0
Male adults:						
Total	3.16	1.76	1.0	10.0	3	4.0
Educated	1.72	1.65	0.0	8.0	1	1.0
Female adults:						
Total	2.82	1.68	0.0	9.0	2.5	2.5
Educated	0.66	1.15	0.0	6.0	0.66	0.5
Male children						
Total	2.46	2.04	0.0	10.0	2.0	2.0[a]
School-going	1.35	1.42	0.0	6.0	1.0	1.0
Female children						
Total	2.35	1.92	0.0	8.0	2.0	2.0
School-going	0.98	1.20	0.0	5.0	1.0	0.5
<u>Farm labor</u> (nos)						
Full-time [b]	2.16	1.28	0.0	6.0	2.0	1.5
Part-time [c]	1.36	1.18	0.0	5.0	1.0	1.5
<u>Farm Managers Attributes</u>						
Age (years)	47.03	17.82	20.0	100.0	48.0	55.0
Education (years)	3.67	4.56	0.0	14.0	0.0	0.0

Notes:

[a] There are 2 modes: 2 and 3.

[b] 132 households reported their full-time labor.

[c] 77 households reported part-time farm labor.

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Within the sample, 54% of male adults had a primary school education, while only 27% of female adults had at least three years of schooling. The maximum level of schooling reported by males was 14 years, compared to 12 years for females. Variability in educational levels among female adults was higher than among male adults (about 1.75 standard deviations about the mean). Indicative of expanding educational opportunities, about 57% of male children and 42% of female children went to school[7] and the variability in educational levels among male and female children was the same.

3.4.2 Land Endowment

The average farmer in the sample owned 25 acres of land (Table 3.2), with owned land ranging from a minimum range of zero to 1,050 acres. In contrast, the average operational farm size of 19 acres exhibited much less variability.

However, average farm size was representative of the majority of the sample farmers. The median and modal amount of land owned by farmers was 10 acres. The median operational area was 12 acres while the modal value was 5 acres. About one-third of farmers reported having only 5 acres of land or less. Each household rented-in an average, of 3.0 acres of land, compared to 74 acres of land being rented out[8].

---

[7] These are gross ratios of schooling because the total number of male and female children include children of school-going age as well as children below school-going age (or those who have already completed their schooling, at whatever level).

[8] Total land rented in does not equal land rented out while only 22 households rented out land, 33 households rented in land. Also, land rented out was skewed upward because a single farm rented out 875 acres.

Approximately 16% more land was rented-in during the kharif (rice) season (3.3 acres) than during the rabi (wheat) season (2.8 acres)[9].

The median, modal and mean parcel of land was 1.87 acres, but ranged from 1 to 85 acres. Nearly one-half of all farmers owned one parcel, while 36% owned two parcels. Only six farms were made up of five parcels. The median distance of parcels from the road was 0.50 miles, while the average distance was 2.05 miles due to the high standard variability in these values (i.e a standard deviation of 4.2 miles).

Land in the study area can be classified into four major types of soil: clay, medium and heavy loams and lighter sandy loams (Table 3.3). The major soil types consisted of silty and clay loams which encompassed 54.% of the total area. Of the remaining land area, 18% was clay and 7.8% of the parcels consisted of sandy loams[10]. Land in the study area suffered from drainage problems. Farmers reported that an average of 17.5% of the area was subject to waterlogging and salinity and 10% of the land was so severely degraded that it was totally uncultivable.

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[9] This may indicate that the main summer crop, rice is more important to farmers than (winter) wheat.

[10] With adequate irrigation and drainage, light soils are appropriate for growing wheat, but unsuitable for growing rice. The opposite situation holds for clayey soil. Only medium and heavy loams are suited to both the production of rice and wheat.

Table 3.2

Variable

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Table 3.2: Seasonal Operational Farm and Parcel Area for 140 Sample Farms, Central Punjab, 1992

Variables	Mean	Median	Mode	Standard Deviation	Minimum	Maximum
Farm Tenure (acres)[a]						
Owned	25.04	10.0	10.0	90.12	0.0	1050.0
Renting-in (Winter)[a]	2.9	0.0	0.0	7.11	0.0	52.0
Renting-in (Summer)[a]	3.3	0.0	0.0	7.47	0.0	52.0
Renting-out (Winter)[b]	8.5	0.0	0.0	4.18	0.0	875.0
Renting-out (Summer)[b]	8.4	0.0	0.0	4.13	0.0	875.0
Operational Farm Area (acres)						
Winter	19.42	12.0	5.0	3.36	1.5	175.0
Summer	5.00	12.0	5.0	3.77	1.5	175.0
PARCEL						
Parcel (numbers)[c]						
Winter	1.73	2.0	1.0	0.99	1.0	5.0
Summer	1.87	2.0	1.0	1.06	1.0	5.0
Parcel Area (acres)[c]						
Summer	10.66	12.00	8.0	0.84	1.0	85.0
Winter	10.91	12.25	8.0	1.14	1.0	85.0
Distance from road (miles)[d]	2.05	0.50	0.0	4.20	0.0	25.0

NOTES:

[a] 40 farmers rented in land during the winter while 44 farmers rented it in during the summer.

[b] 22 farmers rented out land for both the summer and the winter season.

[c] There are a total of 257 parcels in winter and 259 parcels in summer.

[d] Respondents gave answers for 227 out of 262 parcels.

Table 3.3: Sample Area Classified by Soil Type and Season, Central Punjab, 1992

	SEASON: WINTER ACREAGE			SUMMER ACREAGE		
Type of Soil	**Total**	**Average**	**Stdd Dev[a]**	**Total**	**Average**	**Stdd Dev[a]**
Light loam or sandy	222.3	11.7	11.8	223.3	11.8	11.7
Medium/heavy loam	1566.0	11.4	11.9	1496.0	10.9	11.5
Clay	517.3	9.8	7.8	521.3	9.7	7.7
Water-logged	28.0	7.0	4.1	28.0	7.0	4.1
Saline[b]	446.3	10.9	12.5	459.3	11.2	12.5
Saline and Uncultivable[b]	44.0	14.7	15.04	44.0	14.7	15.0
Area not accounted for	14.0	4.7	0.6	20.0	5.0	0.8
Grand Total	2837.9			2791.9		

Note:

[a] Stdd Dev is equivalent to Standard Deviation.

[b] Data regarding area was obtained by summing up all the parcel areas, shown in the above Table.

Summer Saline area = 503.25 acres of a total of 2791.75 acres

Winter Saline area = 490.25 acres of a total of 2837.75 acres

3.4.3 Crops

Crops grown in the study area are seasonal and are grown in single-crop stands. While the total cropping index for both seasons was 166%[11], it averaged 80% during the summer, and 86% in the winter. This cropping index was only slightly less than the level of 180% reported by Amir (1985), who also collected data in the same sample general area (the center of the rice-wheat production system).

Most farmers (86%), reported that they obtain 54% of their cropping income from IRRI rice varieties or the less-profitable but higher quality Basmati rice varieties (Table 3.4). While on average, farmers cropped 50% of their land to rice in the summer and derived 50% of their income from it, rice income ranged from 10% to 90% of farmers' total income. In addition, farmers reported that they obtained 39% of their income from wheat (the agricultural staple), although 56% of their land was sown to this crop.

In recent years the percentage of area sown to rice (50%) and wheat (41%) appear to have declined in this area. For example, Amir and Aslam (1989) reported that farmers devoted 74% of their land in the summer to rice and 77% of their land in winter to wheat in 1982.

In the study area, 30 farmers reported that their winter fruits, vegetables and specialty (berseem) crops contributed to 32% of their farm cash income. This income share is greater than the 26% of total land area sown to these crops, but is less than the proportion of land planted to all cash crops. While farmers reported that only 3% of their income was obtained from summer specialty crops, 6% of the land was sown

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[11] The cropping index of a parcel of land denotes the sum of the proportion of the land which is cropped in both seasons.

Table 3.4: Land Allocation and Income Shares from Crops for 140 Sample Farms, Summer and Winter 1992.

TYPE OF FARM CROP	SEASON			
	SUMMER		WINTER	
	FARM AREA[b]	CROP INCOME	FARM AREA[b]	INCOME
	(percentages)			
RICE/WHEAT (n=)[a]	50[b] (121)	50 (113)	56[b] (131)	39.0 (131)
Livestock	18 (113)	9.3	3 (13)	9.3
SPECIALTY (n=)[a]	6b (47)	3.0 (10)	26 (131)	31 (32)
FALLOW (n=)[a]	20 (80)	--	13 (74)	--
OTHER CROPS (n=)[a]	6	n.a	2	n.a
ALL CROPS	100	n.a	100	n.a

Notes:

Area measures are more objective evaluations, based on measures which farmers recall more easily.
[a] n= number of farms which grew the crop.

[b] This percentage is computed for all farms. For example, while farmers said they derived 3% of their cash income from specialty crops, only 10 farmers obtained 30% of their income from them.

n.a denotes not applicable.

to these crops[12]. It should be noted that this estimate of cash income from subsistence fruits and vegetables, does not include crops grown for home consumption, which increase welfare but are not a source of cash income. Also, large farmers may have neglected to mention income obtained from vegetables, which may be larger than the vegetable crop income of a smaller farmer.

[12] These crops accounted for 30% of the income for the 10 participating households.

Fodder is currently sown on 3% of the winter and 18% of the summer-cropped area. Most (86%) of the households in the study area produced livestock fodder and a combination of fodder and milk sales accounted for 9.3% of farm income.

Finally, during the summer, a larger amount of land (650.38 acres) was left fallow, compared to the winter season (494.5 acres). The main reasons cited for leaving land fallow in both seasons included water scarcity for growing crops and the desire to improve soil fertility. Labor and resource constraints were reported to be more important in the summer than in the winter, while flooding or the danger of flooding along dried river-beds, due to the monsoon rains was only reported during the summer.

3.4.4 Livestock Activity

Most (86%) of the farmers engaged in livestock activity. Water buffaloes were form the main source of milk production, with the number of milking water buffaloes owned per household averaging 2.34 female buffaloes, compared to 0.45 female cattle[13]. Buffalo males and bulls, primarily used for breeding and traction, averaged 1.19 and 0.71 animals per household, respectively[14]

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[13] However, for the households that own cattle, female cattle averaged 2.93 per household.

[14] Water buffalo are the preferred source of power (in descending order) for fodder choppers, transport (buffalo carts) and animal traction. Bulls are preferred to the water buffalo as a power source for animal traction.

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CHAPTER 4: Village Infrastructural Analyses

4.1 Introduction

The empirical information which has been collected with respect to 6 variables across 30 different infrastructural services for 28 villages constitutes a very large data set. Extensive information regarding 180 variables with 180*28 data points was collected. It will be used to do two types of analysis. The data set initially needed to be condensed to a more manageable and usable format by removing some of the (30) infrastructural services which are redundant in order to present information in a parsimonious fashion. Section 4.2 presents analysis which consists of selecting a subset of 13 key indicators from the full set of 30 infrastructural services.

Section 4.3 describes the reasons and then the procedures used to stratify villages according to varying levels of infrastructure. Cluster analysis, the appropriate methodology needed to implement this stratification and classify villages is described in Section 4.3.1. Section 4.3.2 describes the procedure whereby the empirical measure for implementing cluster analysis is selected. The results of the procedure are described for one key indicator and then for two additional indicators in order to verify the choice. Section 4.3.3 describes the choice of the clustering method, in a similar fashion. Initially the most appropriate clustering algorithm is chosen for one key indicator. The choice is verified for two additional indicators. Results obtained from the application of the selected clustering method to all key indicators are interpreted in Sections 4.3.4. An overall index of access to infrastructure is derived from all the key indicators.

4.2 Selection of Critical Infrastructural Indicators

A subset of 'key' indicators was chosen to represent each type and category of infrastructure essential for the farmers needs. This economic basket of key indicators consists of infrastructural services which are either the most 'typical', 'representative' or the most preferred service for each distinctive category of infrastructure. Correlation analysis coupled with economic criteria and subjective judgement (based on the researcher's experience of actual field conditions) was chosen to extract the key indicators from 30 infrastructural services.

4.2.1 Method

Correlation analysis is an appropriate statistical tool for this analysis because it indicates the coincidence or independence of information across indicators. For example, complementary services such as output markets, banks and fertilizer markets appear to have sprung up simultaneously in towns which have become marketing centers. Consequently, there is little independent information to be gained by including measures of each category of infrastructure in the basket of key indicators. Empirical measures of correlation among such services are strong. Other categories of infrastructure consist of distinct services, not jointly available to the farmer. Means of access to the categories are less correlated with one another, indicating that they contain independent information. Consequently, each of these measures are candidates for inclusion in the basket of key indicators. The fixed basket is chosen by subjective interpretation of the correlation results.

However, there are six empirical variables measuring access, and the problem arises as to which empirical variable(s) or subset of such variables should be chosen to measure accessibility. In the interest of clarity and efficiency, one variable will probably need to be used as a proxy for measuring such access. This empirical measure will have to be valid across all indicators. Hence a criterion in the choice of the empirical measure will be one which does not have high correlations with other indicators.

The available measures of physical access include distance, time and fare incurred, mode of transport, its frequency of use and duration of usage. As the frequency and duration of use of the variables yield information dependent upon the mode of transport, they cannot be used independently. These variables yield information regarding the convenience of usage of the mode of transport, or convenience of access rather than actual access. The mode of transport also measures the convenience of access, in this instance, by a certain type of vehicle. Hence these three variables are precluded from consideration as an appropriate measure of accessibility.

Nonetheless, in some instances mode of transport contributed very useful information regarding the convenience of access to an infrastructural access, particularly in cases where such convenience is extremely important. For example, the mode of transport to the girls secondary school was found to be statistically different from modes of transport to other services[1]. In a segregated society such as Pakistan's where fear for girls' security is often cited as a reason for not educating them, such convenience of access (trivial though it may seem!!) along with other factors such as distance to the girls school may be significant in

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[1] The Kruskall-Wallis test was used to determine whether the modes of transport varied between different indicators. This test tests for the probability that the modes of transport are drawn from the same population.

Table 4.1: Correlations for Fare and Time Variables for 13 Key Indicators for 28 Sample Villages, Central Punjab 1992

Indicators:	Bus-Stop	Road	Market Town	Industrial Town	Rice -Mill	Bank	Union Council	Police	Post Office	Extension Agent	Rice Research Institute	Veterinary Agent	Boys Secondary School
Time Variable													
Bus-stop	1.00	0.89	0.83	0.53	0.80	0.72	0.47	0.65	0.77	0.85	0.54	0.71	0.76
Road	0.89	1.00	0.82	0.60	0.72	0.74	0.39	0.64	0.72	0.78	0.51	0.60	0.71
Market	0.83	0.82	1.00	0.54	0.89	0.91	0.42	0.71	0.71	0.76	0.38	0.58	0.88
Industrial Town	0.53	0.60	0.54	1.00	0.44	0.51	0.03	0.52	0.59	0.49	0.68	0.45	0.52
Rice-mill	0.80	0.72	0.89	0.44	1.00	0.86	0.52	0.63	0.68	0.73	0.35	0.67	0.95
Bank	0.72	0.74	0.91	0.51	0.86	1.00	0.30	0.63	0.66	0.60	0.29	0.44	0.85
Union Council	0.47	0.39	0.42	0.03	0.52	0.30	1.00	0.16	0.43	0.59	0.16	0.68	0.52
Police Station	0.65	0.64	0.71	0.52	0.63	0.63	0.16	1.00	0.53	0.55	0.43	0.42	0.67
Post Office	0.77	0.72	0.71	0.59	0.68	0.66	0.43	0.53	1.00	0.77	0.46	0.74	0.68
Extension Agent	0.85	0.78	0.76	0.49	0.73	0.60	0.59	0.55	0.77	1.00	0.37	0.75	0.70
Rice Research Institute	0.54	0.51	0.38	0.68	0.35	0.29	0.16	0.43	0.46	0.37	1.00	0.51	0.42
Veterinary Agent	0.71	0.60	0.58	0.45	0.67	0.44	0.68	0.42	0.74	0.75	0.51	1.00	0.64
Secondary Schools: Boys	0.76	0.71	0.88	0.52	0.95	0.85	0.52	0.67	0.68	0.70	0.42	0.64	1.00
Fare Variable													
Bus-stop	1.00	0.55	0.30	0.33	0.55	0.53	0.59	-0.05	0.47	0.43	0.31	0.45	0.29
Road	0.55	1.00	0.31	0.25	0.44	0.59	0.15	0.11	0.16	0.02	0.08	0.10	0.35
Market	0.30	0.31	1.00	0.48	0.73	0.74	0.02	0.00	0.63	0.12	0.19	0.14	0.59
Industrial Town	0.33	0.25	0.48	1.00	0.29	0.47	0.17	0.02	0.57	0.30	0.66	0.34	0.47
Rice-Mill	0.55	0.44	0.73	0.29	1.00	0.83	0.17	-0.01	0.59	0.37	0.06	0.35	0.65
Bank	0.53	0.59	0.74	0.47	0.83	1.00	0.23	0.02	0.60	0.33	0.08	0.22	0.71
Union Council	0.59	0.15	0.02	0.17	0.17	0.23	1.00	-0.08	0.45	0.54	0.21	0.54	0.32
Police Station	-0.05	0.11	0.00	0.02	-0.01	0.02	-0.08	1.00	-0.01	-0.10	-0.29	-0.11	-0.08
Post Office	0.47	0.16	0.63	0.57	0.59	0.60	0.45	-0.01	1.00	0.61	0.41	0.57	0.74
Extension Agent	0.43	0.02	0.12	0.30	0.37	0.33	0.80	0.37	0.23				
Rice Research Institute	0.31	0.08	0.19	0.66	0.06	0.08	0.21	-0.29	0.41	0.25	1.00	0.33	0.30
Veterinary Agent	0.45	0.10	0.14	0.34	0.35	0.22	0.54	-0.11	0.57	0.80	0.33	1.00	0.40

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determining whether parents will invest in their daughters' education. However, this empirical measure does not yield equally useful information for other indicators. So that it does not appear to be a generally applicable result across the key indicators.

Hence the choice became limited to the three continuous variables namely: time, distance and fares. Times taken to reach different destinations were found to every highly correlated with one another, as seen in Table 4.1 which illustrates correlations only among 14 indicators[2]. Such correlations arose because obtaining access to many infrastructural services from a number of villages often entailed spending a uniform (and disproportionately large) amount of time in getting access to the same bus-stop. As this variable was measured in hours, its range of values was also rather small, from 0.05 hours to 6.5 hours[3], further increasing correlations in values.

The measurement of the fare variable suffered from problems similar to that of the time variable. Nearer destinations appear to be comparatively more expensive to get access to, than further destinations (Table 4.1). This arose because access to nearer services often entailed travelling by a traditional form of transport, (e.g a horse-carriage) and the time incurred in reaching the destination was higher by such transport. However, the correlations among fares to different services are quite low compared to the time variable. These lower correlations may have arisen because the range of values for fares to different infrastructural indicators was much higher

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[2] The 14 indicators include the 13 key indicators and the road indicator, because it is a very important indicator.

[3] Statistical Measures of Centeredness and Dispersion for the Time variable across all indicators:

Range 0- 5.50 hours; Mean =1.35 and standard deviation = 1.31

Table 4.2: Correlations for the Distance Variable for 13 Key Indicators for 28 Sample Villages, Central Punjab 1992

DISTANCE[a]	Bus-Stop	Road	Market Town	Industrial Town	Rice-Mill	Bank	Union Council	Police	Post Office	Extension Agent	Rice Research Institute	Veterinary Agent	Boys Secondary School
Bus-stop	1.00	0.74	0.49	0.09	0.57	0.48	0.55	0.42	0.69	0.63	0.32	0.43	0.49
Road	0.74	1.00	0.53	0.22	0.32	0.63	0.29	0.25	0.49	0.36	0.31	0.22	0.37
Market	0.49	0.53	1.00	0.32	0.49	0.55	0.17	0.76	0.38	0.35	0.14	0.19	0.44
Industrial Town	0.09	0.22	0.32	1.00	-0.15	0.23	-0.05	0.24	0.27	0.18	0.54	0.12	0.18
Rice-Mill	0.57	0.32	0.49	-0.15	1.00	0.54	0.32	0.42	0.40	0.40	-0.08	0.41	0.73
Bank	0.48	0.63	0.55	0.23	0.54	1.00	0.03	0.32	0.41	0.23	-0.02	0.08	0.70
Union Council	0.55	0.29	0.17	-0.05	0.32	0.03	1.00	0.15	0.51	0.54	0.26	0.59	0.18
Police Station	0.42	0.25	0.76	0.24	0.42	0.32	0.15	1.00	0.30	0.26	0.14	-0.04	0.54
Post Office	0.69	0.49	0.38	0.27	0.40	0.41	0.51	0.30	1.00	0.81	0.23	0.56	0.39
Extension Agent	0.63	0.36	0.35	0.18	0.40	0.23	0.54	0.26	0.81	1.00	0.26	0.74	0.25
Rice Research Institute	0.32	0.31	0.14	0.54	-0.08	-0.02	0.26	0.14	0.23	0.26	1.00	0.31	0.01
Veterinary Center	0.43	0.22	0.19	0.12	0.41	0.08	0.59	-0.04	0.56	0.74	0.31	1.00	0.19
Boys Secondary School	0.49	0.37	0.44	0.18	0.73	0.70	0.18	0.54	0.39	0.25	0.01	0.19	1.00

Notes:

Statistical Measures of Centeredness and Dispersion for the distance variable:
[a]Distance: Range 0-240 kms; Mean =18.48, Standard Deviation = 30.36

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than for the time variable: from Rupees 0 (for walking) to Rs 40 but lower than for the distance variable[4].

The distances to various services were not subject to either of the problems which the time and fare variables had. The distance variable also appeared to be a better measure of physical access in a relative sense. Nearer places were associated with smaller distances and vice versa. The measure was also generally applicable across all of the key indicators as well as all of the 30 infrastructural services. The distance variable also had variable values, which yielded lower statistical correlations across different indicators. Hence it was chosen as the most appropriate measure for correlation analysis.

4.2.2 Results

Choice of key indicators is illustrated in Table 4.3. The bus-stop was chosen as the single key indicator representing both transport and physical infrastructure. The correlation coefficient of 0.74 between the road and bus-stop was rather high, as may be seen from Table 4.2 which shows the correlations for the distance measure with respect to 14 infrastructural indicators. This was because many bus-stops were located on the main road, so that relatively little additional information was contained in the road variable. The other available indicator of transport infrastructure, the train, was relatively unimportant being used only by a few villages.

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[4] Statistical Measures of centeredness and dispersion for the fare and distance variable for all indicators:

Fare: Range is Rupees 0- 40; Mean = 18.48, Standard Deviation = 30.36
Distance: Range is 0 - 210 kms; Mean = 21.45 kms,
Standard Deviation= 31.83.

Table 4.3: Types of Infrastructural Services and Key Indicators for 28 sample Villages, Central Punjab, 1992

TYPE OF INFRA-STRUCTURE	SERVICES RELEVANT TO THE FARMER	INDICATORS OF ACCESS
	Roads	Distance to bus stop.
Physical	Rails	n.a [a]
Transport	Trains	n.a [a]
	Motorized road vehicles	Distance to bus stop.
	Non-motorized vehicles	Distance to bus stop.
Commercial	Marketing services	Distance to market town, distance to industrial town.
	Food-processing services	Distance to the rice mill.
	Labor-market services	Distance to industrial town.
	Financial services	Distance to bank.
	Animal health services	n.a [a]
	Telecommunications services	Distance to post office.[b]
Administrative	Land titling and registration services	Distances to Union Council, tahsil and district seats.
Social	Educational services	Distance to boy's secondary school.
	Human health services	Distance to Health Clinic.
	Police (security) services	Distance to the police post.
Institutional	Administrative, contractual and enforcement services	n.a [c]
	Research and extension services	Distance to the Rice Research Institute, distance to closest extension office.

Notes:

[a] Not applicable due to low use.

[b] Postal services are used more than telecommunications among the survey respondents.

[c] Not applicable since the most important services are subsumed in other categories.

A total of eight services represent marketing infrastructure. A number of input and output marketing and repair services (produce and grain markets, seeds and fertilizer markets, workshop repair facilities) available from the same location were highly statistically correlated (by 0.99, 0.99, 0.75 and 0.87) with one another. Thus the market town was a good key indicator for measuring marketing infrastructure.

As rice milling is the leading (and most prevalent) food processing industry, distance to rice mills is the key indicator for food-processing services. However, rice-mills are correlated to other key indicators e.g the market (0.49) and the bank (0.55) to some extent.

The industrial town provides the greatest opportunities for off-farm seasonal employment. Hence it is chosen as a key indicator. The bank serves as the single indicator representing access to credit, although it is correlated with commercial services (0.66).

The veterinary center is another key indicator. It is correlated with (other) publicly provided services such as the union council (0.59) and extension agent (0.53). The Post Office was chosen to be the key indicator for telecommunications in preference to the telephone. Postal services are the most common method of communication with the outside world for most villagers.

There are three indicators of administrative services. They include the district and tahsil (sub-district) towns and the Union Council. Of the three administrative indicators, the Union Council is the most decentralized unit of Provincial Government, with jurisdictional boundaries over eight villages, thereby making it more accessible to farmers. It is also the least correlated with other types of key infrastructural indicators. For example, the district town and the industrial town were correlated by 0.66, while the Union Council and health centers had a coefficient of 0.50. Hence it is chosen to represent Government administrative services. Security services are represented by the Police Post.

Two indicators represent institutional infrastructure. Research support services are represented by the Rice Research Institute (RRI). The RRI is much more accessible to the sample farmers than the Wheat Research Institute (WRI). However, it is correlated with the industrial town by 0.54. Agricultural extension is chosen to be the other key institutional indicator, in spite of its correlation with two other key indicators viz: postal (0.59) and veterinary services (0.53).

Data for both primary and secondary schools (for boys and girls) were collected. However, secondary schools are recognized to be more important to the preservation of adult literacy than are primary schools (Ahmed 1990). As decision-making power within agriculture is predominantly male-dominated, the boys' secondary school is chosen to be the key indicator for human capital development.

Health services serve as the key indicator for health infrastructure.

4.3 Stratifying Sample Villages by Infrastructure

Results from the previous chapter indicate that a subset of 13 key economic indicators was derived from 30 infrastructural services for which empirical data has been obtained. These key indicators serve as a 'proxy ' for the composite variable 'infrastructure'. However, meaningful comparative data analysis in order to test the various farm-household hypotheses formulated in Chapter one can only be undertaken if households can be identified as belonging to more or less infrastructurally-developed villages.

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Infrastructure has to be used to stratify or classify villages into distinct groups such that villages within a particular group have homogeneous levels of infrastructure, while villages in different groups have varying levels of infrastructure. As the stratifying variable itself consists of 13 key indicators, and their related measures, the use of a multivariate statistical method which can stratify a composite variable was called for. The method of cluster analysis was chosen because of its ability to assess the similarity within and between different key indicators with regard to the different villages in the sample.

4.3.1 Stratification Method: Cluster Analysis

Conceptually cluster analysis utilizes the dissimilarity or distance between one or more empirical measure(s), to cluster the most similar villages (or cases) into two or more groups. Cluster analysis offers a choice of six or more methods. The commonality of these methods is that they attempt to maximize the differences between clusters relative to the variation within the clusters. Euclidean distance is often used to measure distance (distinct from the variable distance) in n-dimensional space.

The use of cluster analysis entails that two major issues be addressed. They include choosing the most appropriate empirical variable or variables for measuring access to key infrastructural indicators, as well as finding out the most suitable clustering method.

4.3.2 Empirical Measure(s)

There are six empirical variables which measure access. Taken as a whole, this composite of different variables capture the differences which arise in getting access to a particular location. The problem arises as to which empirical variable(s) or subset of such variables should be chosen to measure accessibility.

The use of cluster analysis itself renders the use of multi-dimensional scaling measures untenable. Cluster analysis assembles together similar information and differentiates unlike information. However, because clustering is a random procedure, cluster analysis does not automatically rank clusters in ascending or descending order of magnitude. Only a single variable can be meaningfully ranked in a manual manner across an economic indicator at a time. Consequently, it became necessary to choose a single variable as a group proxy.

The proxy variable had to be the best available measure of physical access. Moreover, it had to demonstrate the most distinct differences across key indicators, and yield sufficiently dissimilar results from other measures of access. The selected empirical measure had to be valid across all indicators so that cluster analysis could be used to group villages by degree of access. Only then could cluster analysis minimize the distance within clusters and maximize distance between separate clusters.

Through statistical analysis, subjective judgement and economic intuition the six available empirical variables measuring access to an important key indicator were examined, in order to select the most appropriate empirical measure. This analysis was also extended to two other key indicators in order to verify the results from the first application. The statistical procedure and logic used to undertake the analysis is explained in section 4.3.2.A while the results of this procedure are presented in Section 4.3.2.D. The results of the application of these methods to a key infrastructural indicator is described in Section 4.3.2.B. The extension of this application to two additional key indicators is described in Section 4.3.2.C.

4.3.2.A Method

Of the six empirical measures, distance, fares, times, and frequency of the mode of transport to infrastructural indicators consist of continuous variables. Modes of transport to these indicators and their duration of service are represented by discrete variables. Elementary statistical analysis regarding the distribution of the continuous variables with regard to the required key indicators was conducted. Measures of centeredness including the mean, modal and median values as well as measures of variability regarding the behavior of the underlying data were obtained for each of the indicators. Dispersion measures consisted of the range, standard deviation, skewedness and kurtosis. Outliers were also identified.

For the discrete variables, tables of frequency distributions for the different modes of transport and their duration of service with respect to each of the key indicators were generated. The Kruskall-Wallis test was used to determine whether the modes of transport varied with regard to different key indicators.

4.3.2.B Applications to Key Indicators: Industrial Town

The distance and time taken to reach the industrial town appeared to be good choices for group proxies. The fare variable was considered to be an inappropriate measure primarily because walking, a predominant method of transport, had a fare of zero. Thus this measure assigned a zero weight to walking, as opposed to the time and distance variables. Time taken to walk to the infrastructural indicator constituted a good measure of the opportunity cost of obtaining access to the indicator, and distance to the indicator was a good measure of nearness to it. Another reason to discard the fare measure was that the range of fares was rather low, thereby constituting an inappropriate measure of how far apart villages were from the infrastructural indicators.

The time and distance variables were expected to provide complementary information, because infrastructural services nearer in terms of physical distance, might actually be less accessible due to poorer road conditions (and ensuing slower modes of transport). However, village rank regarding access to the industrial town, with respect to these two variables did not vary appreciably, except in very few instances. So the time variable did not add much information to the distance variable.

The average distance to reach the industrial town was 36.48 kms was close to the median value of 31 kms (Table 4.4). Although the distance distribution had three modal values (10, 12 and 68 kms), the values increased in a steady continuum, and the standard deviation was 26.17 kms. These highly variable distances had low correlations with other key indicators. Distance is probably the most unbiased measure as the possibility of measurement error by respondents, appeared to be low[5]. Distances to large cities and the nearest town were particularly well-known.

The time required to reach the industrial town varied from 0.12 hours to 5.50 hours (Table 4.4). Hence the range of values of this variable was lower than that of the distance variable. Its mean was 2.07 with a standard deviation of 1.33.
The time variable was highly correlated across different key indicators (see previous chapter), although fares to different destinations had a larger range of values.

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[5] There is a certain amount of confidence in these measures because the questions regarding the distance to a far-off indicator such as the industrial town were verified and validated by two or more farmers.

Table 4.4: Descriptive Analysis of Distance, Time and Fare Variables of 3 Key Indicators for 28 Sample Villages, Central Punjab, 1992.

KEY INDICATOR/ Variable	Mean	Standard Deviation	Median	Mode	Minimum	Maximum
Industrial Town:						
Distance (kms)	36.48	26.17	31.50	--[a]	7.00	111.50
Time (hours)	2.07	1.33	2.00	2.00	0.12	5.50
Fare (Rupees)	7.63	5.58	6.50	2.00	1.00	24.00
Bus-Stop:						
Distance (kms)	3.11	4.49	2.0	0.00[b]	0.00	20.00[c]
Time (hours)	0.54	0.63	0.00	0.00	0.00	2.00
Fare (Rupees)	0.57	1.69	0.00	0.00	0.00	6.00
Market:						
Distance (kms)	11.77	7.42	10.50	6.00[d]	2.00	37.00
Time (hours)	0.94	0.66	0.00	0.00	0.08	2.50
Fare (Rupees)	3.34	3.08	2.00	2.00	0.00	15 50

Notes: [a]: No single modes in this distribution.

[b]: A bi-modal distribution with one other mode of 2 kms

[c]: There were 3 outlying villages (numbers 22, 7, and 28): 10, 11 and 20 kms distant, respectively.

[d]: A multi-modal distribution with two other modes: 10 and 1 kms

The remaining three variables consist of mode of transport, its duration of service and frequency of travel. As the industrial town is relatively far away, it can only be reached by bus and/or another mode of transport. However, transport modes to the industrial town did not appear to be significantly different from such transport modes to other key indicators (Table 4.5). Results from the Kruskall Wallis test indicated that the probability of incorrect classification of transport methods to go to the industrial town from other such methods was 0.007.

The duration of service and frequency of the mode of transport measure the ease and convenience of travelling associated with the mode of transport. Even if the time taken to reach the industrial town is not high, if the bus passes by, very infrequently, it is not convenient to use it. The duration of bus service is also important. However, these measures cannot represent access as they yield incomplete (though) useful information. One reason is that when there is a change in the mode of transport involved to get to a particular location, or an indigenous form of transport is used to make a long journey, the journey becomes more uncomfortable and inconvenient. So that these two measures cannot even completely measure the convenience or ease of a journey.

Thus the distance measure emerged as the most suitable empirical variable for measuring access to the industrial town. However the analysis was extended to two other key indicators namely: the market town and the bus-stop to verify the selection of the distance measure.

4.3.2.C Verification to Bus-Stop and Market Town

The average distance to the market is 11.7 kms with a standard deviation of 7 kms. While the median value was 10.50 kms, there was a cluster of values at 6 kms, one of three modal values. Mean and range value figures are one-quarter the magnitude of comparable numbers for the industrial town. However, unlike the industrial town, village rankings regarding the time and distance taken to reach this key indicator differed appreciably across a number of villages. Regardless, visual inspection of Table 4.5 indicate that the modes of transport taken to reach the market town, did not vary appreciably from that taken to reach most of the other key indicators. Modes of transport to the industrial town followed a similar pattern.

Analyzing information regarding access to the bus-stop, nine villages had bus-stops within them. Village rankings regarding distance and time variables are fairly consistent across nearly all but a few villages. This indicator does exhibit statistically significantly different modes of transport from the previous two indicators. For example, walking is the most prevalent transport mode. Localized forms of transport charge comparatively higher fares to cover the small distances involved. Hence walking may appear more attractive compared to the disutility of paying higher fares, particularly if weather conditions are favorable. However for the most remote villages (7,27, and 28) horse carriages and suzuki taxis were the most common modes of transport because of the longer distances and poor terrain to be covered.

Distance appeared to emerge as the most suitable empirical measure, in spite of information derived from other indicators, as in the case of mode of transport for the bus-stop and times obtained to reach the market place. Thus the distance

Table 4.5: Modes of Transport to 15 Infrastructural Indicators in 28 Sample Villages, Central Punjab, 1992.

Key Indicators		None	Motorized Public Transport[a]	Horse Cart	Walk -ing	Cycle	Horse-cart +bus	Walk +Bus
Bus-Stop		9	1		18			
Market			10		2		2	11
Industrial Town			10				5	13
Union Council		6	6	4	12			
Rice-Mill		1	9	4	1	0	1	12
Extension Agent		2	8	3	8	0	1	6
Rice Res Institute			10				5	12
Bank			9	4	7		1	7
Secondary School	Boys	2	6	4	8	1	1	6
	Girls	3	7	2	6		2	8
Post Office		9	3	3	10		1	2
Police Post			7	3	2	1	3	12
Health Clinic		6	7	2	8			5
Veterinary Clinic		5	6	2	8		1	5
Roads		7	2	1	1	17		1

Note: [a] Motorized public transport includes: bus, suzuki van, mini-bus, taxi, etc.

variable was chosen to cluster the sample villages across all the key indicators. A more detailed comparative statistical analysis was undertaken for this variable across all the key indicators to examine whether it needed any modification for its use in cluster analysis.

4.3.2.D Statistical Comparison Across 14 Key Indicators

Within the data set, distance exhibits skewed, irregular or flat distributions, with regard to one or more of the economic indicators (see Table 4.6). The distance to some indicators exhibit a skewed modal distribution (demonstrated by positive skewness or kurtokic coefficients) with a right-hand tail. Such indicators often have extreme or outlying values at the tail-end of the distribution of the distance variable. Such indicators e.g bus-stop, extension services, Postal services, Boys's Secondary School, Veterinary Center, and the road are characterized by a proportionately higher number of villages having closer access to these services, with a few villages having poor and very poor access. These services are either decentralized (e.g roadbus-stop) or are publicly-provided by Government as social services (extension, postal and veterinarian services) or as basic infrastructure (roads). Consequently only a few villages do not have good or fair access to them. Access to other more-widely dispersed commercial or less-decentralized services such as the rice-mill or industrial town, and research services (respectively) have a more symmetric statistical distribution, distributed evenly about the mean. The distance measure displays a continuum of steadily increasing values.

The spurious effects of unequal variances generated from the different types of statistical distributions associated with different indicators have been eliminated by normalizing these variables (i.e converting them to z-scores), prior to clustering.

4.3.3 Clustering Method

The most suitable method for clustering the data had to be selected next. The procedure followed was similar to that followed for the selection of the empirical variable. The various clustering methods used were analyzed with regard to one key indicator namely the bus-stop; and then verified with regard to two additional indicators, the market and the industrial town.

Table 4.6: Analysis of Distance to 14 Infrastructural Indicators: 28 Sample Villages, Central Punjab, 1992

Serial Number	Key Indicator	Mean	Stdd: Dev:[a]	Mode	Median	Skewness	Kurtosis
1	Bus-Stop	3.1	4.5	0.0	0.0	2.4	6.8
2	Market	11.7	7.4	6.0	10.5	1.5	3.6
3	Industrial Town	36.4	26.2	10.0	31.5	1.1	0.9
4	Union Council	4.4	4.0	0.0	4.0	2.1	7.6
5	Rice-Mill	10.1	6.0	6.0	9.0	0.3	-0.9
6	Extension Agent	5.8	5.3	5.0	5.0	1.3	1.3
7	Rice Research Institute	82.2	38.3	66.0	80.0	-0.03	-0.3
8	Bank	8.5	6.3	2.0	6.0	0.8	-0.7
9	Post Office	3.7	5.2	0.0	2.0	2.0	3.9
10	Boys Secondary School	7.7	7.8	2.0	4.0	1.4	1.4
11	Police Post	12.7	7.5	10.0	10.5	1.5	3.3
12	Health Clinic	4.6	4.6	0.0	3.5	1.6	3.3
13	Veterinary Center	5.9	6.9	0.0	4.0	2.4	7.1
14	Main Road	4.2	5.1	2.0	2.0	1.8	3.0

Notes:
[a] Stdd Dev: = Standard deviation

After experimenting with five clustering methods, Ward's hierarchical method was used in preference to other hierarchical and non-hierarchical methods. The specific computing algorithms which these methods use are described in greater detail in Appendix II.B. In the following section the process by which these methods are used to classify the sample villages is illustrated.

4.3.3.A Selection: Application to Bus-Stop

The number of clusters into which the distance to the bus-stop can be classified are presented in Table 4.7 and Table 4.8. Cluster results are normally interpreted according to a hierarchical plot which indicates which villages are joined together at each stage (Hair et al, 1992). The information in the hierarchical plot is shown in Table 4.9 which portrays village ranking and clustering (according to Ward's Method).

Table 4.7: Distance to Bus-stop: Clusters/Ranks of 28 Sample Villages, Central Punjab, 1992

	VILLAGE ATTRIBUTES			
Cluster	Frequency of Value in Rank	Rank	Village Number	Distance-Bus-stop
1	1.00	1.00	1.0	0.00
1	1.00	2.00	4.0	0.00
1	1.00	3.00	8.0	0.00
1	1.00	4.00	12.0	0.00
1	1.00	5.00	13.0	0.00
1	1.00	6.00	16.0	0.00
1	1.00	7.00	18.0	0.00
1	1.00	8.00	19.0	0.00
1	1.00	9.00	21.0	0.00
2	3.00	10.00	2.0	1.00
2	3.00	10.00	11.0	1.00
2	3.00	10.00	23.0	1.00
2	1.00	13.00	26.0	1.50
3	4.00	14.00	3.0	2.00
3	4.00	14.00	5.0	2.00
3	4.00	14.00	10.0	2.00
3	4.00	14.00	15.0	2.00
3	4.00	14.00	20.0	2.00
3	4.00	14.00	24.0	2.00
4	1.00	20.00	25.0	2.50
4	1.00	21.00	14.0	3.00
4	2.00	22.00	6.0	5.00
5	2.00	22.00	9.0	5.00
5	1.00	24.00	27.0	6.00
6	1.00	25.00	17.0	8.00
6	1.00	26.00	22.0	10.00
7	1.00	27.00	7.0	11.00
8	1.00	28.00	28.0	20.00

Table 4.8: Distance to Bus-stop Clustered by Average Linkage between Groups: 28 Sample Villages, Punjab, 1992

METHOD	AVERAGE LINKAGE BETWEEN GROUPS							
	Cluster Numbers							
No of Clusters	One	Two	Three	Four	Five	Six	Seven	Eight
3	24	3	1					
4	21	3	3	1				
5	20	3	3	1	1			
6	9	12	3	2	1	1		
7	9	4	8	3	1	2	1	
8	9	4	8	3	1	1	1	1

Distances to the various villages are ranked in Table 4.7. Nine cases (villages) had bus-stops within the village. The method of average linkage between groups clustered the weighted (normalized z_score) data into this category with six clusters (Table 4.8). The five villages (nos 7,17,22, 27 and 28) which are furthest away from the bus-stop are consistently placed in the last set of clusters. When there are five clusters, they are in clusters four and five, with eight clusters, they position themselves in clusters five through eight. There are from 12 to 17 villages in clusters two or two through four depending on the total number of clusters. The normalization procedure is able to separate this medium range of villages into clusters two through five. However, the researcher had to cluster the villages into eight clusters to reach this result because this method maximizes Euclidean average but not Euclidean actual distances between clusters.

Results obtained from two other methods, the Centroid and Median methods are similar to the average-linkage between-groups-method. Table 4.9 shows clustering

Table 4.9: Distance to Bus-Stop: Clustered by Average Linkage Within Groups and Ward's Method: 28 Sample Villages, Central Punjab, 1992.

METHOD — **WARD'S METHOD**

No of Clusters	One	Two	Three	Four	Five	Six	Seven	Eight
	Cluster Numbers							
3	21	6	1					
4	21	3	3	1				
5	9	12	3	3	1			
6	9	12	3	2	1	1		
7	9	4	8	3	2	1	1	
8	9	4	6	3	2	2	1	1

METHOD — **AVERAGE LINKAGE WITHIN GROUPS**

No of Clusters	One	Two	Three	Four	Five	Six	Seven	Eight
	Cluster Numbers							
3	25	2	1					
4	21	4	2	1				
5	21	3	2	1	1			
6	12	9	3	2	1	1		
7	12	9	3	1	1	1	1	
8	12	9	2	1	1	1	1	1

according to two other methods which were used: average-linkage-within-groups as well as the WARD method. The WAVERAGE method of average-linkage-within-groups minimizes euclidean distance within clusters, but does not succeed in separating out differences between the higher and medium level villages. (For instance the nine villages with bus-stops in them are not separated out). Only the WARD method separates medium level villages into high, and lower medium level villages, or clusters two and four. Thus looking only at this key indicator, the researcher would choose eight clusters, and characterize villages in cluster one to have a high level of infrastructure, villages in clusters two and three to have medium levels of infrastructure and villages in cluster four through six to have lower infrastructure. Villages in clusters seven and eight are extreme values or outliers. These villages are outliers because the same villages are constantly relegated to the lowest clusters and rank lowest as successive clustering into a larger number of solutions proceeds.

The non-hierarchical seed clustering procedure yielded results which were similar to Ward's method. However, the researcher decided not to use the seed clustering procedure because the categorical distinctions appeared more clear-cut when using Ward's procedure.

4.3.2.B Verification to Industrial Town and Market

Ward's method was also used to cluster the sample of villages with regard to two other indicators viz: the market town and the industrial town. As clustering average-distance between-groups has proved to be a poor method, clustering results for these indicators are shown with regard to clustering average-distance-within-groups and WARD. While the results of this analysis are discussed for these two methods, the tables are attached in Appendix II.A.

Ward's method was able to divide the villages consistently for the market. Distances to the market town range from 2 kms to 21 kms, with a single outlier of 37 kms. The small range of values required that the sample had to be divided into eight clusters before the villages could be separated out into high, medium, low and outlying groups. The outlier and the three lowest extreme values were detached only at the eighth stage of clustering. Villages ranked fourth were divided at the sixth stage of clustering while those ranked second and third were separated at the seventh stage of clustering. Villages ranked fifth required eight stages of clustering.

Distances to the industrial town on the other hand ranged from 7 kms to 111.50 kms (Table 4.7). Two outlying values were divided out after the algorithm was clustered into seven groups. The highest ranked cluster of villages were separated out into four groups when there were five clusters. The third and fourth clusters were separated out at the eighth stage of clustering. Hence both this method and the number of clusters appear to be appropriate for both of these two indicators.

Hence the analysis can be extended to the 27 other infrastructural services by induction.

4.3.4 Results of Cluster Analysis

Cluster analysis is used to assess the similarity both within and between different infrastructural services, with regard to the different villages in the sample[6].

Ward's hierarchical method of clustering was used to group the 28 villages regarding their access to each of 13 key economic indicators. Division into eight clusters was required before the weighted distances were appropriately clustered for all the villages and extreme and outlying values were separated out. Similar groups of infrastructure were ranked ordinarily, such that within each group, villages have similar measured access to infrastructural services while such access diverges across groups. Villages in cluster one are characterized as having a high level of infrastructure, while villages in clusters two and three have medium (average or above average) levels of infrastructure while villages in clusters four and five have below

[6] The clustering algorithm uses Euclidean distance in 13-dimensional space to measure the difference in access to infrastructural services across villages.

average to poor infrastructure. Villages in cluster six through eight are outliers, with extremely poor infrastructure. Villages are grouped into the appropriate cluster with regard to each indicator.

Table 4.10 consists of 28 rows for each villages and 15 columns; a column for the village number and thirteen columns for the key indicators. The last column is obtained by clustering the rankings of the individual indicators in order to obtain overall grouped rankings which signify the level of infrastructure for each village. There were initially grouped into five groups and interpreted according to differing levels of infrastructure in a consistent fashion.

Groups one and two appear to have a comparative advantage over the other groups with regard to accessibility to nearly all the services. They are some important differences with regard to access to key indicators. Group two has rather good access to the industrial town, while group one has below average access to this indicator. Group two's access to the rice-mill is very poor, while group one has mostly above average access to it. Group one's access to the Rice Research Institute (RRI) although variable, ranges from below average to average. Meanwhile, group two's access to the Rice Research Institute ranges from very good to rather poor, and is thus quite variable.

Groups three and four appear to have a medium (i.e a mixed) level of access to a number of key indicators. However, both groups have rather divergent levels of access to the same indicators. For example, group three has poor access to the industrial town, while group four has relatively average and above average access to this indicator. Group three has relatively worse access to the Rice Research Institute than group four does, and its mixed access to the Extension agent ranks below the (above average) accessibility of group four.

Villages grouped in cluster five are outliers. This cluster consists of villages 6, 17, 22 and 28. It has levels of accessibility to various indicators ranging from below average (four) to extremely poor access (eight). For example, village 28 has nearly uniformly poor access to all services, with its best access being to the Union Council.

Cluster analysis has generated 13 indices representing access to the 13 key indicators. The overall infrastructural index has been constructed from these indicators. Each of the individual indices is divided into eight clusters. The overall index is divided into five clusters. In order to use this information in an economically meaningful way, it is necessary to collapse each of these indices into three ordered groups denoting high, medium and low levels of infrastructural development or accessibility. Villages belonging to group one represent high-access infrastructure, while villages in groups two and three denote medium and low infrastructural access respectively. For the overall infrastructural index, villages in group one and two represent high-access infrastructure, while villages in groups three to five denote medium and low infrastructural access respectively. Likewise each of the village indices representing access to key indicators have been collapsed into three categories in the same manner.

4.4 Utilization of Cluster Analysis

The type of classification described enables the utilization of these infrastructural indices to represent varying levels of infrastructure. Findings obtained regarding the overall index are particularly insightful because this index represents overall access to (most) key infrastructural key services. For example while villages in group two have varying levels of access to key infrastructural services, about 62% of all villages belong to groups one and two. Thus it is clear that most villages enjoy moderate or good access to most infrastructural services as represented by the index of overall accessibility, with 38% of villages enjoy relatively poor access. While most village were characterized by variable access to a number of services, patterns of access to key indicators are perceived. Village access to the industrial town and educational services to boys, other key indicators used in the study was very similar to that of overall accessibility. But not so for the market town. About 50% of sample villages had good access to the market town while the other half had poor access to it.

In subsequent analysis, the key indicator(s) which impact the economic outcome under consideration will be represented by the relevant index(ices) namely: the industrial and/or market town, boys high school etc. There may are also be individual differences within villages, arising from differences in their infrastructural base, or their level of technology, prices, marketing etc. To obtain greater knowledge and understanding of conditions facing each village, Appendix II.C outlines infrastructural, irrigation, agricultural and technological conditions facing each village.

Table 4.10: Construction of Clusters by Access (Distance) to Key Infrastructural Indicators, 28 Sample Villages, Central Punjab, 1992.

Village Name	Bus Stop	Market	Indst. Town	Union Council	Rice-Mill	Ext. Agt.	Rice Res. Inst.	Bank	Post Office	Boys School	Police Post	Health Center	Vet. Center	Over-all Index
Kot Lahndas	1 H[a]	1 H	5 L	6 L	2 M	2 M	4 L	2 M	1 H	2 M	1 H	3 M	2 M	1 H
Gaggar Ke	2 M	1 H	1 H	1 H	2 M	3 M	4 L	2 M	1 H	2 M	2 M	5 L	2 M	1 H
Kot Rattan	4 L	2 M	3 M	6 L	3 M	4 L	6 L	3 M	1 H	3 M	5 L	1 H	4 L	1 H
Bara Pind	3 M	1 H	2 M	2 M	2 M	2 M	6 L	1 H	3 M	2 M	3 M	1 H	2 M	1 H
Ramke Cha Chatta	1 H	6 L	6 L	1 H	1 H	1 H	6 L	6 L	1 H	2 M	1 H	1 H	1 H	1 H
Kot Chinna	1 H	4 L	6 L	4 L	2 M	3 M	7 L	1 H	3 M	2 M	7 L	2 M	2 M	1 H
Kot Sadu Ram	1 H	2 M	5 L	5 L	3 M	3 M	4 L	3 M	4 L	3 M	2 M	4 L	3 M	1 H
Kuri Kot	5 L	2 M	4 L	6 L	3 M	4 L	3 M	3 M	4 L	3 M	2 M	4 L	4 L	1 H
Kothiala Virkan	3 M	3 M	1 H	1 H	4 L	6 L	1 H	5 L	1 H	1 H	3 M	1 H	1 H	2 H
Khori	1 H	3 M	1 H	6 L	4 L	5 L	1 H	4 L	5 L	2 M	3 M	5 L	5 L	2 H
Kirto Pindori	3 M	2 M	2 M	4 L	3 M	1 H	1 H	3 M	1 H	1 H	2 M	1 H	1 H	2 H
Chak No 369/G	5 L	2 M	2 M	5 M	7 L	3 M	5 L	1 H	2 M	6 L	5 L	2 M	3 M	2 H
Bhamman-wala	3 M	5 L	1 H	7 L	7 L	4 L	3 M	1 H	3 M	2 M	5 L	4 L	5 L	2 H
Kot Qazi	1 H	3 M	1 H	7 L	4 L	2 M	3 M	1 H	3 M	2 M	3 M	5 L	5 L	2 H
Dehnsar Bala	1 H	2 M	3 M	1 H	3 M	2 M	3 M	3 M	2 M	1 H	3 M	1 H	2 M	2 H
Chhiani Hajran	1 H	3 M	1 H	2 M	5 L	2 M	6 L	5 L	3 M	2 M	3 M	2 M	1 H	2 H
Amoke	3 M	4 L	1 H	5 L	6 L	3 M	3 M	1 H	1 H	2 M	4 L	1 H	2 M	2 H
Kot Baqir	2 M	4 L	1 H	3 M	6 L	2 M	3 M	2 M	3 M	2 M	4 L	3 M	2 M	2 H
Ladhuana	2 M	3 M	5 L	3 M	5 L	1 H	3 M	5 L	1 H	4 L	3 M	6 L	5 L	3 M
Jatri	1 H	4 L	6 L	7 L	6 L	5 L	5 L	6 L	1 H	5 L	5 L	7 L	4 L	3 M
Rakh Chakh Khali		4 L	8 L	1 H	6 L	6 L	8 L	6 L	6 L	5 L	4 L	7 L	6 L	3 M
Chaindpur Sharif	7 L	7 L	3 M	1 H	8 L	1 H	4 L	8 L	1 H	6 L	6 L	3 M	1 H	4 M
Ghazi Kakkan	2 M	6 L	3 M	3 M	7 L	2 M	2 M	7 L	3 M	8 L	7 L	2 M	2 M	4 M
Chak No 49	3 M	7 L	2 M	4 L	8 L	3 M	1 H	8 L	4 L	7 L	6 L	3 M	3 M	4 M
Chak No 6/58	5 L	5 L	3 M	7 L	7 L	7 L	6 L	3 M	4 L	3 M	2 M	4 L	8 L	5 L
Saakhi	6 L	8 L	7 L	5 L	4 L	6 L	6 L	4 L	5 L	4 L	8 L	3 M	3 M	5 L
Pir Kot[a]	7 L	6 L	4 L	4 L	7 L	8 L	2 M	7 L	7 L	6 L	6 L	3 M	6 L	5 L
Pir Kot[b]	8 L	7 L	4 L	8 L	8 L	8 L	8 L	8 L	8 L	7 L	6 L	8 L	7 L	5 L

Source:
Survey of 28 Villages in Rice-Wheat Cropping System in Central Punjab, 1992

[a] The number represents the cluster number. The letter indicates level of access: H=high, M=medium, L=low.

[b] The (first) Pir Kot is in Nankana Sahib Tahsil in Sheikhupura District

[c] The (second) Pir Kot is in Hafizabad Tahsil in Gujranwala District

CHAPTER 5: INFRASTRUCTURAL-HOUSEHOLD INTERFACE

5.1 Introduction

The agro-ecological features and socio-economic characteristics of 140 farm-households in the sample area have been examined in Chapter three. In Chapter four independently-collected village data was used to form a basket of 13 key indicators which measured infrastructural access to 28 sample villages. This chapter utilizes and develops information from both of these chapters. It examines how some of these key infrastructural indicators which form an important part of the 'external environment' facing farmers expands their 'internal' farm-household opportunity set at three critical junctures (Reardon and Vosti, 1995). Infrastructure thus enables farmers to add to and improve upon the utilization of their farm-household resource endowments.

Infrastructural indicators affect farm-household decisions made at different stages of the Reardon-Vosti decision-making tree. The farm-household generally wants to maximize its income and earnings from both agricultural and non-agricultural sources. Adult farm-household members first decide how to allocate their labor between on-farm and off-farm activities. Section 5.2 also examines the question of how the quantity of off-farm employment is conditioned by access to two key infrastructural indicators.

On the farm, households are constrained to select their major production activity(ies) according to their resources (land, labor, capital etc). They may allocate their land to crops, livestock or fallow. Hence land may be allocated to cash crops, such as rice and vegetables (both annual crops) or fruits (perennial crops), as well as subsistence crops for man and animals (wheat and fodder respectively). Farmers may plant more than one crop on more fertile land. However, land may be left fallow due to soil salinization, lack of drainage etc, or to increase soil fertility. Section 5.3 quantifies which types of infrastructure condition household allocation of farm land to specialty and high-value fruits and vegetables both for the summer and winter crops.

Finally households also make decisions regarding investment in their own human or physical capital resources (e.g educating their children or buying durable inputs). Section 5.4 examines the question of whether access to girls and boys educational facilities has affected literacy and hence rural human capital development.

The method followed in examining each of these three research questions is to state the hypothesis and justify it (or vice versa) by focusing upon the critical salient features of each researchable question (or household decision). Then a gross measure to gauge that particular activity is derived and then tested for, by means of two-way analysis of variance (ANOVA). Descriptive analyses which enhance the understanding of the decision and leads to further understanding of the measures concerned is also undertaken when necessary.

Results derived from the analyses of these questions are linked together in the conclusion. Individual outcomes made at an earlier stage of the decision-making tree are related to outcomes made at a later stage, assuming that household decisions are interdependent and made sequentially. These results are examined and verified for their logic and consistency regarding the behavior being depicted. Inferences for economic development and growth are deduced.

5.2 Infrastructural Effect on Off-farm Employment

Hypotheses

Improved access to off-farm labor marketing and overall infrastructure as represented by off-farm employment opportunities, enables farmers to increase off-farm labor employment, and increase their cash earnings.

5.2.1 Justification of Hypothesis

Initially, the extent to which farmers avail of off-farm employment when their opportunities of obtaining this kind of employment is enhanced is addressed. Economic intuition suggests that better access to overall levels of infrastructure in general lead to greater opportunities for off-farm employment, and increases the supply of off-farm labor. Good access to most or all infrastructural services provides farmers with better information regarding off-farm labor markets, educational facilities and work opportunities in various areas. This information is primarily disseminated from the urban areas and has the effect of increasing the mobility of rural labor. Opportunities for off-farm employment while limited in the village economy, increase in the bigger towns and cities where the demand for labor in the industrial, construction, labor, household and hotel sectors is high. Skilled or professional employment is also more readily available, both in the private and Government sectors, with the latter possessing good long-term benefits.

Thus the primary opportunity for off-farm employment appears to be contingent upon access to the industrial town (a key indicator). The working hypothesis can be refined to state that better access to infrastructure in general, and labor-market services in particular, are likely to increase the use of off-farm, employment opportunities.

The rationale behind this hypothesis is that household members evaluate the returns that they can obtain from wages or returns earned doing off-farm labor employment (or other off-farm activity) relative to their reservation wage[1]. Generally the reservation wage may be influenced by household characteristics such as the operational size of the farm holding, assets and non-labor income and number of other adult labor available to work on the rice crop (Willis 1986 and Sabot 1986), as well as the particular wage-rate(s) and related job amenities etc in question[2].

Generally urban jobs in the formal sector or professional and semi-professional jobs may be the most attractive because they yield a dependable and stable income. Such jobs may constitute a major incentive for people to migrate or commute to the city (Todaro 1981, 1969). However, wages for unskilled labor are particularly relevant, to this sample of mostly small farmers. In this agro-climatic zone, current wage rates are higher particularly in the dry season, when the reservation wage of working in agriculture is lower than in the larger cities and towns. However, during periods of peak agricultural labor demand, agricultural wage rates rise to very high levels and are competitive with wages in the larger towns and cities[3].

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[1] In fact whether these individuals participate in the labor market, depends on the likelihood that the market wage offer is greater than their reservation wage.

[2] Strauss (1986) and Barnum and Squire (1978) show that if production is separable from consumption reservation wages are only dependent on market wage-rates.

[3] High periods of labor demand in this intensive cropping system, include wheat harvesting in April-May, intensive rice operations June-November, and wheat sowing through early December.

Higher wages in the industrial town are expected to attract higher numbers of off-farm labor. Such proximity will increase the returns to labor relative to the costs they incur in obtaining and keeping employment: i.e job search costs, costs of relocating and transport costs, lost utility from extended periods away from home, and the opportunity cost of foregone income from agricultural activities. Better infrastructure is expected to reduce the first three costs. It may increase the fourth cost by making agriculture more profitable, particularly in this intensive agricultural system.

5.2.2 Empirical Measures

Farm-level data regarding the adult male and female labor who work off the farm (either part-time or full-time) in addition to the number of adults or the potential quantity of labor was available. Two measures of off-farm employment utilization were constructed from this data. The first measure was a zero-one indicator of whether any individual in the household is employed off the farm (where one denoted yes). It is derived in Appendix III. The second measure consisted of the (gross) proportion of adults in the household who are employed off the farm, and was derived by dividing the quantity of adult off-farm labor for each household by the size of the household. The second measure yields more information and controls for family size which may be higher in more infrastructurally-developed areas due to higher population densities. Infrastructure is measured by access to industrial town and overall infrastructure. Each infrastructural indicator is divided into good, medium and poor levels of access.

To obtain additional insights regarding off-farm employment, the type of off-farm employment pattern engaged in, by farm-households is portrayed in Table 5.1.

Table 5.1: Type of Off-farm Work done by Male Adults in 140 Sample Households, C. Punjab, 1992

Type of Off-Farm Work Done by Male Adults[a]	Quantity	Percentage
Formal Sector Government[b]		
Unskilled	21	18.8
Semi-professional (Clerical)	7	6.4
Skilled Field Workers	7	6.4
Marketing		
Traders/Dealers	10	8.8
Large Industry		
Industrial workers	13	11.6
Small Business or Micro-enterprise		
Skilled Artisans	4	3.6
Employee in micro enterprise	1	0.9
Service Sector		
Farm Equipment/Transport Rental	6	5.3
Domestic Employment	3	2.8
Seasonal Labor Market		
Construction	8	7.2
Agricultural	10	8.8
Unspecified	22	19.4
Total	112[b]	99.94

Note: The Labor and Industrial Classification code used in the Household and Expenditure Surveys for Pakistan was used in deriving employment classifications.

[a] In the sample only two women (who worked as school teachers) worked outside the household.

[b] The possibility of error exists in that a few government employees may have been misrepresented as on-farm residents with part-time, off-farm jobs, able to return to their villages during times of peak labor demand through vacations, leaves or commuting from the nearby city or town, when they are actually migrant labor.

Off-farm employment has not been classified as to whether it is part-time or full-time. About 25% of all male household adults appear to be working off the farm. This compares favorably with Johnson and Kilby's (1975) finding that 19% of the rural labor force (RLF) in Punjab works in off-farm activity. However, it compares less favorably with more recent findings from studies in Asian developing countries that 20% to 45% of the rural labor force is engaged in off-farm activity (Chuta and Liedholm, 1979, Liedholm and Kilby, 1989, Haggblade and Hazell, 1989). Such activity provides the primary source of employment for 20% to 30% of the RLF; a primary source of income for the landless in Taiwan, India and Pakistan (Andersen and Leisersen, 1988), it decreases income inequality based solely on crop-based income.

Table 5.1 indicates that 45% to 55% of off-farm activity is agriculturally-based (and mostly rural) while 35% to 45% is urban-based. Job-classification on a locational basis, denotes that employees in the formal sector, employed by Government are based in the larger towns and cities [4] (except for field workers); as is construction work and large industry. However, large industry consists is also linked to agricultural activity.

Within off-farm agricultural activity at least 9% of the sample worked in cropping activities not located on their own farms. Production-based activities feeding into agriculture comprised 15% of the total. Forward linkages directly related to cropping and livestock activities made up 21.3% of the total (see below). Thus at least 41% of the total sample was engaged in (mostly) non-farm agricultural-based activities. Some respondents (19% of the total) did not inform enumerators of the kind

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[4] However, all Government jobs are not located in the city. The category Government skilled field workers comprise tubewell operators, veterinary assistant etc whose agriculture-related skills and background enable them to get such 'field' jobs.

of off-farm activity (male) adult household members were engaged in. Hence job descriptions of these household adults have been classified as unspecified[5]. It is also explicitly assumed that they are equally divided between jobs based on agricultural and non-agricultural linkages.

Respondents indicated that a regular part-time job entailed working half of a day at the job; or alternatively working full days off the farm and working (half-time) or evenings and week-ends on the farm. Seasonal off-farm labor migrate to the city during the whole of the dry season from December through March, and are classed as part-time workers[6]. Thus even such part-time workers will generally work (or actively search for work) at least one-third of the year.

Production-based activities consist of three types of activities namely: (1) rental services for both farm plowing and transport equipment (e.g tractors, tractor-trolleys, horse-cart and boats) and complementary labor; (2) non-industrial skilled artisans (blacksmiths, mechanics and (a) mason) who worked on animal traction equipment, tractors etc and irrigation tubewells (respectively) and (3) Government field workers consisting of public tubewell operators, veterinary assistants etc.

Forward-linkage activities deriving from agriculture consisted mainly of traders as well as a single employee in a chakki (grain processing micro-enterprise). However, when employees of large industry located in the area are also included such forward linkages comprised 21.4% of the total. Large industry should be included in

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[5] The enumerators who knew the study area well, indicated that most of these workers probably looked for work in the agriculture and construction markets at a daily fixed wage.

[6] It is generally easy to find work in the cities in the construction business, as buildings and roads are built during the dry season.

forward linkages as it is largely agriculturally-based in this area (leather, carpets, rice and grain-mills).

Formal employment in the Government sector requires High School Certification even for unskilled workers. Such Government semi-professional workers are often graduates and their skilled field workers require specialized training at vocational schools for two years beyond High School. In the private sector, traders require some education. These two broad job categories alone comprise 40% of total off-farm employment. Industrial workers, skilled artisans and skilled labor operating farm equipment, make up 21% of the sample and need skill achievement attained through some type of apprenticeship or training. However construction and agricultural work do not require any apprenticeship or educational achievement.

5.2.3 Results

Formal tests of the above hypothesis was conducted by means of two way analysis of variance (ANOVA). Mean numbers of adult off-farm laborers are classified with respect to their accessibility to overall and urban (industrial town) infrastructure in Table 5.2. The row grouping variable represents the overall infrastructural index while the column grouping variable consists of the index of accessibility to the industrial town.

Table 5.2: Off-Farm Adult Employment Stratified by Access to Overall Infrastructure and Industrial Town for 140 Sample Farms, Central Punjab, 1992

OFF-FARM ADULT EMPLOYMENT PER HOUSEHOLD[a]					
	INDUSTRIAL ACCESS				
	Infrastructural Access Level Combined Effect[b] F_4=3.21 Prob>F= 0.015	*High*	*Medium*	*Low*	*Rows Sums* Ind: Town Effect[b] F_2 = 1.710 Prob > F = 0.185
OVERALL ACCESS	*High*	0.06 (n=11)	0.08 (n=10)	0.05 (n=20)	0.06 (n=41)
	Medium	0.17 (n=44)	0.13 (n=5)	0 (n=0)	0.16 (n=49)
	Low	0.32 (n=5)	0.08 (n=25)	0.09 (n=19)	0.11 (n=49)
	Column Sums Overall Effect[b] F_2=1.79 Prob>F= 0.171	0.16 (n=60)	0.09 (n=40)	0.07 (n=39)	0.11 (n=139)[c] Interactive Effect[b] F_3=2.45 Prob > F = 0.067

Note: [a] The proportions of off-farm labor appear to be low, because they are given in relation to family size. With only two women working outside the home, and large numbers of children, they are necessarily low.

[b] Total Sum of Squares = Explained Sum of Squared Errors (E(SSE)) + Residual Sum of Squares (RSS) = (0.32+0.09+0.084+0.18)+3.23 = 0.498+3.234 = 3.732

where (E)SSE = SSE(Combined+Overall+Ind: town) + SSE(Interactive)

[c] There were missing observations regarding one household.

Results for the entire sample indicate that an average of 11% of the adults are employed in off-farm activities (Table 5.2). The proportion of adults employed off-farm is also 11% for households in villages with low overall access, increasing to 16% for those villages with medium access, but then falling to 6% for those villages with high access. However the percentages of off-farm employment rise unilaterally as levels of access to the industrial town increase. Such employment is 7% for low access, increasing to 9% for medium access and 16% for high access. While the main effects of industrial-town and overall access are not individually significant at conventional levels, their joint and interactive effects are jointly significant at the 1.5% and the 10% (6.7%) levels respectively. However, the proportion of sum of squared errors explained by the model is relatively low (about 13%), suggesting that other factors may be at work (for details see footnote [b] to Table 5.2).

As overall access to overall infrastructure and the industrial town declines, farmers appear to be adversely affected by poor accessibility to all services. Their agricultural opportunities decline even if their agricultural endowments are good. There appears to be some seasonal migration in spite of the high transactions cost of off-farm employment, with nearly one of ten potential adults working off the farm in the areas with low overall and urban access. Such results are not unexpected. They indicate that returns from agriculture in these areas may be low, even if agricultural endowments are good, thereby inducing adult males to commute longer distances in order to get jobs or utilize their skills, in order to supplement incomes. The importance of seasonal migration is reinforced by recent findings from various agro-ecological zones in three West African countries. Results indicate that farmers in zones with agro-ecologically fragile soils with a historical record of poor rainfall (e.g the Sahelian zones of Burkina Fasso and the Sahelian-Sudanian zones of Senegal and Niger) earn a higher proportion of their earnings from off-farm work, even though the migration and transactions cost of obtaining and keeping this employment is high (Reardon, Delgado and Matlon, 1992, 1988; Reardon et al, 1993).

The anomaly in the ANOVA results is the relatively low level of off-farm employment for households in villages with high access to overall infrastructure as well as the industrial town. There are two likely reasons for this result.

One possible explanation is that clustering is not an exact science, and that in clustering relevant information may have been omitted. In particular, five of the eighteen villages with high overall access have poor access to the industrial town, and two have medium access. Consequently, if it is really access to the industrial town that is driving the off-farm employment, then these seven villages may be influencing the measured effects of overall access. However, the low utilization of off-farm employment in villages with high overall and industrial-town access provides some evidence against this explanation.

A second possible explanation is that a high level of overall access increases the returns to labor employed in agricultural enough to mitigate against utilization of off-farm employment opportunities. While this is not an expected outcome, it is possible that access to the industrial town increases the revenues from farming, and overall access to infrastructure decreases the costs, in sufficient amounts to compensate for any increase in net earnings from off-farm employment. This finding is puzzling given that even if revenues from agriculture are high, downstream linkages from such activity are also expected to be high. Both agricultural and non-agricultural activities are expected to be complementary.

5.3 Infrastructural Effects on Crop Choice

Increased access to infrastructural services are expected to decrease the cost of production and transport of high-value fruits and vegetables and other specialty crops relative to grains. Specialty crops tend to be relatively intensive in their use of purchased inputs. Fruits, vegetables, and tobacco are bulky and can be damaged by rough transport. Consequently, better access to market and transport services is expected to induce farmers to increase production of high-value but bulky cash crops. As the industrial town provides the source of most of the demand for the cash crops, better access to the industrial town is expected to have a similar effect. The effects of these key indicators on the cropping patterns of specialty and horticultural crops are stated and discussed separately for the summer and winter seasons.

5.3.1 Summer Cropping

Hypothesis

Farmers in infrastructurally-accessible areas with sufficient irrigation infrastructure have diversified their summer crop to include high-value horticultural crops (fruits and vegetables) and maize, in addition to rice. Such crops are contingent upon having sufficient irrigation water.

5.3.1.A Justification of Hypothesis

As diversification to horticultural crops is conditioned by access to water, there is likely to be more evidence of crop switching during the summer months, when farmers diversify from the traditional, rice cash-crop, to growing fruits and vegetables and other high-value, specialty crops, to increase their income. All of these cash crops are highly management and input-intensive and require regular sources of irrigation water from tubewells (private or Government) and irrigation canals.

5.3.1.B Empirical Measure

To test for the impacts of infrastructure on crop choice, variables representing the percentage of farm area planted to specialty crops (including fruits and vegetables), as well as the percentage of farm area only planted to fruits and vegetables, are constructed. The infrastructural variables used are access to the industrial and market towns.

Before doing two-way ANOVA analysis, the proportions of farm area devoted to the different crops were examined for the summer season. A summary of the cropping patterns of the 140 sample farms (given in Table 5.3) indicates the percentage of sample area devoted to summer and winter crops as well as the total number of farmers involved in their cultivation.

These results indicate that the rice-wheat cropping system is vertically integrated with livestock. While rice is the major crop in summer with 53% of total farmland devoted to it, fodder crops occupy 22% of the land operated by 113 farmers. About 29% of the operated land is left fallow during the summer, primarily due to salinity and water drainage problems.

5.3.1.C Results

The percentage of area planted to specialty crops increases as access to both the industrial town as well as the market town increases (Table 5.4). Both the main industrial and market-town effects of access have F values of 5.02 and 2.62,

Table 5.3: Cropping Pattern for Summer and Winter, for 140 Sample Farms Central Punjab 1992.

Type of Crop	Area Devoted to Summer Crops (%)		Type of Crop	Area Devoted to Winter Crops (%)	
Rice (n=no: of cases)	0.58	0.53	Wheat	0.58	0.56
	(n=127)	(n=140)		(n=136)	(n=140)
Specialty	0.18	0.06	Specialty[a]	0.28	0.26
	(n=46)	(n=140)		(131)	(140)
Fodder	0.22	0.17	Fodder[b]	0.28	0.04
	(n=113)	(n=140)		(n=13)	(n=140)
Fallow	0.36	0.28	Fallow	0.25	0.14
	(n=80)	(n=140)		(n=74)	(n=140)
Total	n.a[d]	1.04[e]	Total	n.a[d]	1.00

Notes:

[a] Berseem, a major component of winter specialty crops is sown to 0.22 of the operational land area of 125 sample farmers.

[b] Adding berseem to 'fodder crops', includes 0.25 of total farm area within this crop categorization.

[c] Horticultural crops are subsumed within specialty crops. In summer 0.16 of the area is cropped by 46 farmers and in winter 0.20 of the area is cropped by 40 farmers.

[d] As the numbers of farmers who grow these crops vary in number, totals are only computed for the following totals column.

[e] Rounding-up error.

which are statistically significant at the 0.01 and 0.09 levels, respectively. The interactive effect of the two indices have an F value of 2.92, also statistically significant at the 0.05 level.

Villages with poor access to each type of infrastructural service plant an average of 8% of their land to specialty crops; villages with high levels of access to each service plant an average of 48% of their land to specialty crops. The number of farmers in these two cells are only four and seven respectively. Yet it is still interesting that the proportion of land devoted to specialty crops when access to both infrastructural services is high (48%), and substantially greater than the proportion when access to either the industrial town (32 %) or market town (29%) alone is high. Households with high access to the industrial and market towns equal eleven and twenty respectively.

A similar pattern arises with respect to the proportion of area planted to fruits and vegetables. Improved access to either the market town or the industrial town is associated with increased area planted to fruits and vegetables. The main effect of access to the industrial town has a F value of which is statistically significant at the 0.062 level. But the main effect of market-town access is not significant at any reasonable significance level and neither is the interaction of the two indices of the industrial and market towns. The failure of the interaction effect to be of significance is somewhat surprising, given the relatively large area planted to fruits and vegetables when access to each type of infrastructure is high.

Table 5.4: Area Cropped to Summer Specialty and Horticultural Crops stratified by Market & Industrial Town Indices, 140 Sample Farms, Central Punjab 1992.

	MARKET TOWN								
	PERCENTAGE OF FARM AREA PLANTED TO								
	SPECIALTY FOOD CROPS[c]					FRUITS AND VEGETABLES[d]			
IND UST- RIAL TOWN	*Level of Access* Combined Effect: $F_4=4.86$ Prob>F=0.003	*High*	*Medium*	*Low*	*Sum* Market Effect:[a,b] $F_2=2.62$ Prob>F=0.09	High	Medium	Low	Row Sums: Market Effect:[a,b] $F_2=0.26$ Prob>F=0.78
	High	0.48 (n=7)	0.21 (n=11)	0.12 (n=2)	0.29 (n=20)	0.34 (n=6)	0.20 (n=11)	.12 (2)	0.24 (19)
	Medium	0.03 (n=3)	0.0 (n=0)	0.17 (n=7)	0.13 (n=10)	0.03 (n=3)	0 (n=0)	0.17 (7)	0.13 (10)
	Low	0.11 (n=1)	0.09 (n=12)	0.08 (n=4)	0.09 (n=17)	0.05 (n=1)	0.09 (n=12)	0.08 (4)	0.09 (17)
	Column Sums Ind: Town Effect: $F_2=5.02$ Prob>F = 0.012	0.32 (n=11)	0.15 (n=23)	0.13 (n=13)	0.19 (n=47) Interactive Effect[a,b]: $F_3=2.92$ Prob>F=0.05	0.22 (n=10)	0.15 (n=23)	0.13 (13)	0.16 (n=46) Interactive Effect:[a,b] $F_3=1.40$ Prob>F=0.26

Note: [a] Effect of Industrial Town = F_2 =2.99 and Prob > F= 0.062.
[b] Combined Main Effect of Ind: and Market Town = F_4 =1.91 and Prob > F= 0.129.
[c] Total Variation for Specialty Crops= Sum (Variation from Main+Ind: Town +Market Town+Interaction)+RSS = (0.58+0.30+0.16+0.26)+1.17 = 0.84+1.17 = 2.01.
[d] Total Variation for Fruits and Vegetables = (0.24+0.19+0.02+0.13)+1.17 = 0.36+1.17 = 1.53.

High access to both types of infrastructural services is associated with 34% of area planted to fruits and vegetables, which is a 70% increase over the next largest cell (high industrial access, medium market access).

5.3.2 Winter Cropping

Hypothesis

Two specific questions will be examined and analyzed: Firstly, in the winter season, farmers in infrastructurally-accessible areas have switched from their production of wheat and lower-value fodder crops, and diversified to high-value fodder crops.

Secondly, availability of irrigation infrastructure, has further enabled such farmers to switch to the production of high-value horticultural crops.

5.3.2.A Justification of Hypotheses

A primary research objective was to measure the change in cropping output from winter wheat to high-value specialty fodder, fruits and vegetables. Sample farmers' cropping pattern in the winter appeared to differ from that in the summer. During winter, a primary objective of farmers appeared to be to ensure their food security by planting over half of their land (56%) to wheat (Table 5.3). The overwhelming majority (95%) of sample farmers have also diversified to livestock farming by growing berseem fodder and other fodder crops, as intermediate inputs for their livestock operations[7]. As milk is an important food nutrient it increases the welfare of farm households even if it is not sold commercially. Access to the market town was expected to increase the expected potential profitability of growing specialty

[7] However only 9.3% of sample farmers reported deriving cash income from sales of livestock or fodder.

fodder crops such as berseem seed and fodder, both for use as an input for milk production or to sell commercially. Berseem is a specialty fodder with farming operations and inputs similar to that of wheat, and is less input and management-intensive than fruits and vegetables.

Although the high demand generated by access to the industrial town was expected to influence farmers choice regarding their crops during this season, this variable was not found to be significant. However, closer overall access to infrastructural services affords farmers with better communications and information regarding new varieties of crops disseminated from research stations and extension agencies. Berseem is a crop which has been actively pursued by research and extension services. Hence it was expected that good general accessibility to all services (the index of overall access) would convince farmers to intensify the percentage of land that they devote to this crop in their winter cropping pattern.

Whether farmers were further able to diversify their crop-mix away from wheat and fodder crops to grow fruits and vegetables was primarily dependent upon their access to adequate irrigation water. Farmers crop choice regarding diversification to horticultural crops are contingent on access to irrigation sources. Hence the hypothesis can be re-stated to say that high levels of overall infrastructural access, combined with proximity to market towns are associated with increased area devoted to specialty fodder crops such as berseem seed and fodder, in addition to fruits and vegetables and tobacco.

5.3.2.B Empirical Measure

The empirical measures used to test the above hypotheses are similar to those used for the summer crop namely: the percentage of farm area planted to specialty crops and fruits and vegetables respectively. Infrastructure represented by the overall index represents general accessibility to all services and the market town represents marketing infrastructure. Infrastructure is divided only into high (equal to one) and low (equal to two) levels of accessibility.

5.3.2.C Results

The proportion of area planted to specialty crops increases as overall accessibility to all infrastructural services improves from 0.23 to 0.30, and as access to the market town also increases (Table 5.5). The combined main effects have an F-statistic of 2.46, and are statistically and significantly different from the overall mean of 0.28 at the 0.089 level of significance. Results for fruits and vegetables were statistically significant only for overall infrastructure at the 0.099 level of significance with an F statistic of 2.88. However the proportion of land devoted to specialty crops when access to both infrastructural services is high, is approximately equal to the proportion when overall accessibility alone is high (30%) or access to the market town (30%) is high.

Most noteworthy are the high number of farmers growing specialty crops. Approximately 91% of farmers on average devote 0.28 of their land to growing specialty crops. Such specialty crops include berseem seed and berseem fodder as well as tobacco and fruits and vegetables. As tobacco is grown by only four farmers, it appears that berseem seed and berseem fodder crops are the major crops grown. In fact most sample farmers appear to have diversified over to this crop. With high (overall) access to all key indicators as well as the market town, 60% of farmers devote their land to this crop.

Table 5.5: Area Cropped to Winter Specialty and Horticultural Crops, Stratified by Market Town & Overall Indices, 140 Sample Farms, Central Punjab 1992.

MARKET TOWN							
OVER -ALL INFRA-STRUCTURE	PERCENTAGE OF FARM AREA PLANTED TO						
		SPECIALTY CROPS			FRUITS & VEGETABLES		
	Infrastructural Access: Combined Effect $F_4=2.46$ Prob> $F=0.089$	High	Low	Row Sums Market Effect:[a,b] $F_2=0.20$ Prob>F=0.66	High	Low	Row Sums Market Effect:[a,b] $F_2=0.22$ Prob>F=0.64
	High	0.31 (n=75)	0.27 (n=9)	0.30 (n=84)	0.24 (n=23)	0.21 (n=3)	0.23 (n=26)
	Low	0.24 (n=14)	0.23 (n=33)	0.23 (n=47)	0.08 (n=4)	0.17 (n=10)	0.14 (n=14)
	Column Sums Overall Inf Effect: $F_2=2.10$ Prob>F = 0.15	0.30 (n=89)	0.24 (n=42)	0.28 (n=131) Interactive Effect:[a,b] $F_2=0.08$ Prob>F=0.78	0.21 (n=27)	0.18 (n=13)	0.20 (n=40) Interactive Effect:[a,b] $F_2=0.78$ Prob>F=0.38

Note: [a] Effect of Overall Inf= F_2 =2.88 and Prob > F= 0.099.
[b] Combined Main Effect of Overall Inf: and Market Town = F_4 =1.69 and Prob > F= 0.198.
[c] Total Variation for Specialty Crops= Sum (Variation from Main+Overall Inf: +Market Town+Interaction)+RSS = (0.169+0.072+0.007+0.003)+4.365 = 4.54.
[d] Total Variation for Fruits and Vegetables = (0.081+0.069+0.005+0.019)+0.865 = .965.

Higher levels of overall accessibility to all services increases the proportion of farm area planted to fruits and vegetables from 0.14 to 0.23, and market access changes it from 0.18 to 0.21. While the augmented effect of market and overall access was only slightly higher at 0.24 in the high-high cells over the low-low (0.17), over 50% of the farmers were in the high-high cell.

5.4 Infrastructural Effect on Education

Hypothesis

Increased access to overall infrastructure and men and women's education infrastructure in particular, affect the levels of male and female literacy respectively.

5.4.1 Justification of Hypothesis

While human capital includes health and education both of which are multi-dimensional concepts, this study concentrates on household choices made with regard to educational investments, as well as how social infrastructure affects these choices.

Education investment in human capital is necessary in realizing potential gains from the modern structural transformation of agriculture. Private returns to education are high (Psachoropoulos 1973, 1981, 1985, Colclough 1982). Hence parents are induced to educate their children, particularly since primary and secondary education is provided publicly and is free of cost. However, if there are no primary schools in the vicinity, children may have to travel long distances to go to school, or they may have to be sent away from their home to stay with relatives. The latter alternative entails a high cost of relocation as well as prohibitively high (emotional as well as monetary) costs for both parents and children. As information regarding children's schooling was incomplete levels of adult schooling were utilized (see empirical measure).

Good access to most infrastructural services will make individual household members more exposed to, and aware of events and happenings in urban areas as well as in different parts of the country. They may also be more open-minded with regard to pursuing certain actions which are not considered necessary within traditional agricultural societies, but are more acceptable in the cities, e.g education. Hence one can postulate that greater access to overall infrastructural services has led to a higher level of adult literacy in sample households. Thus this hypothesis can be further refined to state that if household members have greater access to educational opportunities, it has increased their possibility of being educated, and literate.

5.4.2 Empirical Measure

Educational opportunities for male adults can be represented by access either to the boys primary or secondary school. Although boys' primary schools were available in 21 of 26 villages, the boys' secondary school available in nine villages, was used to represent access to educational opportunities for males, and educational opportunities for female adults were represented by access to the girls' secondary school. The rationale for using these particular key indicators is that previous research has established their importance in preserving adult literacy (Jimenez, 1993, Ahmed 1990). In fact returns to education are found to exhibit increasing returns to scale, at successively higher levels of educational certification.

As data regarding the educational attainment of children is incomplete[8], information regarding current levels of adult schooling (or adults of 18 years or older), was utilized. Although the estimated returns to schooling have been affected by

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[8] While information regarding children's schooling is available, it is not clear as to which children are below school-going age or above it. Without separating these two separate age-groups, it is not possible to compute their educational proportions.

omitted measures of ability, family background and schooling quality, the effect of returns to years of schooling have remained consistently high in recent research studies (Schultz, 1994, Behrman 1990, Strauss and Thomas 1994). Bearing this in mind, two similar measures of literacy are used to quantify the proportion of males and females who are educated. These measures consist of computing the proportion of educated male and female adults within each farm-household. Literacy for males generally denotes five years of schooling while for females it denotes at least two years[9].

It may be noted that an underlying assumption is made that there is there is little or no migration between the household and the city. The rationale is that the majority of adults are tied to their land through hereditary, economic and emotional ties, so that the majority of male (and probably female) adults who have not moved away from their place of residency since they were children, are likely to live within the same village or vicinity in which they have grown up.

A descriptive analysis was also done regarding the presence and distribution of literacy among male and female adults across different villages to shed some light on these sample characteristics before undertaking formal analysis of variance. Male literacy levels were much higher than female literacy levels (see results section). In two villages male literacy was present in only two households. Some level of literacy was present in (all) five households of ten villages, in 80% of eight villages, and in three households for eight villages. There was household literacy in only 40% of the households in two villages. Female literacy was divided differentially across the

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[9] The consensus in the literature is that functional literacy requires at least 5 years of schooling. Hence the women would not be strictly literate by this measure.

sample and appeared to be to be more concentrated in a few villages. A high proportion of female adults in all five households in a village were literate to some extent only in one village (Chak No: 369). Only in two villages was there a large proportion of literate female adults in 80% of the households. Five villages had zero literacy among female adults. Literacy was present in only three households for ten villages in the sample. Meanwhile the modal number of households with literate females was 20% (for ten villages).

Two way analysis of variance methods (ANOVA), were used to test the hypothesis formally. Results obtained are described in Table 5.6.

5.4.3 Results

Table 5.6 is analogous to the format of Tables 5.2, 5.4 and 5.5. The first half of the Table illustrates the mean household proportion of educated adult males stratified with respect to overall and educational infrastructure. Likewise the second half of the table represents mean household proportions of educated female adults stratified with respect to overall and female educational infrastructure. Row and column sums measure the effect of overall and educational infrastructure respectively.

Both the overall infrastructural index and educational indicators represent three ordered levels of accessibility with respect to the sample of 28 villages. Villages in group one, two and three denote high, medium and low levels of infrastructural development or accessibility to male and female educational indicators or the overall index, as the case may be. An increase in the level of overall infrastructure alone, increases male literacy proportions, steadily from 0.45 to 0.55 to 0.61. Male literacy proportions taper off from 0.43 to a plateau of 0.57 for medium and high access to the educational indicator.

Villages with high access to both the educational indicators and overall infrastructure, have an average of 0.65 educated males per farm-household, higher than the separate effects of educational and overall infrastructure, as well as the overall mean of 0.53. While the F statistic for the separate indicators is not statistically significant, the F statistic representing their interactive effect is 5.06 and is statistically significant at the 0.05 level. Lower access to both indicators generally decreases the literacy level. There is an anomaly namely a cell representing overall-cum-educational infrastructure (medium-low) with a literacy rate of 0.72. It has been attributed to the effect of a single village (Chak No 369). It is one of five villages in which all households have a high proportion of well-educated male adults, thereby increasing the male literacy proportion.

Results from the second half of Table 5.6 are similar. Enhanced access to female educational indicators is associated with an increase in female literacy ratios from 15% to 20% to 21%. Increase in overall infrastructure alone is associated with a similar rise in female literacy per household, from 0.14 to 0.24 to 0.22. The combined effect of high access to both types of infrastructure is associated with only a 1% to 2% increase in female literacy. Again only the interactive effects of the two indices, as represented by an F statistic of 2.78 are statistically significant at the 0.044 significance level.

Table 5.6: Male/ Female Literacy Levels Stratified by Overall/Educational Infrastructure, 140 Sample Farms, Central Punjab 1992

OVERALL INF		LITERATE MALE / TOTAL NO: OF MALES				LITERATE FEMALE/TOTAL NO: OF FEMALES			
		EDUCATIONAL INFRASTRUCTURE							
	Level of Access Comb Effect: F_4=1.24 Prob>F=0.3	High	Medium	Low	Row Sums Educ: Effect F_2=0.41 Prob>F=0.67	High	Medium	Low	Row Sums Educ: Effect F_2=0.73 Prob>F=0.49
	High	0.65 (n=26)	0.54 (n=15)	0.00 (n=0)	0.61 (n=41)	0.23 (n=36)	0.00 (n=0)	0.17 (n=5)	0.22 (n=41)
	Medium	0.52 (n=45)	0.00 (n=0)	0.72 (n=5)	0.54 (n=50)	0.23 (n=40)	0.55 (n=5)	0.00 (n=5)	0.24 (n=50)
	Low	0.0 (n=0)	0.60 (n=14)	0.38 (n=35)	0.45 (n=49)	0.0 (n=5)	0.13 (n=25)	0.18 (n=18)	0.14 (n=48)
	Column Sums Overall Effect F_4=0.50 Prob>F=0.6 1	0.57 (n=71)	0.57 n=29)	0.43 (n=40)	0.53 (n=140) Interactive F_3=4.21 Prob>F=0.04	0.21 (n=81)	0.20 (n=30)	0.15 (n=28)	0.20 (n=139) Interactive F_3=2.78 Prob>F=0.04

Note: For the second half of the table: [a] Effect of Overall Inf=F^2=1.641 and Prob > F=0.20 and [b] Combined Main Effect of Overall Inf: and Educational Inf = F_4 =1.076 and Prob > F= 0.371.

[c] Total Variation for Fraction of Educated Males = Sum of Variation (Combined+Educ Inf: +Overall Inf+Interaction)+RSS = (0.74+0.15+0.122+0.63)+20.012 = 1.368 + 20.012 = 21.38.

[d] Total Variation for Fraction of Educated Females = Sum of Variation (Combined+Educ Inf: +Overall Inf+Interaction)+RSS = (0.40+0.31+0.14+0.77 +12.16 = 1.17 + 12.16 = 13.34.

Lower access to the educational indicator has a variable effect but the effect of one village on literacy is again much larger (0.55) than the overall mean (of 0.20). This village is the same lesser accessible village (Chak No 369) in which all households have high rates of literacy.

The absolute and relative magnitudes of male measures of average literacy appear to be higher than those of the Agricultural Census (40%). Female literacy within this sample appear to be comparable or lower.

5.5 Conclusions

This chapter explores the effect of access to infrastructural services on utilization of off-farm employment, crop choice and investments in human capital. As expected, access to off-farm employment opportunities, as indicated by closer proximity to the industrial town leads to greater utilization of off-farm employment. However, overall infrastructure exhibits an inverse J-shaped distribution regarding the pattern of off-farm labor with regard to varying levels of overall access to infrastructure. An anomaly occurs in that in farm households with high levels of industrial town and overall access, the proportion of the adult members of the household employed off the farm diminish.

This phenomenon appears to be contrary to what theory predicts should occur during the structural transformation of an economy. Increasing amounts of labor are expected to be released from the farm to the non-farm sector. Higher non-agricultural wage-rates attract labor to larger towns and cities (e.g industrial town), but while on-farm and off-farm wages are expected to equilibrate, at any one time, the economy is in a continuous state of disequilibrium. Labor and total factor productivity are expected to increase, so that although wages to labor in agriculture may rise, labordisplacing technology [10] (e.g mechanized tractors, in particular), are expected to lead to a decline in the share of labor in total agricultural output and revenues so that labor and other resources are released to the non-farm sector.

One explanation as to why this is not occurring is that by increasing the profitability of foodgrains as well as high-value, bulky, specialty crops such as fruits and vegetables, good access to marketing and industrial town may be increasing total farm and labor productivity, thereby retaining high levels of labor on the farm. Findings from this chapter support this plausible supposition because the proportion of land devoted to such crops (in summer) is highest when access to industrial and market towns is highest. The increase in this proportion is statistically significant and of an economically important magnitude. However, the simple, ANOVA techniques used to generate this evidence do not easily allow a variety of explanatory variables, and the proportion of total variance explained by the infrastructural variables is low. Further investigation of these choices using simultaneous equation models is warranted.

While ANOVA results offer significant evidence that farmers have diversified from rice to specialty crops, rice, is still the main cash crop demanding fairly high usage of labor (for planting, irrigation etc) despite some mechanization [11]. Due to declining productivity in the cropping system, and inadequate application of technology to combat these factors, labor productivity in the system may still be quite low. Such questions are tested with respect to this major crop in Chapter 7.

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[10] For example, better access to agricultural implements and machinery may result in adoption of labor-saving techniques. This would have a negative effect on returns to agricultural labor, ceteris paribus, resulting in lower opportunity costs of off-farm employment.

[11] Technological adaptation has been concentrated in these field operations.

During winter 90% of sample farmers appear to have diversified from wheat to berseem production, which can be used as an input into livestock farming and for sale. Of those sample farmers who enjoy good access to most services, an increase in accessibility to all infrastructural services as well as the market town, appears to be associated with farmers' specialization to this crop. Such farmers grow more of this crop, ostensibly for more commercial purposes.

Results also indicate that while the effect of higher general accessibility to all services combined with greater access to educational opportunities, increases the incidence of both male and female literacy, they have a much more dramatic effect on male literacy. Considering that 25% of the adult males who work off the farm, at least 65% of them require some kind of formal training or apprenticeship, returns to male literacy appear to be much higher than returns to female literacy, in terms of outcomes (jobs). Further research needs to be done linking the types of off-farm employment undertaken with the distribution of formal education across more and lesser accessible areas. Such findings may also further the understanding of why so few people go into off-farm employment near the industrial city. One possibility is that opportunities for off-farm employment may be quite high in (smaller) market towns, due to production linkages feeding into agricultural activities and forward linkages arising from such on-farm activities. Hence they may generate high rates of employment in rural areas.

CHAPTER 6: REGRESSION METHODOLOGY

6.1 Introduction

This chapter provides the methodological base used in the production function analysis developed to quantify the impact of irrigation and other types of infrastructure upon productivity. The use of the production function as the main analytical tool is justified in Section 6.2. The specification of a general theoretical framework is presented in Section 6.2.1, followed by a brief descriptive summary of the variables used. Section 6.2.3 discusses the advantages of using general functional forms as well as the data requirements and restrictions needed for estimation purposes. Selection of the output and input variables for regression analysis, and in particular the choice of the rice crop as the output variable are reported in Section 6.3. This section also presents the methods used to construct and aggregate the variables to the farm level.

6.2 Theoretical Framework

The analytical tool generally used to measure the impact of irrigation and other types of infrastructure on farm production is the production function. The production function for one or more farm outputs represents the technical relationship whereby flows of farm inputs (X_i) which are used to produce specific output(s) are transformed into those output(s). However, in empirical work the information available on some inputs may not be the appropriate measure of services from the flows of those inputs; thus, the function which will be estimated will be a 'production-like' type of function rather a 'pure' production function since some measures are proxies. For convenience, this function will still be called a production function.

Ideally a multi-product multi-input production function would be estimated. However, as indicated in Chapters 1 and 5 farmers shifted to the production of cash crops (including rice and horticultural crops) due to their access to irrigation infrastructure as well as other types of infrastructure. Thus rice was selected as the farm-household output for analyses because of its good access to irrigation infrastructure and associated technology. Farmers have intensified their production of rice so that it is currently the most important cash crop within this farming system, both as an income-earning source and in terms of acreage. Further details regarding the choice of rice as the output crop are given in Section 6.3.1.

Of the sample of 140 farmers, 127 grew rice. Of the farmers who grew rice, certain farms are shown to be outlying observations according to the results of outlier analysis which is conducted in Chapter Seven. Thus the number of farmers whose production behavior analyzed is 113.

6.2.1 Theoretical Framework

A generalized formulation has been specified for the estimation of the rice enterprise production function. If the variables are expressed in logarithmic terms, this function becomes the translogarithmic function, a second-order approximation to a Taylor series around the logarithm of one is given by equation (1). In principle, the estimation of a second-order function such as the translog is preferred over a simpler functional form. But this judgement can only be made after examination of the data.

$$\ln Y = \alpha_0 + \sum_{i=1}^{5} \alpha_i * \ln X_i + \sum_{i=1}^{4} \sum_{j=1}^{4} \beta_{ij} * \ln X_i * \ln X_j \qquad (1)$$

where the parameters of the function are conditioned on irrigation variables, I_t (canal water, private tubewell and government tubewell) and the market and industrial town, O_i.

That is, the parameters of the production function is conditioned by the level of availability to various types of irrigation infrastructure, as well as their level of access to other types of infrastructure such as input/output and off-farm labor markets. Key economic factors, such as the market and industrial town, influence farmers' relative profitability in output mix (through prices), and in input use. Allocation of inputs among different activities may also affect the efficiency of inputs used in farm outputs.

Total factor productivity (TFP) will be used to measure the total productivity of the rice crop. While productivity denotes the ratio of output to input, or the amount of output per unit of input, total factor productivity consists of the total output weighted by a bundle of inputs where the weights are the elasticities of inputs with respect to output. TFP is a useful summary index to compare the relative performance of different farms.

The total factor productivity of the rice farming system can change due to changes in either the intercept or "slope" parameters or both according to the characteristics of the irrigation systems facing farmers. However the pathways whereby the different irrigation sources impact on factor productivity needs to be specifically examined in greater detail in order to implement how the various types of irrigation and other infrastructure will be accommodated within the production function.

6.2.2 Variable and Parameter Definitions:

There are three types of variables, which contribute to the observed variation in output, Y; specifically (1) farm inputs X_i, (2) irrigation infrastructure I_i; and (3) infrastructure O_i. Specifically,

Y = $P_1*Q_1 + P_2*Q_2 + \ldots P_n*Q_n$

where **Y**, **P** and **Q** = revenue, price and quantity vectors for (1..n) rice varieties respectively.

X = Column vector of 5 (n*1) inputs where $X_i = X_1, X_2, X_3, X_4$ and X_5.

X_1 = Quality-adjusted land planted to rice, with land acreage adjusted for salinity, water-logging and drainage.

X_2 = Stock of male and female family and hired labor available during the rice season (in standardized man hour units).

X_3 = Total cost incurred on four inputs within the rice activity namely: chemical fertilizer, manure, pesticides, and zinc for the rice crop (Rupees). Cost in bags per acre is multiplied by the cost per bag and then summed for all four components.

X_4 = The stock of capital goods for plowing technology (in horsepower units).

X_5 = Quantity of seed uprooted from the rice nursery and transplanted to land sown to rice (total kgs).

X' = Cross-product vector of the first 4 inputs X_1, X_2, X_3 and X_4. There are 4 squared input terms $(x_i x_i)$ and 12 cross-product terms $(x_i x_j)$.

Irrigation infrastructure is classified into three sources of water availability according to where it is derived from:

I_1 = CW_inda = Canal water is derived from two indexes:

= CW_indx+H11_loc where CW_indx = access to canal water (0=none, 1=moderate, 2=good, 3 or more = very good);

and H11_loc= comparative location with regard to the head of the water-course: 0=none, 1=tail, 2=middle, 3=head; if h11_loc=0 cw_indx=0.

I_2 = PTW_IND1 = Farmers' access to water from private tubewells =

PTW_Indx * number of private tubewell farmers have access to,

where PTW_indx = categories of access to private tubewells; (0=none, 1=hired, 2=shared or landlord's and 3=own).

I_3 = GTW_IND1 = GTW_Indx * Number of Government tubewells

where GTW_indx = Access to Government tubewells (0=none, 1=moderate, 2=good).

O_1 = Index of access to industrial town

O_2 = Index of access to market town

O_1 and O_2 are categorical infrastructural indices (i=1,2), with accessibility measured by 1= high access, 2 = medium access and 3= poor access.

6.2.3 Flexible Functional Forms

The theoretical equation is specified as a generalized flexible functional form. Both the advantages and requirements necessary for the estimation of these functional forms are pointed out for the implementation in this study.

6.2.3.A Discussion

Flexible functional forms consist of a class of functions with the desirable property that they are generally more accommodating than first-order functions such as the Cobb-Douglas. These types of functions can capture subtle relationships in the data, and are less constraining regarding the production structure. As flexible functions depict a three-stage production function, they can also capture variable elasticities of substitution, and elasticities of output with respect to inputs. For example, the translogarithmic function allows variable elasticities of substitution among input pairs, as well as variable elasticities of output with respect to a given bundle of inputs; the Cobb-Douglas does not.

Flexible functional forms have the desirable property of local flexibility or Diewart flexibility[1]. Thus they are particularly useful in estimating a standard optimizing model, with first and second order conditions. However the drawback of these forms is that they do require richer data sets and better information than simpler functional forms, in order to specify production relationships adequately. If the data set is not rich enough or there is multicollinearity among variables, parameter estimates will be worse than if a simpler functional form were used. As Griffen et al, 1988 point out, second-order forms (particularly the Taylor series expansions), if wrongly used, impose large errors on the approximating function and its derivatives away from the point of perfect approximation. Thus, if a general functional form does not appropriately represent a data set, a more restrictive function will probably represent a more accurate representation of the data. For example, both the translogarithmic and Cobb-Douglas functions are logarithmic functions with the ability to capture farm scale and size issues well. But the Cobb-Douglas is a more restrictive first-order functional form, which is 'nested' within the translog function. The Cobb-Douglas function is defined in the following manner:

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[1] Local flexibility implies that an approximating functional form conveys zero error (perfect approximation) for an arbitrary function and its first two derivatives at a particular point (Fuss, McFadden and Mundlak).

$$lnY = \alpha_0 + \sum_{i=1}^{5} \alpha_i * lnX_i \tag{2}$$

It is a special case of the translog function in which the $\Sigma_i \beta_{ij} = 0$ for all i and j. The translog reduces to the Cobb-Douglas model, if the elasticity of substitution among inputs is restricted to unity and the elasticities of output with respect to input use are constant.

6.2.3.B Constraints Imposed on Models

The translog model approximates the true production function provided the proper set of constraints are imposed on its parameters. The following constraints have to be imposed on these models.

i) Symmetricity $\beta_{ij} = \beta_{ji}$ *for* $j \neq i$;

The translogarithmic function needs to have symmetry imposed upon the parameters of the variables in the function in order to yield unique parameter estimates. This condition is necessary for the applicability of Young's Theorem to integrable functions.

ii) The translog function is homogeneous of degree k[2] if and only if:

$\Sigma \alpha_{ij} = k$ and $\Sigma_i \beta_{ij} = 0$ for all i.

A function is homogeneous of degree one if $\Sigma \alpha_{ij} = 1$. While such a constraint would need to be imposed on the translogarithmic function, the Cobb-Douglas function has the property that it is linearly homogeneous of degree one.

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[2] The PF is homogeneous of degree K iff there is a k,t > 0 s.t $Y*t^k = F(t*k)$ or $Y(t^k\mathbf{X}) = k*F(t*\mathbf{X})$.

The sum of the interaction β_{ij} parameters of the inputs including squared parameters equal zero (Antle 1988). Otherwise the translog is neither homogeneous nor homothetic.

6.3 Variable Selection and Aggregation

Farm-household data for inputs and outputs have been gathered in a disaggregated form. Variables used in the production function of rice have had to be aggregated to the crop level and in some instances to the farm level in order to estimate the farm production function. Conversions of disparate information to the same units for ease of aggregation as well as quality adjustments have also had to be made.

This section describes how the appropriate input and output variables and their measures were obtained for the estimation of the production function. The procedure used to describe each variable is similar. Initially the type of information or concepts which need to be captured by that variable are described. Next the appropriate variable which measures this information is discussed in detail. All the steps to obtain this measure including the various conversions, adjustments and aggregations made, are described. The statistical analysis of the concerned variable obtained from the whole sample of 140 farmers is then briefly presented. Finally the drawbacks of these and (where relevant) alternative measure(s) which could be used are described.

6.3.1 Output(s)

The first decision made was concerned with the choice of crop(s) used to measure farm output.

Selection

Rice has been selected as the single crop enterprise for estimation of the production function. Water is a critically-needed input for rice production. As indicated previously, increased water availability resulting from enhanced irrigation infrastructure was a major catalyst in farmers' initial diversification from fodder crops or fallow land to rice. Irrigation infrastructure investment combined with available Green Revolution technology consisting of high-yielding varieties of rice seed (HYVs) induced farmers' initial switch from subsistence fodders to rice production in summer (M.H.Khan, 1985, M.J Chaudhry, 1990, Karamat Ali, 1982). Currently further intensification within the rice crop acts as an avenue to increase productivity and farm revenues so that rice ranks as the major cash crop and income-earning source of the majority (86%) of sample farmers who derive 64% of their farm income from it. Rice is also responsive to marketing infrastructure because its expected higher returns (and /or expected lower costs) as well its being both a food and a cash crop, often induces farmers to increase rice yields (Amir and Aslam 1989, Amir, 1985).

Measurement

Rice output was measured in terms of total revenue derived from the crop. Although rice is measured in monetary terms, it is a total physical product measure. As there are two major varieties of rice grown in the study area, it became necessary to reduce physical product to value terms. Rice varieties consist of IRRI and Basmati. Higher yields obtained from the IRRI varieties appear to compensate for their proportionately lower prices as compared to Basmati-385. The preferred method is to make the price of the most common rice variety the numeraire price. Then the physical production is weighted by the price paid by the farmer relative to the numeraire price. As there were two major rice varieties grown in the study area this was not possible.

Total revenue was derived according to the following formula:

$$\text{Total Revenue} = \sum_{i=1}^{n} Price_i{}^{*}\ Quantity_i$$

The quantity of rice was measured in terms of quantity of maunds (equivalent to 40 kgs), an indigenous unit of measure. Each of the IRRI and Basmati varieties of rice was priced differently. Hence the output of each variety was multiplied by the price obtained by the farmer for that particular variety, in order to obtain the revenue for each rice variety. As certain farms grow more than one variety of rice, the aggregate revenue of rice was then obtained by summing over all the varieties of rice grown at the household level.

Table 6.1 indicates that the median amount of revenue obtained from the crop was Rs 22,800 per farm. However the average revenue was much higher at Rs 45,622. The standard deviation is equal to one and a half times the mean value.

6.3.2 Land

Sample farmers gave reliable information regarding their acreage sown to rice. However, survey results show that 20% of the land had salinity, water-logging, or drainage problems. The amount of land affected by the specific drainage problems have been reported in Chapter three. As rice is only mildly tolerant to salt, it is

Table 6.1: Descriptive Statistics of Variables used in the Rice Production Function for 113 Farmers in Central Punjab, 1992.

Variable	Unit of Measure	Mode	Median	Mean	Minimum	Maximum	Stdd Dev	Skew-ness	Kurt-osis
Revenue	Rupees	15000	22800	45623	1920	476665	70015	4.35	23.11
Land	Acres	2.5	7	11	1	100	13	4.06	22.33
Labor	Hours	1500	2700	3115	162	9164	2047	0.88	0.35
Seed	Kgs	5[a]	24	45	2	600	68	5.45	40.48
Purchased Inputs	Rupees	500	2609	6166	212	75818	10420	4.02	20.51
Fertilizer	Rupees	500	1985	4197	212	49318	7113	4.37	23.19
Chemical	Rupees	90	90	1718	0	22933	3901	3.60	14.17
Zinc	Rupees	0	0	250	0	5500	684	4.93	31.87
Horsepower (HP)	Horsepower passes	50	207	257	2	1120	216	1.18	1.80

Note: [a] Seed has two modes namely 5 and 25.

susceptible to yield loss through salt-stress[3]. Hence a quality-correction adjustment is made, to account for reduction in yield due to these soil drainage and salinity constraints. Conservative estimates of 25% decrease in yield due to salinity and 10% decrease in yield due to water-logging and drainage problems were used (Foth 1990). However, while information regarding the soil type of individual parcels of land was available, it was not always clear as to which crops were grown on these parcels of land because specific information regarding individual crops or livestock operations (type, area, output) had been collected at the farm-level. The quality of the land specifically sown to rice could not be ascertained with certainty. Thus it was assumed that if a farm had land which was saline, water-logged or had any type of drainage problems, there was an equally likely probability that rice would be grown on any one or more parcels within that farm. The probability that land sown to rice was subject to any of these three problems was obtained by dividing the affected parcel area by the total farm area.

Quality-adjusted Rice Area = I + II + III where

I = Rice Area[1- Pr(saline land)* 0.25].

II = Rice Area[1 - Pr(waterlogged land)* 0.10].

III = Rice Area[1-Pr(drained land)* 0.10].

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[3] The effect of salts on plants reduces water uptake by roots, seeds and microorganisms, and has an effect akin to soil drying. Soil salinity is measured by the electrical conductivity of saturated soil extract, the EC_e, saturated-extract electrical conductivity directly related to the field moisture range from field capacity to the permanent wilting point. Foth (1990) has classified the rice crop to be fairly salt-sensitive with an EC^e ranging from five to eight at 25° C. At an EC^e = 5, 6 and 8; yield reductions are normally 10%, 25% and 50% respectively compared to growth on normal soils.

With this information, the quantity of land was reduced or adjusted downward by the expected amount that salinity would most probably decrease output potential. The quality-adjusted rice area for saline land was obtained by multiplying the probability that the land was saline by the actual amount of area grown to rice and the percentage amount (25%), by which salinity would decrease yield. Deducting this probable output decrease from actual rice area yielded the quality-adjusted land. The procedure for obtaining the yield-adjusted rice area of land having water-logging or improper drainage is similar except that yield decreases on waterlogged or improperly-drained land are less (10% of total yield).

Table 6.1 shows that the modal value of farm area devoted to rice (for fully one-third of the sample) was 2.5 acres while the median value was 6.9 acres. The average was 10.6 acres.

6.3.3 Labor

The stock of labor available for the rice enterprise was obtained by summing up male and female labor and family labor. The stock of male and female labor are derived separately but the procedure used was similar. Factors accounted for in the derivation of this labor variable consisted of farm-household member composition and characteristics, as well as the off-farm labor activities of adult male and female labor and reported child labor.

Analysis involving classification of total labor according to the gender composition of family and hired labor, was done for the whole sample of 140 households. However, the procedure regarding labor aggregation both for total and gender-wise distribution of labor was only done on the 113 sample farms which were rice farms. As these figures were found to be very useful for descriptive purposes and are presented. Farm-households were found to consist predominantly of family adults (90%), permanent (male) labor (7.1%) and child labor (see Table 6.2). The numbers of males were initially divided into adult cohorts who are able to work (normally between the age of 15 and 59), children below the age of 15 years, and adults over the age of 60 years, who were either involved in management activity or did not work at all. The distribution of adult male labor among on-farm and off-farm activities was examined next.

The majority of adult men (62.4%) were engaged in full-time on-farm activities, while a minority (28.1%) worked on the farm on a part-time basis. Full-time on-farm male labor included an average of 1.8 (ranging from one to six) long-term hired laborers employed by 33% of households[4]. Part-time labor included household students and men engaged in off-farm labor activities. An additional 3.4% of male students reported that they were not doing any farm-work. Men over the age of 60 years who were defined to be old, either did not do any farm-work (3.2%), or were only engaged in management activities.

The next step was to standardize the labor input within farm-households. The length of the growing season for rice was seven months (or 210 days). Most farmers do not work on Friday which is the day of prayer. Thus 30 days were deducted from 210 days to yield 180 days. Eight hours form the standard duration of a work-day so that a half-work day was four hours. Hence the total number of hours of on-farm work by full-time adult workers was obtained by means of the following formulas:

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[4] This labor constitutes permanent labor, and is available on the farm on an on-going basis. Permanent hired labor is hired on a yearly or at least seasonal basis and is distinct from labor engaged on a daily or piece-rate basis, which forms part of the variable inputs on the farm.

i) Hours worked by Full-time Male Workers

= Number of workers * Length of rice season (days) * 8 hours

ii) Hours worked by Half-time Male Workers

= Number of workers * Length of rice season (days) * 4 hours.

of workers* number of days * number of hours

A similar procedure was followed in order to obtain a measure for female adult hours worked. Female adults' were also divided into adult cohorts who are able to work (normally between the age of 15 and 59), children below the age of 15 years, and adults over the age of 60 years, who are generally not able to work. The division into adult and older cohorts was not as clear as for males and may have been under-reported. The majority of women (84.5%) were employed in housework (see Table 6.2). About 10% of the women (44) were occupied with full-time farm work including vegetable-growing. Only 3.4% of the women were reported to engage in livestock activities. There were two adult female students and two women who were engaged in off-farm activity. The latter were school-teachers.

Women who worked full-time on the farm were assumed to work eight hours a day, part-time workers were assumed to work a four hours a day, while women who worked in light activities were assumed to work three hours a day. But women who were reported to do only housework were also assumed to work three hours a day on farm activity. This was because animal activities and vegetables, particularly for subsistence (and own-household consumption) needs, are normally

Table 6.2: Distribution of Labor among 140 Sample Farm-households, Central Punjab, 1992

TYPE OF ACTIVITY OF HOUSEHOLD[a]	ADULT NUMBERS (percentage)		CHILD NUMBERS		TOTAL QUANTITY
	Male	Female	Male	Female	
Farm-Work					
Full-time	276 (62%)	12 (3%)			288
Part-time	124 (28%)	44 (11%)	1	7	176
Light:	14	0			14
Management	(3%)	(0%)	12	5	17
Housework	0 (0%)	332 (85%)			332
None: Students	15 (3.3%)	4 (1%)	n.a[b]	n.a[b]	19
Old Age	13 (2.9%)	1 (0.3%)			14
Total	442 (100%)	393 (100%)	13	12	860

Note: As indicated previously these figure were taken for the whole sample of 140 farms and then the outlying farms were dropped.

[a]: This family labor constitutes 90% of farm labor, permanent labor (7.1%) and child labor.

[b]: Most children within the sample went to school.

done by women, as part of their housekeeping activities. It is assumed that due to the small size of animal or vegetable enterprises, these activities have been subsumed under housework. But observations made by the enumerators in the villages also suggest that (male) farmers' seriously under-reported the work contribution of all household women and children, probably due to socio-economic and cultural bias.

For both sexes there is not a clear division of children into very young cohorts (below the age of seven or eight) and older cohorts. Thus only the child labor reported by parents is included in the potential hours worked.

The conversion rates assume that men and women's work is interchangeable and that children's work is equivalent to 75% that of adults. The underlying rationale for this assumption is that respondents themselves did not distinguish between male and female labor on those farms where 14% of the women were classified as farm laborers. Another reason is that even when the distinction might arise, adults probably work on those tasks in which they have a natural advantage. Hence transplanting and uprooting of rice, which require painstaking precision, are often done by female family members and children. Shorter height can offer a natural advantage in these tasks. On the other hand, a task such as plowing, which requires physical strength, is generally done by men.

The problem with the aggregate measure of man-hours obtained was that the measure was often similar for sample farmers who had large acreages cropped to rice, as well as those farmers who cropped small areas to rice. Hence the aggregate labor hours were adjusted downward by multiplying by an adjustment factor consisting of the percentage amount of total farm area cropped to rice.

According to Table 6.1, farm-households in the sample contribute an average of 3,115 hours labor to the rice crop. The median number of hours worked were 2,700 hours. The mean household devotes the equivalent of more than two full-time adult workers to rice production.

Drawbacks to the Measure

The labor input is a stock measure, and while it does not measure actual labor hours spent on the rice plant, it is assumed that the flow of labor services to the rice crop are proportional to the labor stock. While information regarding the actual flow of labor services to the rice crop was obtained, there was large measurement error due to poor recall by many respondents regarding the amount of time they spent doing the tasks. Hence this information was not utilized.

The assumptions regarding the hours worked by women and children were subjectively determined based on the observations made by the researcher in consultation with one or more enumerators. Estimating actual female labor supplied is beyond the scope of this study[5].

6.3.4 Purchased Inputs

Purchased inputs consisted of total costs incurred on fertilizer, manures, pesticides and zinc applications. Most sample farmers recalled the number of bags of fertilizers, zinc or pesticides bought and applied per acre to rice. Per acre purchases were converted to total purchases for each input applied by multiplying by the number of acres devoted to rice. Manure costs were obtained by multiplying the total number

[5] Whether women do on-farm work is actually determined by caste, socio-economic status and household characteristics such as family size and composition and religious values held.

of carts applied to the crop by the cost of each cart, and adding any labor cost involved.

Purchased Inputs = I.a+I.b. + II + III where

I.a = Cost of Chemical Fertilizer per acre* Numbers of Acres.

I.b = Manure Cost per acre* Number of Acres.

II = Pesticide Cost = Pesticide Cost * Number of Acres.

III = Zinc Cost = Zinc Cost * Number of Acres

where Costs for Fertilizer, Zinc or Pesticide

= Number of bags applied*Cost per bag and

Costs for Manure = Number of carts*Cost per cart+ Labor Cost per cart*Cost per cart.

Table 6.1 illustrates that the average amount that farmers spent on purchased inputs (Rs 6,165.7), was subject to high variability with the standard deviation more than 150% of the mean value. Most farmers spent less than this amount, so that expenditure on purchased inputs was skewed to the right. Hence the mode was Rs 500 or less and the median was Rs 2,609.

Expenditure incurred on individual components of purchased inputs were also examined. While all sample farmers incurred expenditure on purchased inputs, and farmers used fertilizers, pesticides and zinc in declining order of importance, more of the variability in purchased inputs came from costs incurred on pesticides and zinc rather than on fertilizer.

Separate components of Purchased Inputs

i) Fertilizer can be applied at three different stages to the rice plant; a (pre-transplanting) dose in the rice nursery, a basal dose after transplanting (in the flooded rice field) and a top dose at the crop sprouting stage. Most farmers appeared to apply a top dose of fertilizer, normally Urea (46-0-0), with a nitrogen content of 46%. Some farmers applied Diammonium Phosphate which has a higher percentage of phosphorus relative to nitrogen (18:36). Survey data also suggests that some farmers substituted manure for fertilizer both at the pre-transplanting stage and for the basal dose[6].

Farmers spent an average of Rs 4,197 on both chemical fertilizer as well as farm-yard manure. Values for fertilizer purchases were skewed to the left. The mode was Rs 500 and the median was Rs 1,985. Thus most farmers spent less than half of the sample average on fertilizers. Farmers incurred most of their expenditure on chemical fertilizer, rather than farm-yard manure, as indicated previously.

ii) Pesticides were applied at three stages of the rice crop: as a preventive measure in the nursery; and as a reactive measure to eradicate weeds and finally to control insects[7]. Approximately 72% of sample farmers used pesticides in the rice nursery, largely because the pesticide department of the extension agencies applied BHC dust to most farmers' rice nurseries. An imputed value per acre was derived from the cost incurred by the few farmers who paid for their own pesticide use. This preventive cost averaged only Rs 152 as rice nurseries are not large.

The preferred measure for pesticides would have been to weight the actual amounts of pesticides used by the quantity of pesticide recommended by the

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[6] Of the 25% of sample farmers who used phosphorus fertilizer, an average of 92.9 kgs was derived from farm-yard manure compared to 25.8 kgs derived from DAP.

[7] Pesticides consist of weedicides (or herbicides) and insecticides. Weedicides eradicate weeds and replace manual labor used for weeding. Insecticides normally control rice-specific insects.

extension department or research institutes. However, pesticides have only been tested for, and adopted by farmers during the past ten to fifteen years, so that knowledge of maximum potential dosages recommended for the different brand names are difficult to obtain. Hence the actual costs incurred were used as the proxy for the quantity of pesticide applied.

An average amount of Rs 1,719 was spent on pesticides. The median value spent was only Rs 90, because most farmers used pesticides provided by Government pesticide agencies only for the rice nursery. There was a great deal of variability in the amount of pesticide applied as the standard deviation was more than twice the mean. Most farmers used name brands of pesticides and herbicides which were more costly, some farmers (including large farmers) used less expensive local remedies, which involved mixing kerosene oil with the extract of oilseeds [8].

iii) Zinc was used by only 30 farmers[9], and expenditure incurred on it ranged from Rs 90 to Rs 5,500. The mean outlay on zinc was Rs 941. However, the average outlay of all farmers including those who did not use zinc, was much lower (Rs 250).

Alternative Disaggregated Measures of Purchased Inputs

Preliminary production function regressions were run on the three separate fertilizer, pesticide and zinc variables. The nutrient content of fertilizer was calculated and used instead of the cost of fertilizer to represent the effect of fertilizer in these estimations. The pesticide and zinc variables were measured in the same way as

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[8] But the most cost-effective of all appeared to be a prayer of supplication (it worked!)

[9] Zinc, an important micronutrient, is normally broadcast onto the rice plant prior to rice transplanting. Zinc deficiency does not need to be treated every year but only periodically.

previously. The quantities of the nutrient proportions of nitrogen, phosphorus and potassium (N:P:K) within fertilizer and manure used were computed by converting the nutrient content of each fertilizer or manure used by farmers[10]. Then the three separate nutrients within fertilizer and manure were summed together in order to yield three aggregate variables. They consisted of aggregate nitrogen, phosphorus and potassium fertilizer nutrient contents[11]. However, a single variable namely: aggregate nitrogen was used as a proxy to represent the effects of all three nutrients. The justification behind this choice is that nitrogen had the highest nutrient value and formed the most important nutrient component of fertilizers and manure. Aggregate nitrogen per farm was also found to be highly correlated with nitrogen derived from chemical fertilizer as well as manure.

6.3.5 Horsepower

The amount of physical capital used in land preparation for the rice crop was required. Land preparation consisted both of plowing and planking land[12]. The traction equipment used for land preparation in the rice-wheat production system consists of tractors and bullocks. It should be noted that usage of either type of

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[10] The conversion rates for manure were obtained from rates for feeder cattle in the U.S (Brady, 1984 pp 632). With a feces/urine ration of 80:20 and a water content of 85%, the N:P:K ratio was found to be 6.0:1:3. These conversion rates were found to be similar to those obtained from ICRISAT publications in India. They are generally applicable because livestock in the rice-wheat system are fed a similar high-fibre diet of rice and wheat straw and protein (oilseeds).

[11] The drawback of the aggregate nutrient measures is that the additional water content and/or water retention properties of manure, which differentiate it from fertilizer, could not be distinguished.

[12] Planking of the land consists of digging and burrowing into subsurface soil and turning and aerating the earth over at a great depth by means of a large blade, attached to the tractor.

traction involves making the explicit assumption that labor is used in fixed proportions to tractors or bullocks so that there are fixed person hours per tractor or pairs of bullocks.

Most sample farmers prepared the land for transplanting the rice seed when it was dry by planking and then plowing. Some sample farmers undertook additional plowing and planking of the wet rice fields to form an anaerobic clay pan. A few farmers preferred bullocks for this 'wet' land preparation.

The type of measure required consisted of the flow of horsepower used for plowing and planking the total land adjusted by actual usage and time taken. The proportions of passes made incorporate the actual usage of the tractor. This measure (HP^1) consisted of horsepower hours used per farm, adjusted by the number of land passes made. This could be done because the time taken to plough an acre by means of both tractor and bullock hours was assumed invariant. Weighted horsepower devoted to both the wet and dry operations were added together. This measure was derived by the following method:

Horsepower for rice per farm =

Σ_i Hp_1 of bullocks* No of passes of i'th technique

+ Σ_i Hp_1 of tractors * No of passes of i'th technique

where i = land preparation techniques 1..4 such that: 1= dry plowing,

2 = dry planking, 3 = wet plowing and 4 =wet planking.

The horsepower for particular land preparation techniques and operations for the rice crop was first computed by multiplying the horsepower of the technique used for a particular operation by the number of passes made during the operation. Then the horsepower obtained for all operations by each technique was summed to obtain all operations done by both techniques on the rice crop. Finally total horsepower obtained for the two separate techniques (bullocks and tractors) was aggregated to yield horsepower used per farm.

Horsepower per farm appeared to be the same for sample farmers who had large rice acreages, compared to those farmers who cropped small areas to rice. As in the case of the labor input, aggregate horsepower passes were adjusted downward for the amount of land grown to rice, by multiplying by the adjustment factor which consisted of the percentage amount of total farm area cropped to rice.

As part of the above measure, tractors and bullocks first needed to be standardized to common horsepower units. A pair of bullocks were assessed to be equal to four horse-power units (De Datta, 1985). Tractors were standardized by obtaining a quantitative measure of the horse-power inherent in the different tractor models. Specifications obtained from farmers regarding the year, make and model of the tractors made it possible to derive the horsepower for the different types of tractors used by the farmers[13]. Horsepower per tractor was found to be 34 or more.

Farmers' average use of available horsepower was 257 horsepower passes. The mode and median were 50 and 207 horsepower passes. Hence the mean and median measures were not very different. Variability as measured by the standard deviation was approximately equal to the median.

Drawback of this Measure

The main drawback to this measure is that it may not be appropriate to assume that bullock and tractor hours taken to plough a field are constant because

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[13] The horsepower of these older tractor models was derived from various publications of the Handbook of Tractors ranging from 1970 to 1994.

plowing a one-acre field by means of a medium-sized tractor takes only half an hour while it takes four hours with a pair of bullocks. In other words large tractors use much higher quantities of horsepower and fewer tractor hours (as well as complementary labor man-hours) to plough a field relative to bullocks which use much less horsepower and much higher bullock hours (and complementary labor man hours). The measure probably overweighs the value of the tractors' horsepower; for example, a single plowing by a tractor has a value at least seven times that of a single plowing by a bullock team.

This measure of tractor effectiveness also does not appear to differentiate between the farmers who rented in tractors and those who owned them. Owners normally use tractor(s) at their own convenience, and at a cheaper average cost while renters may have to wait, to obtain a tractor. Hence renters probably conduct fewer passes at a higher rental rate.

Alternative Measure

An alternative method of computing the opportunity cost of owned tillage equipment could have been used by means of computing an average cost of capital (ACC), based on age of machine, cost of diesel and average maintenance costs of tractors. However, it was not possible to compute an ACC for bullocks because this information was not available. However mechanized ACC could have been compared to market rental rates for those farmers who hired in tractors.

6.3.6 Seed

The relevant measure for the total amount of seed applied to the rice crop by each farmer consisted of the total amount of rice seed transplanted to the rice fields from the rice nursery. Rice is initially planted with high plant density in a rice nursery and then the seedlings are uprooted and transplanted to the fields. The quantity of seed sown is measured in kilograms applied per marla (a local unit= 1/160 of one acre), the unit of measure in the rice nursery. The total quantity of seed used on the rice plant is thus obtained by multiplying the total amount of seed uprooted in the rice nursery by the area sown to rice:

Seed used per farm = Kgs/marla * Number of marlas * Rice area.

There was some missing data for smaller farmers who obtained rice seed free of cost [14]. Such data points were replaced with the product of the average values of rice seed transplanted by the remainder of the sample with the acreage planted to rice.

The median quantity of seed used was 24 kgs per farm, as may be seen from Table 6.1. The mean quantity of seed applied was higher (45 kgs). The quantity of seed (seed rate) used per acre had two modal values of 5 kgs and 25 kgs. These modal and median values indicate that there are a group of farmers who have small acreages of land devoted to rice. The seed rate also varied widely from to 0.99 kgs to 13.50 kgs. Such variability in the data was worrisome because the maximum seed rate is 6 kgs per acre. It appears that some farmers allowed other farmers or tenants to uproot part of their nursery. Such farmers informed enumerators of the total nursery uprooted rather than the area uprooted for their own crop. They may have not have wanted to disclose contributions from their nursery which would constitute a form of transfer payment to tenants, relatives, friends etc.

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[14] Such farmers obtained rice seedlings from farmers who had planted larger nurseries or from friends or relatives.

6.3.7 Industrial Town and Market Town

The market town serves as a good proxy of dissemination of technology and exchange of ideas; as well as the effect of good marketing information. Increased prices for rice may be anticipated to increase the expected profitability of the rice crop, by increasing revenues which farmers expect to obtain from their rice crop and decrease their expected costs. The demand-pull effect of the industrial town is also expected to increase the revenue-generated productivity measure obtained from growing high-value labor-intensive cash crops including rice. This effect will reinforce the price effect exerted by close access to the market town.

Access to these two key indicators of infrastructure was initially measured by means of the distance to sample villages. Then the distance to each key indicator was classified into an ordinal index by means of cluster analysis. The methods used have been explained in Chapter four. As these two key indicators have been constructed at the village level, all farms within a village are assumed to have identical access to both the industrial town and the market town.

The ordinal index increases in scale as the level of access to either of these key infrastructural indicators rises. Levels of access to both services are denoted by ranked values such that: one denotes poor (or low) access, two denotes moderate (or medium) access and three denotes good (or high) access.

Table 6.3: Accessibility to the Market and Industrial Towns for 113 Rice Farmers, Central Punjab, 1992

Level of Accessibility	Industrial Town	Market Town
	Quantity of Farm-households (percentage of total)	
Good	34 (30%)	15 (13%)
Moderate	37 (33%)	34 (30%)
Poor	42 (37%)	64 (57%)
Total	113 (100%)	113 (100%)

Access to the industrial town appears to be evenly divided across the sample of rice farmers with 30% to 37% of farmers belonging to any one category (see Table 6.3). However about 57% of the sample have poor access to the market town, while only 34% and 15% have moderate and good access.

CHAPTER 7: ESTIMATION OF PRODUCTION FUNCTION PARAMETERS

7.1 Introduction

The specification of the production function and the output and input variables was described in Chapter six. Chapter seven presents the procedures for and the results of estimating the production function. The hypotheses to be tested using the production function framework are presented in Sections 7.2 through 7.4. Section 7.5 examines and pre-screens the data for the detection and handling of anomalous individual farm information. It also discusses measurement error issues in some of the major inputs and how they were treated in estimation. Selection of an appropriate functional form is discussed in Section 7.6 including consideration of scale/size economies or dis-economies. The results of the final regressions are presented in Section 7.7.

7.2 Impact of Irrigation on Crop Productivity

Irrigation infrastructure makes the production of the rice crop physically possible, given the agro-climatic (semi-arid) conditions, in the Central Punjab. It is required throughout the growth cycle of rice, particularly in the early stages. Farmers need to water the rice nursery, on a daily basis, to grow rice seedlings. Next the rice fields have to be flooded[1], and worked into a uniform mud (by means of human or animal traffic). The pressure pan created decreases soil permeability and the standing water promotes rice growth, which enables rice seedlings to be transplanted into the soil. Farmers ideally need to water the fields every eighth day for

[1] Rice puddling is the condition whereby rice fields by means of human or animal traffic are worked into a uniform mud and form a compact layer or pressure pan which is impermeable for rice production.

the first three months and thrice a month thereafter until harvesting (i.e for one to two months, depending on rice variety).

Irrigation water directly affects the soil fertility of the land[2] by increasing nutrient availability. Standing water in a flooded rice field reduces soil permeability and promotes rice growth by relieving water stress and moving towards pH neutrality. Potential soil productivity[3] is also enhanced, such that more output can be produced from the same inputs.

7.2.1 Systems of Irrigation by Different Sources

Water availability to farmers depends on the different water sources available to them. Total factor productivity across farm-level irrigation systems may thus be different, depending upon the efficacy of the individual water sources, as well as the ranking and categories within the water sources. Further, some farmers may have access to more than one water source, as well as differential levels of availability of water within individual sources. Total factor productivity across these irrigation systems may depend upon the efficacy of the combinations and ranking or categories within individual sources and with system combinations.

A detailed examination of the various irrigation systems is warranted. This examination proceeds by constructing access indexes or categories of water availability from various irrigation sources. The distribution of water availability according to the levels or categories of irrigation sources are described in Table 7.1.

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[2] Soil fertility is defined as the ability of a soil to maximize plant growth and provide nutrient elements and non-toxic amounts of minerals.

[3] Soil productivity includes soil fertility as well as other factors such as soil management practices.

Table 7.1: Distribution of Irrigation Sources by Class/Index Water Availability, Sample of 113 Farmers, C Punjab, 1992

Irrigation Source by Class or Index of Availability of Water		
Irrigation Source	Class or Index of Availability	Quantity of Farmers (percentage of farms)
Canal Water	none	20 (17.7)
	low	5 (4.4)
	medium	18 (15.9)
	high	43 (38.1)
	very high	27 (23.9)
Private Tubewell	none	25 (22.1)
	hired	6 (5.3)
	landlord or share	15 (13.3)
	owned one or more	67[a] (59.3)
Government Tubewell	none	74 (65.5)
	medium	31 (27.4)
	high	8 (7.1)

Note: [a] Out of 67 farmers, nine percent of the sample (10 farmers) owned more than one tubewell.

Three types of irrigation infrastructure are available to farmers who grow rice: government tubewells, canal water, and private tubewells. Canal water and private tubewells are the most extensive water source used by the sample farmers as shown in Table 7.1. Eighty two percent of farmers have access to canal water, while 77.9% have access to private tubewells. Owners comprise 76% of the sample of farmers with access to private tubewells. Of farmers who have access to canals, 75% have an index of availability that is high or medium high. Government tubewells are used by 35% percent of sampled farmers, but only 20% of the farmers with access derive a high quantity of water from them.

Canal Water

Canal water is the public irrigation investment most widely available to the 113 sampled farmers. It enables farmers to grow rice, even if they cannot afford to invest in tubewells themselves.

Information used in forming the canal water index consists of the addition of two separate indexes containing interrelated information: where the farmer is located with regard to the head of the water-course and whether the types of existing obstructions to water delivery simply obstruct some of the water flow or cut it off entirely.

The index of canal water location indicates that access to canal water is farm-location-specific depending on whether the village and farms within the village are located at the head, middle or tail-end of the water-course. Locations at the head of the water-course are assigned an index of three, those in the middle are assigned an index of two and those at the tail-end of the water-course are assigned an index of one.

The second index captures water-availability factors such as lack of pavement of water-courses and lack of repairs which may cause the water-level in the canals to decline. Upstream farmers can also adversely affect the level and availability of water for downstream farmers by blocking the water-course. Water availability was assigned an index of three when there were no obstructions to obtaining canal water, an index of two was assigned when there were minor obstructions and an index of one was assigned when there were serious obstructions. Farmers with no access to canal water have a zero value for this index. Such farmers also have a value of zero for the location-specific index.

Farmers may prefer canal water relative to other water sources because they obtain a relatively uniform level of water in the fields. This water may also be holding valuable soil nutrients in suspension. The Government Irrigation department is also responsible for maintaining the main irrigation canals and farmers may have to do relatively less maintenance of the canals in order to irrigate and drain the rice fields using this method. This discussion leads to the following hypothesis:

Hypothesis

Total factor productivity is greater for those farmers who have canal water relative to those who do not. Further, higher values of water availability indexes indicate decreasing water stress, and higher total factor productivity relative to farmers with lower availability indexes.

Private Tubewells

Table 7.1 indicates private tubewells are a very important source of irrigation, with only 22% of the farmers sampled having no access to private tubewells. Those farmers who do not have a capital constraint and access to canal water may be expected to make up any deficiency in the required level of water availability for the rice crop from canal water by investing in their own (private) tubewells. The probability of this occurrence is expected to be higher particularly in those villages where farmers do not have access to canal water, although access to government tubewells may make a difference. Irrigation through private tubewells entails farmers undertaking investments in digging and maintaining water canals for flooding the rice fields.

Water availability from the private tubewell is a categorical variable using a descriptive index rather than the ordinal index used to rank canal water. Farmers who cannot afford to invest in their own private tubewells may buy water from another tubewell owner. Some farmers participate with other farmers in a tubewell-share-owning arrangement and for others a landlord provides tubewell water to tenant farmers in exchange for a higher rent relative to other tenants. Also some farmers own one tubewell.

The categories for private tubewells are based on ownership rights in the water source change. Private tubewells form a very important source of irrigation and their effects on total factor productivity are expressed by the following two hypotheses:

(1) Total factor productivity is greater for those farmers who have access to private tubewell water relative to farmers who do not have access to them.

(2) Increased levels of availability of water from canal water in combination with private tubewells are expected to have a larger impact on total factor productivity than availability of canal water alone.

Government Tubewells

During the 1960s a large number of tubewells were built under a Salinity and Reclamation Program initiated by the Government Water and Power Development Authority. However, since the 1970s, no new investment in government tubewells has been made.

Sample farmers complained that the tubewells which have been built are poorly maintained, and often out-of-order; hence, they are unreliable sources of irrigation water. Most of the users of Government tubewells fall in this category and they have been assigned an index of one. Only eight farmers out of 39 sample farmers with access to government tubewells enjoy good access to this irrigation source. Due to their location-specificity, the use of government tubewells is currently not widespread. No farmers appear to rely on government tubewells for their exclusive supply of water because they need water on an on-going basis for the rice crop[4].

This source of irrigation may be expected to exercise a much smaller impact on total factor productivity, relative to other irrigation systems consisting of private tubewells and canal water, in combination with one or the other or both of them. This statement is expressed by the following hypothesis:

Farmers with irrigation systems consisting of only government tubewells have a lower total factor productivity than farmers who avail of separate or combined irrigation systems with access to canal water and/or private tubewells.

7.3 Impact of Production Inputs

It is assumed that farmers are maximizing the use of the resources they have at their disposal. Hence factor productivity for the rice crop is primarily expected to be dependent upon the different amounts of inputs that farmers apply to the rice crop. Among factors of production, land and labor particularly play a major role in rice production. Due to rapidly-rising populations there is increasing pressure on existing land resources (in the sampled area), which are intensively used.

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[4] It may also be harder for farmers to transport water to their fields from the government tubewells.

Hence rice yields as well as the elasticity of output with regard to land are expected to be positive. Increases in land area devoted to rice production are expected to be associated with positive increases in output. This relationship is expected to hold particularly as the area of land subject to drainage, water-logging and salinity problems has been adjusted downward to account for the decrease in its yield potential.

The impact of other production inputs (seed, purchased inputs and horsepower) are also expected to be positive, indicated by positive elasticities of output with respect to these inputs. For example farmers are also expected to increase their usage and management of purchased inputs such as seed, soil nutrients (including chemical nitrogenous and phosphatic fertilizer and organic farm-yard manure), micro-nutrients (zinc), and pesticides (international name-brands and locally-made brews). All of these bio-technological inputs are complementary to land, increasing its productivity.

The quantity of horsepower units used for land preparation are also complementary to land as they enhance its productivity. Hence the interaction of land with horsepower is hypothesized to lead to increased land and horsepower productivity, resulting in a positive coefficient of output elasticity for horsepower.

As rice is a labor-intensive crop, the application of irrigation water throughout the rice cropping cycle requires a constant stream of labor. This labor is normally provided from the household's labor stock consisting of family members, particularly females and children. The elasticity of output for labor is expected to be positive. With total revenues rising (i.e via higher yields) and constant prices of inputs and outputs the share of income earned by an increasing stock of labor is also expected to rise.

7.4 Impact of Market/Industrial Towns on Total Factor Productivity of Rice Farms

Both access to the industrial town and the market town may be expected to induce farmers to use input resources more efficiently in rice production. The effects of these two key indicators operate through separate as well as overlapping channels.

7.4.1 Impact of Market Town

Farmers travel to markets to sell their output and buy inputs. Closer overall access to the market town provides farmers with opportunities to exchange information with other farmers and marketing agents. They exchange information on the design and management of production systems with other farmers, farmers input procurement and commission agents. While most farmers have acquired information regarding new varieties of seed and fertilizer brands from the research stations, extension agencies and communication agencies such as the radio, they often discuss this information with friends and other farmers before using the technology. Hence access to the market serves as a proxy for access to information, resulting in learning new techniques which will enable farmers to use a given bundle of resources more efficiently in rice production.

Closer access to the market town may also affect prices. Such increased access to the market town (via the road) road reduces transport, marketing and transactions costs of obtaining inputs and selling outputs while there may a simultaneous increase in the expected price which rice may be expected to fetch in the market. Since the measure of rice output is revenue generated from rice production, these price effects may translate into higher productivity as outputs and purchased inputs are described on a revenue and cost basis.

7.4.2 Impact of Industrial Town

The results of the Analysis of Variance (ANOVA) presented in Chapter five indicate that closer access to an industrial town results in increased levels of off-farm employment. Access decreases the cost of transport for labor to work in off-farm labor markets. Even if off-farm labor cannot commute to the city, their cost of relocation decreases while the benefits from such relocation in the form of increased cash income from construction and labor jobs in the city increases. There is also an increase in the mobility of labor from the farm to the industrial town, so that farmers exchange information regarding off-farm labor opportunities. Hence the labor to land ratio for the rice crop is expected to decrease as access to the industrial town increases. While the average product of land decreases and the average product of labor rises, relative to farmers further from industrial towns, the technical relationship between inputs and outputs, as measured by the production function, is not expected to be affected. This difference in the land-labor ratio is already expected to be captured by the relative proportions of inputs. Hence the industrial town is included in the production function to validate the hypothesis that access to the industrial town does not affect the efficiency of resource use within the rice crop.

The demand-pull effect of the industrial town increases the profitability (and revenues) obtained from growing high-value labor-intensive cash crops including rice. This effect may reinforce the price effect exerted by close access to the market town.

7.5 Outlier Analysis

Outliers are farms which are very unlikely to be from the population of interest or they are farms for which the reported data are probably in error. They are excluded from the production function analysis. Outlier detection is conducted by examining the data for logical consistency, sources of differences identified in the questionnaire/interviewing process that make the information an anomaly, as well as statistical tests. The process of identifying anomalous farms begins with obvious logical and measurement problems and then proceeds to statistical identification. Examination and pre-screening of the data for the 127 rice-growing farm-households was undertaken with the objective of detecting anomalous information.

Diagnostic pretesting of the data indicated the presence of two major types of outliers; namely, outliers which were subject to an occurrence which was unusual for the rest of the sample farmers as well as farms which appeared to have non-feasible input-output and input-input proportions. The methods and results used to identify and handle each type of outlier are presented next.

7.5.1 Flooded Farms: Procedure and Results

While visual examination of the data and questionnaires helped to identify farms which had been flooded, additional statistical analysis helped to bring to light facts which corroborate the premise that these farms were anomalous. The procedure and results of this analysis are briefly summarized in this section.

The rice crop for seven farms located in three villages had been flooded and wholly destroyed[5]. The phenomenon of flooding was a natural disaster, wholly dependent on the location of the farm. It was an unusual occurrence for the rest of the sample farmers and had not affected them at all. It also provided little information about rice-cropping operations in a normal year. These farms were thus dropped from the sample on these grounds and the number of farms with valid data decreased from 127 to 120.

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[5] There was large-scale flooding at various points of the Indus River in 1992.

A proportion of the land cropped to rice on three additional farms was also flooded. Those farms which only had some proportion of their farm areas destroyed by floods, were retained. Rice yields of these farms were adjusted upward by the percentage of the rice crop which had been destroyed (as crop spoilage occurred due to an event beyond the farmers control). The rationale behind this decision was that such farms contained valuable information regarding rice outputs and the application of the types and quantities of inputs on the rice crop, in accordance with their management practices.

7.5.2 Farms with High Leverage

A more formal type of analysis was undertaken to distinguish farms which exerted unduly high leverage on regression coefficients. Regression procedures as well as the statistical (descriptive) methods used to identify and examine these outlying farms are described before the results of the analysis are presented.

7.5.2.1 Methods

Two major tools were used to identify these types of potential outliers. The first method was based upon standard methods of identifying outliers for equations estimated using Ordinary Least Squares (OLS) estimation of the parameters of the production function. The second method used a combination of empirically derived yield per acre and other average products, inputs per acre (standardized inputs) and proportions of each of these measures to a robust measure of central tendency to identify which farms did not appear to have expected relationships (e.g low yield, but high inputs per acre).

The first method entailed estimating a model containing the five production inputs (land, labor, purchased inputs, seed and horsepower) and obtaining the residuals. By definition, OLS residuals sum to zero. Farms which are three standard deviations or more above or below the mean were candidates for outliers. A second measure used was DFBETA, the standardized change in the coefficient of each explanatory variable, if the farm were dropped from the analysis (Weisberg 1984). The series of DFBETAs for each input from each farm were used to identify the influence each individual farm exerted on individual parameters. The questionnaire information for unusually influential farms was double checked to verify the correctness of the data.

Further statistical analysis was done on farms which were identified as outliers through DFBETA analysis. This pre-screening exercise led to the deletion of a number of farms from the data set, so that farms with valid observations further decreased from 120 farms to 113.

Tables 7.2 and 7.3 present the cleaned-up data set containing all the input variables, three irrigation and two other infrastructural variables. In Table 7.2 the data is sorted in descending order of yield per acre. The data on output, seed, purchased inputs, labor and horsepower have all been standardized by the acreage devoted to rice, in order to generate yields and inputs per acre respectively. Table 7.3 shows the values of land, yield, seed, purchased inputs, labor and horsepower relative to the medians value of those inputs. These individual farm values are interpreted as proportions (percentiles) relative to the median values.

The purpose of the analysis was to examine scale/size economies and range of substitution between input pairs. It helped in determining whether individual farms yielded information which was consistent with plausible rates of substitution between inputs.

Farm information, including inputs per unit of land, were sorted in ascending order of yields and of total output. Farms were visually compared. Consistency entails finding out whether there was land-deepening (particularly as land is the scarce factor in this farming system) so that high yields would be associated with high flows of inputs per acre. Farms identified as outliers were compared to the sample median in order to evaluate their relative position vis-a-vis the rest of the sample. The median was preferred to the mean as a measure of central tendency, as it is not influenced by outlying values, and is thus a 'resistant' estimator.

The residuals were evaluated for normality using the normal probability plot (SPSS Statistical Data Analysis manual; SPSS/PC+ Statistics 4.0 1990). The p-plot consists of the plot of the cumulative probability distributions of observed residuals against the cumulative probability distribution of the expected residuals based upon the normal probability distribution. The expected residuals consist of a diagonally straight line through the origin in positive X-Y space.

7.5.2.2 Results

DFBETA analysis showed farms 22, 24, 66, 83 and 99 to be outliers. Further investigation indicated that three of these farms (22, 24 and 83) shared similar traits. Overall the information regarding rates and levels of substitution among inputs and outputs appeared to be implausible and illogical, so that these farms were deleted from the data set.

Farms 66 and 99 both appeared to derive very high yields from the application of low inputs per acre. While these two farms exerted high leverage on the coefficients it was decided that they were not anomalous, so those cases were retained.

When outlier farms 22 and 24, as well as farms subject to flooding, were deleted from the regression analysis, four additional farms became outliers. Parcel areas devoted to rice were very small (0.5 acres or less) constituting only a very small proportion of the operations of such farms. Two of these farms (41 and 42) were predominantly tobacco-growing farms and thus had very little acreage sown to rice. As these four farms were clearly atypical rice farms, they were dropped from the sample. Acreages cropped to rice on these farms were very small, yet they exerted a large effect on coefficient estimates.

Table 7.2: Market/Industrial Town Indices, Irrigation Sources, and Standardized Outputs/Inputs, 113 Rice Farmers, Central Punjab 1992

Farm number	Market town	Industrial town	Ouput	Land acres	Water source: PTW	CW	CW&P	CW&G	ALL	Ouput and Inputs/acre: Output	Seed	Purchased	Labor	Horsepower
61	2	2	33475	4.98	1	0	0	0	0	6716	5.0	256.9	294.5	31.4
99	3	3	225225	33.69	0	1	0	0	0	6686	6.2	207.0	167.4	12.1
107	3	2	39520	6.00	0	0	0	1	0	6587	2.5	765.1	427.5	37.7
92	3	1	32375	5.00	0	0	1	0	0	6475	6.0	435.5	1080.0	2.2
66	1	2	476665	75.71	0	0	1	0	0	6296	3.2	667.0	86.5	8.8
53	2	1	73260	12.00	0	0	1	0	0	6105	6.0	227.7	240.0	33.5
114	3	3	108000	18.01	0	0	0	0	1	5997	5.0	1076.9	125.8	9.8
75	3	3	37000	6.30	0	0	1	0	0	5873	3.2	288.9	540.0	1.6
32	3	2	64350	11.00	0	0	0	1	0	5850	3.0	240.5	459.0	45.6
46	3	1	92800	16.00	0	0	1	0	0	5800	3.1	348.5	200.0	11.3
65	2	2	57135	10.00	1	0	0	0	0	5714	5.5	513.3	390.0	1.3
1	1	3	22800	4.00	0	0	1	0	0	5700	6.0	1286.8	1105.7	78.9
45	3	1	11400	2.00	0	0	1	0	0	5700	3.0	231.4	1080.0	103.5
105	3	2	178838	31.38	0	0	0	1	0	5700	3.3	942.5	288.0	17.4
119	3	1	11400	2.00	1	0	0	0	0	5700	3.0	553.3	201.2	38.0
90	3	3	44400	8.00	0	0	1	0	0	5550	3.0	679.5	229.1	31.4
49	1	1	18500	3.35	1	0	0	0	0	5516	2.5	117.4	480.0	43.1
94	3	1	50138	9.12	0	0	1	0	0	5496	4.4	341.2	585.0	18.7
35	3	2	81900	15.00	0	0	1	0	0	5460	6.0	21.7	342.0	35.7
12	2	1	38200	7.00	0	0	1	0	0	5457	2.9	114.0	450.0	94.9
93	3	1	19100	3.50	0	0	1	0	0	5457	6.0	225.0	660.0	57.5
106	3	2	108100	20.00	0	0	1	0	0	5405	6.0	301.4	310.9	13.9
118	3	3	27000	5.00	0	0	1	0	0	5400	3.0	543.2	247.5	30.9
95	3	1	188000	35.50	0	0	1	0	0	5296	3.4	1053.5	172.7	11.7
19	2	1	17680	3.38	0	0	0	1	0	5239	8.0	443.5	576.0	86.2
10	2	3	7800	1.50	0	0	0	1	0	5200	3.8	229.0	108.0	7.5
26	3	2	30860	6.00	0	0	0	0	1	5143	3.3	808.0	654.5	2.0
55	2	1	15263	3.00	1	0	0	0	0	5088	2.8	700.5	771.4	27.7
103	3	3	48750	10.00	0	0	0	1	0	4875	4.5	466.4	450.0	57.8
101	3	3	53625	11.00	0	0	0	1	0	4875	6.0	635.8	158.4	69.0
115	3	3	22500	4.64	0	0	0	0	1	4846	4.3	251.0	295.2	1.0
47	3	1	13300	2.75	0	0	1	0	0	4836	2.2	223.3	654.5	188.2
76	3	3	19160	4.00	0	0	1	0	0	4790	2.5	667.5	792.0	69.0
117	3	3	95160	20.00	0	1	0	0	0	4758	6.0	760.0	349.7	18.5
87	3	3	21600	4.58	0	0	0	0	1	4713	7.2	274.0	220.0	62.3
13	2	1	131313	28.00	0	0	1	0	0	4690	4.3	510.0	240.0	32.7
67	1	2	41828	9.00	0	0	1	0	0	4648	2.2	587.4	244.8	30.8
84	2	1	65040	14.06	0	0	1	0	0	4625	1.6	1060.5	345.6	27.6
31	3	2	462500	100.00	0	0	0	0	1	4625	6.0	758.2	91.5	11.2
48	1	1	27740	6.00	1	0	0	0	0	4623	3.3	307.6	885.0	28.7

Table 7.2 (continued): Market/Industrial Town Indices, Irrigation Sources, and Standardized Outputs/Inputs, 113 Rice Farmers, Central Punjab 1992

Farm number	Market town	Industrial town	Ouput	Land acres	Water source PTW	CW	CW&P	CW&G	ALL	Ouput and inputs/acre Output	Seed	Purchased	Labor	Horsepower
89	3	3	140400	30.61	0	0	1	0	0	4587	3.7	660.2	156.0	16.6
116	3	3	41175	9.00	0	0	1	0	0	4575	3.0	854.6	324.0	46.6
102	3	3	73200	16.00	0	0	0	1	0	4575	6.0	442.7	150.0	43.1
36	3	3	102125	22.50	1	0	0	0	0	4539	4.4	614.1	324.0	11.9
54	2	1	13323	3.00	1	0	0	0	0	4441	4.7	497.6	462.9	61.6
58	2	2	98970	22.46	0	0	1	0	0	4406	3.1	1179.4	254.1	7.6
70	1	2	79140	18.00	0	0	1	0	0	4397	3.6	346.4	150.0	17.0
71	1	2	17520	4.00	0	0	1	0	0	4380	2.5	590.0	720.0	75.5
44	3	1	14250	3.33	0	0	1	0	0	4275	7.2	297.8	440.0	57.5
88	3	3	38500	9.08	0	0	1	0	0	4239	2.5	233.4	125.5	15.7
27	3	2	58500	14.00	0	1	0	0	0	4179	3.6	218.5	654.5	2.2
60	2	2	72800	17.83	0	0	1	0	0	4082	2.7	964.5	217.1	9.0
91	3	1	8910	2.25	0	0	1	0	0	3960	4.4	1233.8	1584.0	103.5
17	2	1	31500	8.00	0	0	0	0	1	3938	2.5	110.0	820.0	57.5
96	2	3	3900	1.00	0	0	0	0	1	3900	4.0	668.4	382.5	59.3
57	2	2	26600	6.91	0	0	1	0	0	3851	1.4	604.7	252.0	51.7
100	3	3	64600	17.00	0	0	0	0	1	3800	6.0	795.4	180.0	45.4
104	3	2	26460	7.00	0	0	0	1	0	3780	4.3	372.8	810.0	43.1
78	3	3	18500	5.00	0	0	0	0	1	3700	3.0	466.8	320.0	19.6
56	2	2	13300	3.60	0	0	1	0	0	3694	2.1	430.7	396.0	51.7
33	3	2	14400	4.00	0	0	0	0	1	3600	3.8	240.9	609.2	2.2
34	3	2	18000	5.00	0	0	0	0	1	3600	4.5	225.0	312.0	12.6
11	2	1	116870	34.00	0	0	0	0	1	3437	5.3	976.3	190.2	15.4
80	3	[illegible]	73350	21.38	0	0	1	0	0	3432	2.8	839.6	176.4	19.8
81	2	1	13240	4.00	0	0	1	0	0	3310	4.1	612.2	698.8	3.1
28	3	2	15710	4.75	0	0	0	0	1	3307	3.2	221.8	847.1	3.5
3	1	3	18432	5.58	0	0	1	0	0	3304	4.9	768.5	196.9	29.4
108	3	2	5700	1.75	0	0	1	0	0	3257	2.9	509.4	523.6	125.4
29	3	2	22425	7.00	0	0	0	0	1	3204	3.6	225.8	550.6	4.2
120	3	1	4750	1.50	1	0	0	0	0	3167	2.0	231.7	2610.0	107.8
126	3	3	7863	2.50	1	0	0	0	0	3145	6.0	536.2	270.0	1.8
16	2	1	43950	14.00	0	0	0	0	1	3139	4.3	394.0	221.5	13.3
63	2	2	9415	3.07	0	1	0	0	0	3067	3.3	493.2	396.0	35.7
72	3	3	39750	13.00	0	0	1	0	0	3058	4.6	452.0	456.9	39.8
14	2	1	15200	5.00	0	0	1	0	0	3040	4.0	493.6	846.0	86.2
86	3	3	30500	10.08	0	0	0	0	1	3025	4.0	473.1	228.0	0.9
59	2	2	3384	1.13	0	0	1	0	0	3008	3.1	293.3	1200.0	172.5
74	3	3	9000	3.00	0	0	1	0	0	3000	5.0	340.4	930.0	29.4
69	1	2	6000	2.00	0	0	1	0	0	3000	2.4	225.0	792.0	43.1
113	3	2	18000	6.00	0	0	0	1	0	3000	6.0	580.0	560.0	72.9

Table 7.2 (continued): Market/Industrial Town Indices, Irrigation Sources, and Standardized Outputs/Inputs, 113 Rice Farmers, Central Punjab 1992

Farm	Market	Industrial		Land	Water source					Ouput and Inputs/acre				
number	town	town	Ouput	acres	PTW	CW	CW&P	CW&G	ALL	Output	Seed	Purchased	Labor	Horsepower
5	1	3	4416	1.50	0	0	1	0	0	2944	3.0	347.4	576.0	86.2
98	2	3	2925	1.00	0	1	0	0	0	2925	3.0	218.3	495.0	86.3
43	3	1	23312	8.00	0	0	1	0	0	2914	5.0	223.9	360.0	21.6
39	3	3	11520	4.00	1	0	0	0	0	2880	6.0	229.4	202.5	24.3
127	3	3	5760	2.00	1	0	0	0	0	2880	1.0	243.0	495.0	2.2
25	2	2	22800	8.00	0	0	1	0	0	2850	6.0	304.4	522.0	25.9
21	2	2	77040	27.05	0	0	0	1	0	2848	3.0	457.5	75.0	9.6
121	3	1	8505	3.00	1	0	0	0	0	2835	4.0	241.3	420.0	35.9
68	1	2	53250	19.00	1	0	0	0	0	2803	2.5	461.6	270.0	23.7
30	3	2	35880	13.00	0	0	0	0	1	2760	4.5	430.9	237.6	1.1
40	3	3	8100	3.00	1	0	0	0	0	2700	5.0	237.1	288.0	7.2
4	1	3	3840	1.50	0	0	1	0	0	2560	3.8	217.7	800.0	29.4
85	2	1	12780	5.00	0	0	1	0	0	2556	3.0	1158.8	330.0	115.0
77	3	3	40830	16.00	0	0	1	0	0	2552	2.2	467.5	79.2	16.5
79	3	3	2520	1.00	0	0	0	1	0	2520	2.4	630.0	456.9	1.8
37	3	3	5022	2.00	1	0	0	0	0	2511	6.0	1658.8	864.0	63.2
109	3	2	47000	19.13	0	0	0	1	0	2458	6.3	431.8	130.9	22.0
110	3	2	38665	15.75	0	0	0	1	0	2455	5.7	431.0	265.7	24.6
73	3	3	38343	15.92	0	0	1	0	0	2408	2.5	937.2	325.4	19.6
50	1	1	16800	7.00	0	0	1	0	0	2400	1.5	224.3	302.4	13.4
20	2	1	30300	13.00	0	0	0	0	1	2331	4.6	641.7	285.9	15.2
18	2	1	16188	7.00	0	0	0	0	1	2313	2.9	655.0	247.5	53.9
52	2	1	16065	7.00	1	0	0	0	0	2295	4.3	241.8	405.0	37.7
8	2	3	4560	2.00	0	0	0	1	0	2280	3.0	218.8	224.3	1.0
38	3	3	4560	2.00	1	0	0	0	0	2280	4.5	508.5	1170.0	129.4
111	3	2	15725	7.13	0	0	0	1	0	2207	5.6	349.6	738.0	34.5
9	2	3	1920	1.00	0	0	0	1	0	1920	1.5	212.0	540.0	37.7
2	1	3	2250	1.19	0	0	1	0	0	1897	2.5	328.7	720.0	25.6
82	2	1	12500	7.00	1	0	0	0	0	1786	4.9	265.7	382.5	41.0
23	2	2	22800	15.00	0	0	0	1	0	1520	3.3	380.0	371.3	16.2
51	1	1	14800	10.00	1	0	0	0	0	1480	1.5	486.0	210.0	43.1
112	3	2	9000	6.50	0	0	0	1	0	1385	6.0	563.0	672.0	86.2
6	2	3	2112	2.00	0	0	0	1	0	1056	2.3	220.5	567.0	16.5

Table 7.3: Outputs & Inputs/acre as Proportions of Median Output and Input/acre sorted by Land, 113 Rice Farmers, Central Punjab, 1992

Farm	Market	Industrial		Land	Water source					Land as prop	Output and input/acre as a proportion of the median output and input/acre					
number	town	town	Ouput	acres	PTW	CW	CW&P	CW&G	ALL	of median acr	Output	Seed	Purchased	Labor	Horsepower	(Lab+HP)/2
31	3	2	462500	100.00	0	0	0	0	1	14.47	1.22	1.61	1.71	0.25	0.38	0.31
66	1	2	476665	75.71	0	0	1	0	0	10.96	1.66	0.85	1.51	0.23	0.30	0.27
95	3	1	188000	35.50	0	0	1	0	0	5.14	1.39	0.91	2.38	0.47	0.40	0.43
11	2	1	116870	34.00	0	0	0	0	1	4.92	0.90	1.42	2.21	0.51	0.52	0.52
99	3	3	225225	33.69	0	1	0	0	0	4.88	1.76	1.67	0.47	0.45	0.41	0.43
105	3	2	178838	31.38	0	0	0	1	0	4.54	1.50	0.90	2.13	0.78	0.59	0.68
89	3	3	140400	30.61	0	0	1	0	0	4.43	1.21	1.00	1.49	0.42	0.57	0.49
13	2	1	131313	28.00	0	0	1	0	0	4.05	1.23	1.15	1.15	0.65	1.11	0.88
21	2	2	77040	27.05	0	0	0	1	0	3.91	0.75	0.79	1.03	0.20	0.33	0.26
36	3	3	102125	22.50	1	0	0	0	0	3.26	1.19	1.19	1.39	0.87	0.41	0.64
58	2	2	98970	22.46	0	0	1	0	0	3.25	1.16	0.82	2.66	0.68	0.26	0.47
80	3	3	73350	21.38	0	0	1	0	0	3.09	0.90	0.75	1.90	0.48	0.68	0.58
117	3	3	95160	20.00	0	1	0	0	0	2.89	1.25	1.61	1.72	0.94	0.63	0.79
106	3	2	108100	20.00	0	0	1	0	0	2.89	1.42	1.61	0.68	0.84	0.47	0.66
109	3	2	47000	19.13	0	0	0	1	0	2.77	0.65	1.68	0.98	0.35	0.75	0.55
68	1	2	53250	19.00	1	0	0	0	0	2.75	0.74	0.68	1.04	0.73	0.81	0.77
114	3	3	108000	18.01	0	0	0	0	1	2.61	1.58	1.34	2.43	0.34	0.33	0.34
70	1	2	79140	18.00	0	0	1	0	0	2.60	1.16	0.95	0.78	0.40	0.58	0.49
60	2	2	72800	17.83	0	0	1	0	0	2.58	1.07	0.72	2.18	0.58	0.31	0.45
100	3	3	64600	17.00	0	0	0	0	1	2.46	1.00	1.61	1.80	0.48	1.54	1.01
46	3	1	92800	16.00	0	0	1	0	0	2.32	1.53	0.84	0.79	0.54	0.39	0.46
77	3	3	40830	16.00	0	0	1	0	0	2.32	0.67	0.59	1.06	0.21	0.56	0.39
102	3	3	73200	16.00	0	0	0	1	0	2.32	1.20	1.61	1.00	0.40	1.47	0.94
73	3	3	38343	15.92	0	0	1	0	0	2.30	0.63	0.67	2.12	0.88	0.67	0.77
110	3	2	38665	15.75	0	0	0	1	0	2.28	0.65	1.53	0.97	0.72	0.84	0.78
35	3	2	81900	15.00	0	0	1	0	0	2.17	1.44	1.61	0.05	0.92	1.22	1.07
23	2	2	22800	15.00	0	0	0	1	0	2.17	0.40	0.90	0.86	1.00	0.55	0.78
84	2	1	65040	14.06	0	0	1	0	0	2.04	1.22	0.43	2.40	0.93	0.94	0.94
16	2	1	43950	14.00	0	0	0	0	1	2.03	0.83	1.15	0.89	0.60	0.45	0.52
27	3	2	58500	14.00	0	1	0	0	0	2.03	1.10	0.96	0.49	1.76	0.07	0.92
20	2	1	30300	13.00	0	0	0	0	1	1.88	0.61	1.24	1.45	0.77	0.52	0.64
30	3	2	35880	13.00	0	0	0	0	1	1.88	0.73	1.21	0.97	0.64	0.04	0.34
72	3	3	39750	13.00	0	0	1	0	0	1.88	0.60	1.24	1.02	1.23	1.35	1.29
53	2	1	73260	12.00	0	0	1	0	0	1.74	1.61	1.61	0.51	0.65	1.14	0.89
101	3	3	53625	11.00	0	0	0	1	0	1.59	1.28	1.61	1.44	0.43	2.35	1.39
32	3	2	64350	11.00	0	0	0	1	0	1.59	1.54	0.81	0.54	1.24	1.55	1.39
86	3	3	30500	10.08	0	0	0	0	1	1.46	0.80	1.07	1.07	0.61	0.03	0.32
103	3	3	48750	10.00	0	0	0	1	0	1.45	1.28	1.21	1.05	1.21	1.97	1.59
51	1	1	14800	10.00	1	0	0	0	0	1.45	0.39	0.40	1.10	0.57	1.47	1.02
65	2	2	57135	10.00	1	0	0	0	0	1.45	1.50	1.48	1.16	1.05	0.05	0.55
94	3	1	50138	9.12	0	0	1	0	0	1.32	1.45	1.18	0.77	1.58	0.64	1.11
88	3	3	38500	9.08	0	0	1	0	0	1.31	1.12	0.67	0.53	0.34	0.53	0.44
67	1	2	41828	9.00	0	0	1	0	0	1.30	1.22	0.60	1.33	0.66	1.05	0.85
116	3	3	41175	9.00	0	0	1	0	0	1.30	1.20	0.81	1.93	0.87	1.59	1.23
25	2	2	22800	8.00	0	0	1	0	0	1.16	0.75	1.61	0.69	1.41	0.88	1.14
17	2	1	31500	8.00	0	0	0	0	1	1.16	1.04	0.67	0.25	2.21	1.96	2.08
43	3	1	23312	8.00	0	0	1	0	0	1.16	0.77	1.34	0.51	0.97	0.73	0.85

Table 7.3 (continued): Outputs & Inputs/acre as Proportions of Median Output and Input/acre sorted by Land, 113 Rice Farmers, Central Punjab, 1992

Farm	Market	Industrial		Land	Water source					Land as prop	Output and input/acre as a proportion of the median output and input/acre					
number	town	town	Ouput	acres	PTW	CW	CW&P	CW&G	ALL	of median acr	Output	Seed	Purchased	Labor	Horsepower	(Lab+HP)/2
90	3	3	44400	8.00	0	0	1	0	0	1.16	1.46	0.81	1.53	0.62	1.07	0.84
111	3	2	15725	7.13	0	0	0	1	0	1.03	0.58	1.51	0.79	1.99	1.17	1.58
82	2	1	12500	7.00	1	0	0	0	0	1.01	0.47	1.30	0.60	1.03	1.40	1.21
104	3	2	26460	7.00	0	0	0	1	0	1.01	0.99	1.15	0.84	2.18	1.47	1.82
12	2	1	38200	7.00	0	0	1	0	0	1.01	1.44	0.77	0.26	1.21	3.23	2.22
29	3	2	22425	7.00	0	0	0	0	1	1.01	0.84	0.96	0.51	1.48	0.14	0.81
50	1	1	16800	7.00	0	0	1	0	0	1.01	0.63	0.40	0.51	0.81	0.46	0.64
18	2	1	16188	7.00	0	0	0	0	1	1.01	0.61	0.77	1.48	0.67	1.83	1.25
52	2	1	16065	7.00	1	0	0	0	0	1.01	0.60	1.15	0.55	1.09	1.28	1.19
57	2	2	26600	6.91	0	0	1	0	0	1.00	1.01	0.38	1.37	0.68	1.76	1.22
112	3	2	9000	6.50	0	0	0	1	0	0.94	0.36	1.61	1.27	1.81	2.94	2.37
75	3	3	37000	6.30	0	0	1	0	0	0.91	1.55	0.87	0.65	1.45	0.05	0.75
48	1	1	27740	6.00	1	0	0	0	0	0.87	1.22	0.90	0.69	2.38	0.98	1.68
107	3	2	39520	6.00	0	0	0	1	0	0.87	1.73	0.67	1.73	1.15	1.28	1.22
26	3	2	30860	6.00	0	0	0	0	1	0.87	1.35	0.90	1.83	1.76	0.07	0.92
113	3	2	18000	6.00	0	0	0	1	0	0.87	0.79	1.61	1.31	1.51	2.48	1.99
3	1	3	18432	5.58	0	0	1	0	0	0.81	0.87	1.32	1.74	0.53	1.00	0.77
118	3	3	27000	5.00	0	0	1	0	0	0.72	1.42	0.81	1.23	0.67	1.05	0.86
92	3	1	32375	5.00	0	0	1	0	0	0.72	1.70	1.61	0.98	2.91	0.07	1.49
14	2	1	15200	5.00	0	0	1	0	0	0.72	0.80	1.07	1.11	2.28	2.94	2.61
78	3	3	18500	5.00	0	0	0	0	1	0.72	0.97	0.81	1.05	0.86	0.67	0.76
34	3	2	18000	5.00	0	0	0	0	1	0.72	0.95	1.21	0.51	0.84	0.43	0.63
85	2	1	12780	5.00	0	0	1	0	0	0.72	0.67	0.81	2.62	0.89	3.91	2.40
61	2	2	33475	4.98	1	0	0	0	0	0.72	1.77	1.35	0.58	0.79	1.07	0.93
28	3	2	15710	4.75	0	0	0	0	1	0.69	0.87	0.85	0.50	2.28	0.12	1.20
115	3	3	22500	4.64	0	0	0	0	1	0.67	1.28	1.16	0.57	0.80	0.03	0.41
87	3	3	21600	4.58	0	0	0	0	1	0.66	1.24	1.93	0.62	0.59	2.12	1.36
1	1	3	22800	4.00	0	0	1	0	0	0.58	1.50	1.61	2.86	2.98	2.68	2.83
76	3	3	19160	4.00	0	0	1	0	0	0.58	1.28	0.68	1.51	2.13	2.35	2.24
71	1	2	17520	4.00	0	0	1	0	0	0.58	1.15	0.68	1.33	1.94	2.57	2.25
39	3	3	11520	4.00	1	0	0	0	0	0.58	0.76	1.61	0.52	0.55	0.83	0.69
81	2	1	13240	4.00	0	0	1	0	0	0.58	0.87	1.10	1.38	1.88	0.10	0.99
33	3	2	14400	4.00	0	0	0	0	1	0.58	0.95	1.01	0.54	1.64	0.07	0.86
56	2	2	13300	3.60	0	0	1	0	0	0.52	0.97	0.57	0.97	1.07	1.76	1.41
93	3	1	19100	3.50	0	0	1	0	0	0.51	1.44	1.61	0.51	1.78	1.96	1.87
19	2	1	17680	3.38	0	0	0	1	0	0.49	1.38	2.15	1.00	1.55	2.94	2.24
49	1	1	18500	3.35	1	0	0	0	0	0.49	1.45	0.66	0.27	1.29	1.47	1.38
44	3	1	14250	3.33	0	0	1	0	0	0.48	1.13	1.93	0.67	1.19	1.96	1.57
63	2	2	9415	3.07	0	1	0	0	0	0.44	0.81	0.87	1.11	1.07	1.21	1.14
54	2	1	13323	3.00	1	0	0	0	0	0.43	1.17	1.25	1.12	1.25	2.10	1.67
40	3	3	8100	3.00	1	0	0	0	0	0.43	0.71	1.34	0.54	0.78	0.25	0.51
55	2	1	15263	3.00	1	0	0	0	0	0.43	1.34	0.75	1.58	2.08	0.94	1.51
74	3	3	9000	3.00	0	0	1	0	0	0.43	0.79	1.34	0.77	2.50	1.00	1.75
121	3	1	8505	3.00	1	0	0	0	0	0.43	0.75	1.07	0.55	1.13	1.22	1.18
47	3	1	13300	2.75	0	0	1	0	0	0.40	1.27	0.59	0.50	1.76	6.40	4.08
126	3	3	7863	2.50	1	0	0	0	0	0.36	0.83	1.61	1.21	0.73	0.06	0.39
91	3	1	8910	2.25	0	0	1	0	0	0.33	1.04	1.19	2.79	4.27	3.52	3.89

Table 7.3 (continued): Outputs & Inputs/acre as Proportions of Median Output and Input/acre sorted by Land, 113 Rice Farmers, Central Punjab, 1992

Farm	Market	Industrial		Land	Water source					Land as prop	Output and input/acre as a proportion of the median output and input/acre					
number	town	town	Ouput	acres	PTW	CW	CW&P	CW&G	ALL	of median acr	Output	Seed	Purchased	Labor	Horsepower	(Lab+HP)/2
6	2	3	2112	2.00	0	0	0	1	0	0.29	0.28	0.60	0.50	1.53	0.56	1.04
8	2	3	4560	2.00	0	0	0	1	0	0.29	0.60	0.81	0.49	0.60	0.04	0.32
38	3	3	4560	2.00	1	0	0	0	0	0.29	0.60	1.21	1.15	3.15	4.40	3.78
45	3	1	11400	2.00	0	0	1	0	0	0.29	1.50	0.81	0.52	2.91	3.52	3.22
119	3	1	11400	2.00	1	0	0	0	0	0.29	1.50	0.81	1.25	0.54	1.29	0.92
127	3	3	5760	2.00	1	0	0	0	0	0.29	0.76	0.27	0.55	1.33	0.07	0.70
69	1	2	6000	2.00	0	0	1	0	0	0.29	0.79	0.63	0.51	2.13	1.47	1.80
37	3	3	5022	2.00	1	0	0	0	0	0.29	0.66	1.61	3.75	2.33	2.15	2.24
108	3	2	5700	1.75	0	0	1	0	0	0.25	0.86	0.77	1.15	1.41	4.27	2.84
4	1	3	3840	1.50	0	0	1	0	0	0.22	0.67	1.01	0.49	2.15	1.00	1.58
10	2	3	7800	1.50	0	0	0	1	0	0.22	1.37	1.01	0.52	0.29	0.26	0.27
120	3	1	4750	1.50	1	0	0	0	0	0.22	0.83	0.54	0.52	7.03	3.67	5.35
5	1	3	4416	1.50	0	0	1	0	0	0.22	0.77	0.81	0.78	1.55	2.94	2.24
2	1	3	2250	1.19	0	0	1	0	0	0.17	0.50	0.68	0.74	1.94	0.87	1.41
59	2	2	3384	1.13	0	0	1	0	0	0.16	0.79	0.84	0.66	3.23	5.87	4.55
96	2	3	3900	1.00	0	0	0	0	1	0.14	1.03	1.07	1.51	1.03	2.02	1.52
79	3	3	2520	1.00	0	0	0	1	0	0.14	0.66	0.63	1.42	1.23	0.06	0.65
98	2	3	2925	1.00	0	1	0	0	0	0.14	0.77	0.81	0.49	1.33	2.94	2.13
9	2	3	1920	1.00	0	0	0	1	0	0.14	0.51	0.40	0.48	1.45	1.28	1.37

7.5.3 Variables

Statistical analysis was also done on variables which are particularly subject to measurement error. They consist of seed, horsepower and labor.

Seed appears to capture more than seeding rate; it may also contain payment in kind to labor from large farmers to small farmers. Some farms were found to have a seeding rate far in excess of agronomic recommendations. An upper limit on the highest value that the seed variable could have was set at 6 kgs/acre. In spite of this adjustment, seed still seems to be exhibiting the typical behavior of a variable capturing the effects of a missing variable(s).

The labor and horsepower variables are subject to measurement error. The source of this error arises from the fact that the stock of labor and horsepower probably do not correctly measure the flow of inputs to rice production. Labor is a stock measure derived from the size and composition of the farm family. The stock of labor is adjusted for the amount of land grown to rice, by multiplying by an adjustment factor consisting of the percentage amount of total farm area cropped to rice. However the proportion of the stock of family labor devoted to rice may vary from household to household because a number of farmers in the system do not use family labor but hire out piece-rate contract labor to undertake certain rice operations. Hence the stock of family and hired labor in such circumstances does not approximate the actual flow of services to the rice activity in these circumstances.

Likewise horsepower consists of the horsepower of individual animals and tractors multiplied by the number of passes that each individual source of horsepower makes. The amount of horsepower used is aggregated across each individual farm. But this aggregation across techniques does not appear to be consistent for both techniques. For example, tractors generally use a higher amount of horsepower compared to bullocks which use little horsepower relative to the time they take to plough one acre.

7.6 Selection of functional form

The choice of functional form is very important because it determines the flexibility of assessing the nature of the economies of scale/size and shape of the isoquants. Preliminary regression analysis conducted for outlier detection were also used to help in determining the choice of functional form.

Very flexible functional forms require rich, accurately measured data sets; i.e there must be a wide range in input-input and input-output ratios, low collinearity among inputs and a wide range of farm sizes. Relatively general mathematical forms were discussed in Chapter six with the Cobb-Douglas being a special case.

The cleaned-up data set does not exhibit a wide range of input-input ratios with respect to the conventional inputs. But on examining correlations between individual pairs of variables, land was found to be highly correlated with purchased inputs as well as with the seed variable as shown in Table 7.4. These correlations were 0.96 and 0.96 respectively. A condition index of 30 is a point at which it becomes difficult to disentangle individual effects as the index gets higher. Collinearity among variables in both of the final regression models is confirmed by high condition indexes of 69 or more.

The seed variable exhibits the typical behavior of a 'left out' variable. When seed is left out of the regression, the coefficient on land increases dramatically, as does its statistical significance with no improvement in any of the other variables.

Table 7.4: Correlations between Irrigation Sources, Outputs/Inputs/Indexes of Market and Industrial Town, 113 Rice Farmers, C. Punjab, 1992

	Quantity	Land	Labor	Horsepower	Purchased Inputs	Seed	Dummy PTW	Dummy CW	Dummy CW+GW	Dummy CW+PTW+GTW	Dummy CW:1	Dummy CW:2
Quantity	1.00	0.96	0.59	0.56	0.89	0.88	-0.15	0.10	-0.05	0.08	-0.05	0.00
Land			0.62	0.61	0.93	0.93	-0.16	0.06	-0.02	0.13	-0.07	0.02
Labor				0.48	0.57	0.58	-0.15	0.16	0.00	0.02	-0.07	-0.17
Horsepower					0.56	0.61	-0.19	-0.05	0.15	-0.05	-0.09	-0.04
Purch Inputs						0.86	-0.15	-0.01	-0.04	0.15	0.0	0.10
Seed							-0.14	0.10	0.0	0.19	-0.08	-0.04
Dummy for PTW								-0.09	-0.21	-0.20	-0.09	-0.20
Dummy for CW									-0.09	-0.09	0.16	0.02
Dummy for CW+GW										-0.20	-0.09	0.05
Dummy for CW+PTW+GW											0.01	0.00
Dummy CW:1												-0.09

	Dummies:CW:3	CW:4	GTW:1	GTW:2	PTW:1	PTW:2	PTW:3	Towns:Market	Industrial
Quantity	-0.01	0.17	-0.08	0.18	-0.04	-0.13	0.10	0.03	0.0
Land	-0.01	0.18	-0.04	0.24	-0.04	-0.15	0.11	0.03	-0.02
Labor	0.05	0.25	0.0	0.06	0.02	-0.13	0.0	0.14	-0.20
Horsepower	0.17	0.05	-0.01	0.18	0.13	-0.07	-0.11	0.03	-0.12
Purchased Inputs	-0.08	0.14	-0.05	0.26	-0.05	-0.13	0.15	0.02	-0.10
Seed	0.02	0.18	-0.01	0.31	-0.03	-0.14	0.06	0.12	0.0
Dummy for PTW	-0.36	-0.25	-0.28	-0.12	0.0	0.21	0.05	-0.08	-0.12
Dummy for CW	-0.08	0.08	-0.13	-0.05	-0.05	0.03	-0.25	0.05	0.13
Dummy for CW+GW	-0.30	-0.15	0.65	0.05	-0.10	-0.18	-0.55	0.14	0.15
Dummy for CW+PTW+GW	-0.10	0.30	0.41	0.42	-0.10	-0.11	0.32	0.15	0.01
Dummy CW:1	-0.16	-0.12	-0.03	-0.05	-0.05	-0.08	0.09	-0.01	0.08
Dummy CW:2	-0.34	-0.24	0.11	-0.12	-0.10	-0.03	0.06	-0.06	0.11
Dummy CW:3		-0.43	0.17	0.0	0.13	0.0	-0.27	0.0	0.08
Dummy CW:4			-0.01	0.24	-0.04	-0.10	-0.16	0.12	-0.12
Dummy GTW:1				-0.16	-0.14	-0.19	-0.25	0.23	0.16
Dummy GTW:2					-0.06	-0.11	0.08	0.02	-0.02
Dummy PTW:1						-0.09	-0.28	-0.03	-0.11

While there is confusion as to what seed is measuring, it has been decided to retain this variable in the equation specification, since it is highly significant and may improve the estimation of other parameters. Thus the data did not appear to be strong enough to disentangle the effects of these separate inputs in particular.

The data contained a wide range of land sizes cropped to rice. Visual examination of Table 7.3 indicates that there was a tendency for farmers with small acreages cropped to rice, to employ more of both labor and horsepower per unit of land. Larger farms, on the other hand appear to enjoy significantly increasing economies of size with regard to these two variables. Farmers with larger acreages cropped to rice used relatively smaller bundles of these input pairs. Hence there is increasing returns to size or scale with regard to the resource bundles which are represented by combinations of these two inputs, as they are currently measured.

Another problem is that some of the data appears to suffer from serious measurement error. The previous section indicates that horsepower and labor variables have measurement problems. Measurement problems in the horsepower and labor variables lower the degree of confidence regarding the information conveyed by these variables as well. For example the degree of confidence regarding probable economies of size/scale with regard to the horsepower and labor bundle of inputs are lessened by measurement error.

There may also be different elasticities of output with respect to inputs present at different scales of production. Using land cropped to rice as a proxy for farm size, preliminary regressions estimated by including the squared variable of land cropped to rice in the equation indicated that the adjusted R^2 declined and the land squared coefficient was insignificant. These results indicated that the coefficient estimates or elasticities of production with regard to land did not change. Thus the elasticity of output with respect to inputs did not appear to vary with the scale of production and the data in its present form appeared unable to capture the variable elasticities of output or variable elasticities of input substitution.

Given the limitations of the data set, the first-order Cobb-Douglas functional form was chosen as the preferred functional form. It has a constant elasticity of substitution of output with respect to inputs and could capture constant elasticities of output with respect to scale. Collinearity and measurement error issues in the data also appeared to preclude the use of a higher order functional form. The Cobb-Douglas function generated residuals which did not exhibit any systematic variation when plotted against land cropped to rice as well as with regard to other variables such as seed, purchased inputs and output. As these four variables were so highly correlated it did not make much difference which one variable among them was to be used to indicate whether residuals varied with regard to farm size/scale. The probability plot generated by the residuals from the estimated Cobb-Douglas function also generated a normal cumulative plot of residuals. Hence statistical tests such as the t-test and F-tests based on the normal probability distribution could be tested on regression coefficients.

A (non-unitary) constant elasticity of substitution function would permit greater generality while maintaining a constant elasticity but the gains, if any, did not seem to be worth the additional estimation difficulties. Collinearity among variables would imply a very large standard error for the elasticity of substitution. The Cobb-Douglas has an elasticity of substitution of unity which is intermediate between the substitution elasticities of the fixed proportions (Loentief) and the linear functions.

7.7 Analytical Impact of Irrigation Systems.

The hypotheses deal with whether there were differences in total factor productivity across the different types of irrigation systems. In order to test the hypotheses the irrigation systems were classified by two methods. The individual irrigation systems were first defined with regard to the sources as well as the levels or categories within each irrigation source as identified in Table 7.1. As combinations of irrigation sources were anticipated to be important in determining productivity, irrigation systems were then classified according to all the combinations of irrigation sources available within the sample. There were not enough observations available to capture all the interactions of classes and levels of individual irrigation sources within these combinations.

7.7.1 Estimation Strategy

Hence the estimation strategy to be followed primarily consists of estimating two production models using the Cobb-Douglas function in logarithmic form. Both production models contain the production inputs, the market and the industrial town. In addition the first model contains the three individual irrigation sources and their levels (or categories) in the form of dummy variables (or intercept shifters). This model will be tested to see whether the coefficients on all irrigation sources and then irrigation levels within each source are statistically significant. If ranks within individual sources of irrigation appear to be statistically insignificant in explaining variation in total output, a second production model will be estimated in which irrigation systems are defined by interactions between the sources of irrigation. The results derived from the coefficients of the first and second models are derived. Results from the second model are also used to test for the effects of the industrial and market town. More importantly, they are used to compute total factor productivity for all combinations of irrigation sources and to verify results obtained from the previous two models.

7.7.2 Empirical Combinations of Irrigation Sources

Table 7.5 shows the combinations of irrigation sources which farmers have access to. Canal water is the most extensive water source used in the sample; 4.4% of farmers use only canal water, but 82.3% of all farmers use canal water in combination with private tubewells or government tubewells. About 17.7% of the sample farmers have access to only private tubewells; 43.9% have access to canal water and private tubewells. Thus, canal water and private tubewells constitute the most widespread (combined) source of irrigation. Government tubewells in combination with canal water are used by only 17.7% of sample farmers.

Table 7.5 shows that the irrigation variables are not highly correlated with one another. The highest correlation amongst this group consists of the combination canal water, government and private tubewells which is correlated with the combination canal water and private tubewells; the correlation coefficient is 0.41.

7.7.3 Results of Model I Representing Irrigation Levels/Sources

Results derived from the estimation of Production Model I are initially presented in this section. Findings from Model II are presented next.

Model I has as dependent variables the five production inputs, the industrial town and market town indicators and irrigation variables. In this model, the different sources of irrigation were sub-divided into different variables according to the levels or categories of irrigation that they represented. Hence canal water is represented by four dummy variables in the regression (very high, high, medium, low access). Government tubewells are represented by two levels of irrigation (good and poor)

Table 7.5: Distribution of Irrigation Sources by Class or Index of Water Availability, Sample of 113 Farmers, Central Punjab, 1992

Irrigation Source by Class or Index of Availability of Water		
Irrigation Source	Class or Index of Availability (percentage of farms)	Quantity of Farmers
Canal Water	none	20 (17.7)
	low	5 (4.4)
	medium	18 (15.9)
	high	43 (38.1)
	very high	27 (23.9)
Private Tubewell	none	25 (22.1)
	hired	6 (5.3)
	landlord or share	15 (13.3)
	owned one or more	67[a] (59.3)
Government Tubewell	none	74 (65.5)
	medium	31 (27.4)
	high	8 (7.1)

Note: [a] Out of 67 farmers, nine percent of the sample (10 farmers) owned more than one tubewell.

access. Private tubewells are represented by four categories which correspond to the four ownership classes represented by this irrigation source (see Table 7.1). Model I implicitly imposed the restriction that there are no interaction effects (e.g., combined effects are additive when more than one irrigation is used. These representations of the categories of irrigation sources assume that each level of an irrigation source will be compared with the base of no irrigation.

Production Model One has a good fit (see Table 7.6). The R squared adjusted for the degrees of freedom is 0.91. The correlations among the regression coefficients associated with highly correlated inputs (land, seed and purchased inputs) are high and reflected in the high condition index for the equation[6] (Tables 7.6 and 7.7).

The base irrigation system in the statistical model is no irrigation. Irrigation system ranks/categories are represented as dummy (0,1) variables in a log linear regression. A two-level sequential approach was taken to analyze the impact of irrigation sources. First the impact of all irrigation sources taken as a whole were tested relative to the effect of having no irrigation source within the regression model. Results of the F-test of the null hypotheses that the irrigation sources and level/categories did not have an impact on rice output were rejected at the 95%

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[6] The condition number or index κ is defined to be the square root of the maximum eigenvalue relative to the eigenvalue of the smallest eigenvalue (Weisberg, 1985). If a matrix is ill-conditioned, small changes in the values of the dependent or independent variables may lead to large changes in parameter values, with as many near dependencies as there are large condition indices.

Table 7.6: Production Regression Model I for Levels/Sources of Irrigation Systems, 113 Rice Farmers, C. Punjab, 1992

Variable		Regression Model		
		Coefficient Estimates	Standard Error	t-statistic
Canal Water	Low Access (n=5)	0.388	0.197	1.97
	Medium Access (n=18)	0.119	0.135	0.88
	Good Access (n=43)	0.192	0.114	1.69
	Very Good Access (n=27)	0.139	0.124	1.13
Private Tubewell	Hired (n=6)	-0.078	0.193	-0.40
	Share/Landlord (n=16)	0.136	0.148	0.92
	Owned (n=67)	0.082	0.114	0.74
Government Tubewell	Moderate Access (n=31)	-0.208	0.106	-1.95
	Good Access (n=8)	-0.321	0.157	-2.05
Purchased Inputs		-0.010	0.061	-0.17
Labor		-0.034	0.079	-0.43
Horse Power		-0.017	0.033	-0.51
Land		0.980	0.138	7.12
Seed		0.150	0.099	1.50
Infrastructure	Industrial Town	-0.050	0.051	-1.05
	Market Town	0.109	0.057	1.92

Model I: Regression Statistics:
R^2 = 0.908, Adjusted R^2 = 0.89, Standard Error = 0.37
and Condition Index = 65

Table 7.7: Correlation Matrix for Regression Coefficients in Model I (Levels/Sources of Irrigation Systems), 113 Rice Farmers, Central Punjab, 1992

	Indus-trial Town	Purch-ased Inputs	Dummy CW:3	Dummy PTW:2	Dummy PTW:1	Dummy GTW:2	Dummy CW:1	Market Town	Dummy GTW:1	Dummy CW:2	Horse Power	Dummy CW:4	Dummy PTW:3	Labor	Seed		Land
Industrial Town	1.0	-0.18	-0.17	0.07	0.14	0.09	-0.14	-0.22	0.09	-0.07	0.21	-0.09	0.18	0.33	-0.03		0.0
Purchased Inputs		1.0	0.06	-0.1	-0.12	-0.17	-0.09	-0.01	-0.03	-0.11	-0.09	0.07	-0.07	-0.10	0.0	-	0.48
Dummy CW:3			1.0	0.11	-0.05	-0.14	0.36	0.08	-0.23	0.54	-0.11	0.66	0.09	-0.14	0.0	-	0.01
Dummy PTW:2				1.00	0.44	0.16	0.15	0.17	0.37	0.07	0.04	0.04	0.64	-0.04	0.0		0.10
Dummy PTW:1					1.0	0.16	0.07	0.0	0.28	0.01	-0.02	-0.05	0.48	-0.01	0.0		0.10
Dummy GTW:2						1.0	-0.02	0.02	-0.06	0.0	0.07	-0.27	0.14	0.20	-0.15		0.10
Dummy CW:1							1.0	0.03	-0.13	0.33	-0.16	0.32	-0.01	-0.05	0.08		0.05
Market Town								1.0	0.01	0.02	0.06	-0.01	-0.01	-0.16	-0.26		0.21
Dummy GTW:1									1.0	-0.19	0.21	-0.22	0.5	0.10	-0.06		0.02
Dummy CW:2										1.0	-0.05	0.47	0.0	0.16	0.20	-	0.16
Horsepower											1.0	-0.06	0.20	-0.04	-0.08	-	0.04
Dummy CW:4												1.0	-0.05	-0.20	0.06	-	0.06
Dummy PTW:3													1.0	0.05	0.01	-	0.02
Labor														1.0	0.0	-	

level of significance. As the null hypothesis was rejected in this form, the second stage of the sequential strategy was implemented.

The second set of hypotheses to test are whether there is a systematic variation in output associated with variation in levels/categories. For example, the null hypothesis for canal water is that the parameters associated with each of the level dummy variables (low, medium, high and very high) are equal against the alternative that they are not equal. This test was carried out for each irrigation source.

Results of the F-test indicated that the null hypothesis that individual canal water rankings of access had equal impact on rice output was not rejected at the 90% level of significance; impacts appear to be equal across ranks. The magnitude of the estimated coefficients of the individual levels or categories of irrigation and the precision of their estimation were also examined in order to verify these results. Two of the four coefficients exerted a statistically significant effect on output. The coefficients of 0.39, 0.12, 0.19, and 0.14 for low, medium, good and very good access to canal water, appear to be essentially the same except for the coefficient on low access. But the low access ranking contains only five cases and its standard error is relatively larger than that of higher levels of canal water (0.19 versus 0.12). Hence the number of farmers with a low access rating are too few to be confident that it is generating an effect of different magnitude than those with medium, high and very high access.

Results of the F-test also indicated that the null hypotheses that categories of private tubewells had equal impact on rice output failed to be rejected at the 90% level of significance. The null hypothesis that the ranks of government tubewells had equal impacts also failed to be rejected. The difference was 0.11, and less than the standard error of the difference. Knowledge of rank/category does not appear to make a difference; just source. This finding holds across sources. Source does matter; the weighted average coefficients for canal water, private tubewell and government tubewell were 0.17, 0.08, and -0.23, respectively. The magnitude of the estimated coefficients of the individual categories and the precision of the estimates were also examined to assist in our understanding of these results. Private tubewells had a mixed impact on output. Farmers with access to hired tubewells had a coefficient of 0.08, while farmers who shared access and who owned tubewells had coefficients of 0.14 and 0.08 respectively. However, as shown in Table 7.6, only six farmers used hired private tubewells compared to 16 farmers with shared and 67 wholly owned private tubewells; the standard error for the estimate of hired tubewells is 0.19 while the standard error for shares and owned tubewells is 0.13. The difference between hired versus shared or owned, is 0.19, which is not large enough relative to the precision of estimation to be deemed different.

Government tubewells appeared to exert a negative effect on output relative to the average level of irrigation. The coefficients of 0.21 and 0.32 are statistically and significantly different from zero.

7.7.4 Results of Model II Representing Irrigation Sources/Combinations

Based on the analysis of irrigation effects in Model I, the restriction that all coefficients on levels/categories within a system were equal was imposed. Levels of access to each category of water source did not differ from each other. Consequently, a set of dummy variables was created for each combination of water sources, taking on the value of one when the farmer had access to the specified combination, and no access to any other source/combination and zero otherwise. The dummy variables were mutually exclusive; a farmer could only appear in one category.

Combined access to canal water and private tubewell water was used as a base against which other combinations of irrigation sources were compared. Thus Model II contains the five production inputs as well as the industrial town and market town indexes. The categories of the combination of irrigation sources considered as shown in Table 7.8 are canal water alone; canal water plus private tube-wells; canal water and government tubewells; canal water, private and government tubewells; private tubewells alone; and government tubewells with canal water. The base combination did not enter the regression equation.

In Model II adjusted R^2 was 0.89. High correlations between the log of land and seed (0.74) and log of purchased seed and land (0.48), support high multicollinearity among the variables as indicated by high condition indices (65). Multicollinearity precludes reaching any definitive statement about the impacts of individual production inputs.

Model II was utilized first to test for the null hypothesis that the market and industrial towns were jointly significant in affecting the efficiency of resource use in rice output. The null hypothesis of no impact failed to be rejected at the 90% level of statistical significance. This was slightly unexpected because the hypothesis that the market town alone did not affect the efficiency of input use in rice production was rejected at the 90% level.

Table 7.8 Regression Production Model II for Single/Combined Irrigation Systems, 113 Rice Farmers, C. Punjab, 1992

Variable Name		Coefficient Estimates	Standard Error	t-statistic
Irrigation[a] (no of cases)	Canal Water (no of cases)	-0.09 (5)	0.18	-0.52
	Private Tubewell (no of cases)	-0.17 (20)	0.10	-1.64
	Canal Water and Government Tubewell (no of cases)	-0.31 (20)	0.10	-3.05
	Canal Water, Private and Government Tubewell (no of cases)	-0.23 (19)	0.11	-2.14
Inputs	Purchased Inputs	-0.02	-0.02	-0.28
	Labor	-0.02	0.07	-0.29
	Horsepower	-0.01	0.03	-0.44
	Land	0.97	0.13	7.39
	Seed	0.15	0.09	1.58
Infrastructural Indicators	Industrial Town	-0.04	0.05	-0.73
	Market Town	0.10	0.05	1.90

Model II Regression Statistics:

Adjusted R^2 = 0.89, R^2 = 0.90, Standard Error =0.38 and Condition Index = 67.

Table 7.9: Correlation Matrices for Regression Coefficients of Model II (for Single/Combined Irrigation Systems), 113 Rice Farmers, Central Punjab, 1992

	Industrial Town	Purchased Inputs	Dummy: all Sources	Dummy: C.W	Market Town	Dummy: PTW	Dummy: CW+GTW	Horse-Power	Labor	Seed	Land
Industrial Town	1.0	-0.2	0.07	-0.15	-0.19	0.13	-0.08	0.19	0.33	-0.04	0.02
Purchased Inputs		1.0	-0.02	0.11	0.01	0.01	0.03	-0.11	-0.03	0.02	-0.52
Dummy: All sources			1.0	0.19	-0.12	0.30	0.32	0.29	0.10	-0.17	0.04
Dummy: CW				1.0	-0.01	0.15	0.20	0.05	-0.05	-0.09	0.01
Market Town					1.0	-0.01	-0.14	0.11	-0.16	-0.24	0.18
Dummy: PTW						1.0	0.29	0.14	0.08	-0.11	0.09
Dummy: GTW+PTW							1.0	0.02	-0.11	-0.12	0.04
Horsepower								1.0	-0.09	-0.13	0.01
Labor									1.0	-0.08	-0.21
Seed										1.0	-0.74
Land											1.0

Note:
Correlations between variables are reported on and above the diagonal. The correlations of any specific variable with itself is 1.

7.7.5 Comparison of Models I and II

While Production Model II had the same production input variables and market and industrial town infrastructural variables as did Model I, irrigation was represented only by source but with explicit modelling of combination of sources. The assumption of additive effects in Model I was eliminated; interaction effects are possible. The adjusted R^2, standard deviations and condition numbers were nearly identical in value (Table 7.9), corroborating that rank/categories did not make a difference.

Results obtained from Production Models I and II indicate that among inputs only the land coefficient (or elasticity of production with respect to land) has high explanatory power, and it is the only variable which is statistically significant. However, multicollinearity with other production inputs precludes definitive estimation of their individual impacts and measurement errors are a problem. Estimation of the impacts of the sources of irrigation and the industrial town and the market town are not constrained by collinearity problems.

7.7.6 Total Factor Productivity Analysis:

In order to test the hypotheses more fully, there is a need to obtain an estimate of total factor productivity with the available information. If resource bundles are similar across irrigation systems, the regression coefficients on the dummy variable (intercepts) associated with water systems summarize all the information about TFP. Furthermore if there is not a good measure of the elasticity of output with respect to the production inputs, forming a TFP index using the OLS coefficients is problematic.

7.7.6.1 Derivation of TFP Measure

Information from this model can be utilized to derive the differences in the index of total factor productivity (TFP) formed by comparing the pairs of irrigation systems as defined in the model (either individual sources or a combination thereof). Differences in parameter estimates and their standard errors are also reported in Table 7.10 in addition to TFPs.

7.7.6.2 Interpretation of Irrigation Coefficients

The combination of private tubewells and canal water has the highest total factor productivity and has been assigned a TFP index of one. Canal water is 0.91 times as efficient as the base Canal water and private tubewell combination (see Table 7.10), while private tubewells rank third and are 0.85 times as efficient as the base of canal water and private tubewells. The efficiency of this irrigation combination appears to result from combining the two most efficient irrigation sources.

While all other combinations of irrigation sources are less efficient than these three combinations, combinations which include government tubewells are the least efficient. The detrimental effect of government tubewells is so predominant that government tubewells and canal water are the least efficient combination of irrigation sources being only 0.73 as efficient as that of private tubewells and canal water. In fact the combination of all three sources (government and private tubewells and canal water together) has a TFP of 0.79; that is less efficient than the subset of canal water and private tubewells.

Table 7.10 Derivation of Total Factor Productivity (from Model II) for Single /Combined Irrigation Systems, 113 Rice Farmers, C. Punjab, 1992.

Index of Total Factor Productivity: Pair-wise Comparison of all Individual /Combined Water Sources			Difference in Parameters	Standard Error of Difference
Canal Water: 0.911 (number of cases=5)	versus	Private Tube-wells: 0.846	0.074	0.192
		Canal Water +Private Tubewell: 1.0	-0.094	0.179
		Canal Water + Government Tubewell: 0.732	0.219	0.188
		Canal Water + (Government + Private) Tubewells: 0.787	0.139	0.192
Private Tubewells: 0.846 (number of cases=20)		Canal Water + Private Tubewell: 1.0	-0.168	0.102
		Canal Water + Government Tubewell: 0.732	0.145	0.122
		Canal Water + (Government + Private) Tubewells: 0.787	0.065	0.125
Canal Water + (Government + Private) Tubewells: 0.787 (number of cases=19)		Canal Water + Private Tubewell: 1.0	-0.233	0.109
		Canal Water + Government Tubewell: 0.732	0.080	0.123
Canal Water + Government Tubewell: 0.732 (number of cases=20)		Canal Water + Private Tubewell: 1.0	-0.31	0.102

The magnitude of the precision of the estimates of the impact of differences in the TFP's of irrigation systems in Model II were evaluated through pair-wise comparisons of the differences in the standard errors relative to differences in the estimated parameter coefficients; the number of cases within the individual systems also provided insight into the precision of the estimates (see Table 7.10). For example, the first comparison testing done was the null hypothesis that the impact of canal water on TFP is equal to the impact of private tubewells. The difference in parameters, 0.074 was divided by the standard error, 0.192. The ratios follow a 't' distribution. The ratio is 0.39; thus, the null hypothesis that the difference is zero cannot be rejected.

The second comparison was between canal water and the combination of canal water and private tubewells. Again, the null hypothesis of no difference is not rejected. As only five farmers use only canal water, the difference in parameter coefficients is not large enough relative to the difference in the standard errors between canal water and private tubewells, to be statistically significantly different from zero. It is difficult to distinguish if canal water is drawn from a random draw of the population due to the small numbers involved. In fact the difference in the parameter estimates between canal water and any other irrigation combination using canal water is that the difference in the parameter estimates of TFP are not large enough relative to the differences in the variability of the data.

Private tubewells in the middle of the scale of total factor productivity, have a statistically significantly different TFP from canal water and private tubewells, at the 90% level. Private tubewells by themselves have a lesser TFP relative to canal water and private tubewells, as indicated by a negative difference in parameter estimates.

At the lower end of the TFP scale, the difference in the parameter estimates between all three irrigation combinations compared to canal water and private tubewells are negative (equaling 0.23) and statistically significantly different from zero at the 95% level. However, the difference in parameter estimates between canal water and private tubewells and canal water and government tubewells have the highest negative value and are statistically significant at the 99% level. Not only are the combinations of canal water and government tubewells, as well as all three irrigation sources the least efficient when compared to canal water and private tubewells, but the hypothesis that they come from the same population is rejected with a high level of statistical confidence.

7.7.6.3 Interpretation of Production Coefficients

Of the large amount of dispersion within the water system relatively little was explained by the production inputs. As already indicated in previous sections, results from both production models indicated that of the five input variables the land and seed coefficients appeared to capture most of the explanatory power in the models. In Model II (Table 7.8) the coefficients on land and seed were 0.97 and 0.15 respectively. In the Cobb-Douglas function these coefficients are interpreted as elasticities of output with respect to land and seed respectively. Both of these inputs exhibited low standard errors compared to the size of the coefficients, so that the parameter estimates are statistically significant at the 99% and 85% levels respectively. The remaining bundle of inputs had lower standard errors relative to the size of the parameter coefficients. These low or near-zero coefficient values were imprecisely measured. Model I results were very similar to these results (Table 7.6).

The major drawback to both of the production models was that collinearity among inputs such as land, seed and purchased inputs, was quite high making it difficult to separate out the effect of the parameter coefficients. The seed variable also appeared to be picking up effect(s) of (a) missing variable(s) which was highly correlated with land, as was seed itself. Land in particular appeared to capture most of the explanatory of variables such as seed, purchased inputs and horsepower which were complementary to it.

These results primarily indicate that salinity-adjusted land acreage and irrigation systems consisting of canal water, private tubewells and their combination are particularly important in determining total factor productivity for rice.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction/Strategy

Two major types of research questions and hypotheses which have were described in Chapter one. The first, broader hypotheses assess the impact of various types of infrastructure on (1) crop choice; (2) off-farm employment; (3) education; and (4) the linkages among them. The second set of hypotheses focus on the rice enterprise to assess the (1) direct impact of different types of irrigation infrastructure upon the rice production function; (2) the direct effect of increased levels of farm inputs upon the efficiency on rice output; (3) the direct effect of marketing infrastructure on inputs used and the efficiency of resource use; and (4) the indirect effect of increased access to marketing infrastructure and of as better access to industrial towns on inputs used, prices paid, prices received, and the efficiency of resource use.

Empirical findings with regard to infrastructural access are shown in Section 8.2. Key results regarding the testing of the three broader farm-household hypotheses using ANOVA methods are presented in Sections 8.3 to 8.5. Additional findings are presented when available. Findings are interpreted with regard to how the hypotheses link, contributing to our understanding of the effects of various types of infrastructure on farm-household decisions. Hypotheses, methods and results pertaining to the testing of the second set of hypotheses regarding the impact of irrigation infrastructure, other types of infrastructure, and on rice productivity are presented in Sections 8.6 to 8.9 respectively.

8.2 Infrastructural Access: Measure and Findings

One objective was to measure physical infrastructural access to the types of infrastructure important to farmers. The various types of infrastructure were each represented by one or more infrastructural services; that is, commercial (including agricultural markets and off-farm labor markets), physical, administrative, social and communication. Time and distance were the most informative and, hence, complete measures of physical access; other data regarding time taken, fare incurred, mode of transport used, (in addition to its frequency and duration).

Distances to various infrastructural indicators yielded more statistically-independent information (through correlation analysis). Thus distance was used to measure physical access to all of the thirty infrastructural services. Access to each major type of infrastructure was represented by a smaller basket of thirteen key infrastructural services or indicators. Cluster analysis was used to rank infrastructural access to each of these thirteen indicators. Infrastructural access to each indicator was ranked to denote high, medium and low levels of access. An overall index of general accessibility was also constructed from the key indicators.

Using this measure the majority of villages (62%) are found to have good access to a variety of key infrastructural services, represented by the overall index of general accessibility. Approximately 38% of villages appear to have poor access to such services. The patterns of village access to the industrial town and educational services to boys, two other key indicators used in the study, appear to be very similar to that of the index of overall accessibility. But, village access to other services was more variable. For example, while 50% of sample villages have good access to the market town, the remaining one-half have poor access. Another significant finding was that the type and convenience of the modes of transport available to obtain physical access to female secondary educational facilities was drawn from a different underlying population than transport modes to other infrastructural services. This result was obtained by applying the Kruskall-Wallis test to modes of transport to each of the key indicators.

8.3 Infrastructural Effects on Crop Choice

The decision regarding the choice of crops to be planted was primarily contingent upon water availability in the summer. Hence the hypotheses tested for, during the summer and winter seasons, differed to some extent.

8.3.1 Summer

The major hypothesis tested was that farmers in infrastructurally-accessible areas with sufficient irrigation infrastructure have diversified their summer crop to include high-value horticultural crops (fruits and vegetables) and maize, in addition to rice. A sub-hypothesis was that such farmers in infrastructurally-accessible areas have primarily diversified their summer crop to include fruits and vegetables. Such crops can only be grown if there is sufficient irrigation water available.

This set of hypotheses was tested using ANOVA methods. Thirty-three percent of farmers in the sample grow summer specialty crops, principally horticultural crops. The proportion of summer farm area planted to specialty crops increases with better access to both the industrial and market towns. Farm-households in villages with high levels of infrastructural access plant an average of 48% of their land to specialty crops, while farms in villages with poor access to infrastructure plant an average of 8% of their land to specialty crops.

8.3.2 Winter

Two hypotheses were tested for the winter crop. The major hypothesis was that farmers in infrastructurally-accessible areas have decreased the amount of farm area sown to wheat and lower-value fodder crops, and primarily diversified to berseem, a specialty livestock fodder crop. A sub-hypothesis was availability of irrigation infrastructure has further enabled farmers to shift to the production of high-value horticultural crops.

While berseem and horticultural crops are grown by 94% of all farmers, berseem is grown by 90% of sample farmers. The first hypothesis tested was the broad hypothesis as to whether farmers in infrastructurally-accessible areas have decreased the amount of farm area sown to wheat and lower-value fodder crops and diversified to specialty crops.

An increase in farmers accessibility (from low to high) to the market town is associated with an increase of 24% to 30% of total farm area sown to specialty crops. A similar increase in the ranking of the overall index of general accessibility is associated with an increase of 23% to 30% of total farm area cropped to specialty crops. The combined effect of market and overall access was statistically significant; the null hypothesis of no association was rejected.

Berseem is used as an input into livestock farming and for sale. Of those sample farmers who enjoy good access to most services, an increase in overall access to all infrastructural services as well as to the market town, is associated with farmers' specialization to this crop. Over 50% of farmers had access to both of the two infrastructural indicators.

The (null) sub-hypothesis tested was the percentage of farm area grown to fruits and vegetables increased with an increase in the general index of overall accessibility as well as an increase in market access. The null hypothesis of no increase was not rejected; the percentage of farm area grown to fruits and vegetables, although grown by 36% of farmers, was highly variable, both with regard to increasing market town access as well as overall access.

8.3.3 Policy and Research Recommendations

These findings indicate diversification into horticultural crops and an associated decrease in rice specialization in summer cropping. In winter there is diversification into livestock farming or fodder specialization (alone) and decrease in wheat specialization. Such diversification is often a step towards specialization in fruits and vegetables in summer and livestock farming in winter. Specialization to fruits and vegetables and livestock farming forms part of the process of agricultural development in a market economy and may only be undertaken by farmers with adequate cash for purchased inputs and traction, often accompanied by larger land and labor resources. Even if this specialization does not occur, diversification into horticultural and livestock crops increases the nutritional variety, food content and welfare of even those farmers with very small acreages of land.

Additional research should be undertaken to improve the measure of access used in order to verify these results and provide further insights upon the effect of infrastructure on crop choice. Such an access measure could utilize additional information regarding methods of transport and time taken to traverse distances (which incorporates information regarding the condition of the road as well as actual distance). Access measured as time-weighted distance may be particularly appropriate given the importance of walking (a time-intensive mode of transport) in the sample.

8.4 Infrastructural Effect on Off-farm Employment

The hypothesis tested is that access to labor markets, as indicated by closer proximity to the industrial town, enables farmers to increase their off-farm labor employment and earnings. Cross-tabulation was used to illustrate the amount and kinds of off-farm labor employment engaged in. Analysis of Variance (ANOVA methods were used for hypothesis testing.

8.4.1 Results

One-third of total male labor is employed off the farm. Labor is a gross measure consisting of percentage of male adults employed off the farm in the study. About one-third of the sample is employed off the farm for at least one-third of the year. Most adult males are gainfully employed in trades and skilled jobs which occupy at least half of their time. Even casual laborers appeared to search for work for about four months during the agricultural off-peak season when dry weather coincides with increased road and building construction activities particularly near more urbanized towns.

Approximately 45% to 55% of off-farm activity was agriculturally-based, and included production and downstream linkages stemming from agricultural activity. Cropping and livestock activities and production-based activities feeding into agriculture comprised 21% and 15% of total off-farm activities. At least 9% of the sample worked in cropping activities not located on their own farms. Around 35% to 45% of the total sample was engaged in non-farm agricultural-based activities.

Access to off-farm employment opportunities, measured by proximity to the industrial town and by an ordinal ranking of overall infrastructural access, leads to greater utilization of off-farm employment. However, an anomaly exists; in farm households with high levels of industrial-town and overall access, the proportion of adult household-members of the household employed off the farm diminishes. An explanation for this unusual occurrence is given in the next sub-section.

8.4.2 Linkages and Implications Among Results

A possible explanation for this anomalous finding is that by increasing the profitability of foodgrains as well as high-value, bulky, specialty crops such as fruits and vegetables, good access to marketing and industrial town may be increasing total farm and labor productivity, thereby retaining high levels of labor on the farm. The percentage of rural household labor employed in agriculture may be following a J-shaped curve when plotted against levels of infrastructural access. At low levels of infrastructural access, there is a higher percentage of labor in agriculture because of lack of alternative forms of employment while at medium levels of access farmers may divert to off-farm employment. At the highest levels of overall infrastructural access and access to industrial town, farmers may be availing of higher expanded revenues from taking advantage of higher expected agricultural returns. This type of high infrastructural access particularly increases the profitability of producing high-value, bulky, specialty crops such as fruits and vegetables.

Findings in Section 8.3.1 of this chapter support this plausible inference because the proportion of land devoted to such crops (in summer) is highest when access to industrial and market towns is highest. The increase in this proportion is statistically significant and of an economically important magnitude. However, the

ANOVA methods used to obtain this evidence do not easily allow a variety of explanatory variables, and the proportion of total variance explained by the infrastructural variables is low.

Additional research needs to be undertaken in two directions. Data regarding the proportion of land devoted to horticultural crops could be re-examined with improved access variables incorporating extra information as suggested previously in Section 8.3.3. A second line of research as to whether ranked variables such as the market and industrial town affect the choice to work may also be undertaken. Also, whether this choice affects agricultural productivity through an increase in the percentage of area devoted to fruits and vegetables needs to be assessed. Two-step recursive dichotomous dependent variable models such as logistic models could be used.

8.5 Infrastructural Effect on Education

The two hypotheses formulated were that increased access to overall infrastructure and men and women's education infrastructure, in particular, affect the levels of male and female literacy respectively. These hypotheses were tested for using ANOVA.

8.5.1 Results

While the effect of higher general accessibility to all services, in combination with greater access to educational opportunities, increase the incidence of both male and female literacy, they exercise a much more dramatic effect on male relative to female literacy ratios. High levels of overall access and educational access are associated with 65% male literacy, while low levels of both types of infrastructural access are associated with 38% male literacy. The F statistic for the interactive infrastructural indicators is statistically significant. High levels of overall access and educational access are associated with 23% female literacy, while low levels of both types of infrastructural access are associated with 18% literacy. The underlying population for the sample consisting of those farms (and villages) having good access to overall and key educational indicators were found to be significantly different from those farms with poor access to the two indicators.

8.5.2 Linkages Among Results

About 32% to 40% of off-farm male employment consists of skilled trades, professional or government employment for which technical education or a high-school diploma is a prerequisite. Hence it appears that farm-household male adults are benefiting from their investment in human capital accumulation (i.e education) to increase their levels of off-farm income. In contrast, only two adult females (in separate households) in the sample of 140 households, benefited from their educational investment; they worked off the farm as school-teachers. The only other type of female off-farm employment was domestic employment which was engaged in by four girls.

8.5.3 Directions for Further Research

It is important to undertake additional research regarding women's contribution to farm and off-farm activities. Farm-household survey results which indicate that the majority of women worked solely in their households, and list only 14% of women as full-time agricultural labor are disappointing. Anthropological surveys (e.g Bahar, 1992) indicate that most women contribute to farm-household production activities, particularly vegetable-growing substantially. Hence these results indicate under-reporting by respondents. Women's contribution to farm activities may be particularly important given off-farm migration or employment by male adults. Their contribution to off-farm income through sub-contracting of embroidery etc and domestic employment may also have been under-reported due to an unwillingness to discuss the work activities of female household members.

The type and convenience of the modes of transport used to reach female secondary educational facilities may also play an important role in determining literacy, given that they appear to be drawn from a different underlying population than modes of transport to other infrastructural indicators. Such issues could be investigated further, both by using refined measures of infrastructural access as indicated in Sections 8.3.3 and by using discrete statistical analysis such as the Kruskall-Wallis test.

8.5.4 Policy Recommendations

The Government should increase educational facilities so that all villages should have primary schools for both boys and girls, as well as moderate access to secondary schools. However while enhancing such facilities may increase literacy, it also appears to be important to increase the awareness of the relevance and importance of education in the rural areas (particularly female education). In spite of positive returns to male education, some farmers expressed a very negative outlook on education for both boys and girls; such respondents did not send their male children to school, even if their village had good access to a boys school.

8.6 Impacts of Irrigation Infrastructure on Total Factor Productivity

Irrigation infrastructure is the most important type of infrastructure to affect rice productivity within the rice-wheat agro-ecological system. Irrigation infrastructure was categorized by source, level and various combinations of irrigation infrastructure which farmers used for rice production.

The level of water availability from canal water was measured by means of the addition of two canal water indices: a location-specific index and a water-availability index. The first index measured the relation of the canal to the head of the water-course; by means of a ranked index of three, two and one depending on whether it was at the head, middle or tail-end of the water-course. The water availability index was assigned an index of three, two or one depending on whether there were no obstructions, minor or serious obstructions to obtaining canal water. Farmers with a zero value for the additive index (due to insurmountable obstructions in obtaining water from the water-course) had no access to this water source. Availability of water from government tubewells was generally measured by means of a ranked index similar to the canal water availability index (0,1,2 and > =2) denoting no access, poor and good access depending on successively fewer obstructions in acquiring water from this source. Water availability from private tubewells was measured by means of a descriptive index: one, denoting farmers who bought water from another tubewell owner; two, farmers who participated in tubewell-share-owning arrangements with other farmers or a landlord; three or more, depending on whether the farmer owned one or more tubewells.

8.6.1 Results

All of the 113 rice farmers used some type of irrigation infrastructure. Canal water was availed of, by 82% (or 93) of the rice farmers and was the most widely-used source, either alone or in combination with either one or both of the other sources. About 62% of rice farmers had very good or good availability to canal water while 20%

had low or medium availability. Canal water was primarily used in combination with other irrigation source(s). In combination with private tubewells it was availed of, by 43% of farmers; with government tubewells by 18% of the farmers; but only 4.4% of rice farmers relied on it as the sole irrigation source. In combination with both private and government tubewells it was used by 17% of rice farmers.

About 59% of rice farmers had sole ownership of one or more tubewells. Of the remaining farmers, 18.6% either shared tubewell water with two or more adjoining farmers; bought water from them or obtained it through their landlord. While 39% of rice farmers used water from government tubewells, only 7% enjoyed abundant availability.

A series of hypotheses were defined with respect to the impact of irrigation sources, levels and categories within source and combinations of irrigation sources, on total factor productivity. These hypotheses were tested using two production function models which were a function of standard production inputs (land, labor, seed, purchased inputs and horsepower) and were conditioned by sources, levels, categories within sources and combinations of irrigation sources, as well as market and industrial town access indexes. Both models used a Cobb-Douglas production function framework for the econometric estimation of parameters associated with production inputs, water sources and market and industrial town access. The Cobb-Douglas form was used because collinearity among seed, purchased inputs and land and measurement problems with respect to labor and horsepower precluded estimation of a more flexible functional form such as the translog.

Two production models were estimated. Irrigation infrastructure was treated as an input into production and categorized into the combinations of irrigation infrastructure which farmers used. Irrigation systems are represented by dummy (0,1) variables. Among the production inputs land, seed and purchased inputs, horsepower and labor were all measured by means of continuous variables. Of these variables land, seed and horsepower were quantified by means of actual amounts used while purchased inputs were represented by expenditure incurred.

The initial broad hypothesis tested was obligatory: whether irrigation sources, taken as a whole, had a significant impact on total factor productivity (TFP). The null hypothesis was rejected as expected; water source matters.

According to a priori information, particularly with respect to government tubewells, differences in total factor productivity (TFP) were due to individual irrigation sources, levels and categories within sources, and combinations among levels and sources. The large number of potential combinations of sources/levels and categories of irrigation relative to the size of the sample could not be estimated within a single production model. Hence one set of hypotheses with regard to levels and categories within irrigation source, were first tested by means of a production model, in order to decrease the number of irrigation sources/levels and categories. A second set of hypotheses regarding the efficacy of the relevant individual irrigation sources/levels and categories and combinations thereof were then tested by means of a second production model.

For the first set of hypotheses, the null hypothesis that the impact of level/rank of canal water availability on productivity was the same within source was tested. The null hypothesis of no level/category effects was not rejected. This was an unexpected result because increased levels of canal water access were expected to increase total factor productivity relative to lower levels, as canal water access was ranked by means of an ordinal index. The magnitude of the estimated coefficients of the individual levels or categories of irrigation, and the precision of their estimation were also examined in order to verify these results.

The null hypotheses that there were no differences due to category within private tubewells was not rejected; categories do not appear to be systematically related to variation in output. This result was expected as categories of irrigation did not correspond to an increasing index of availability. A similar result was obtained for government tubewells although such tubewells were ranked through an increasing index. Hence better irrigation was expected to have a positive impact on productivity. However, precise results could not be obtained because of the few number of cases of well-functioning government tubewells.

While knowledge of irrigation rank/category did not appear to make a difference; source did matter. Weighted average coefficients of the dummy variables (0,1) for canal water, private tubewells and government tubewells were 0.17, 0.08, and -0.23, respectively indicating that the effect of individual irrigation sources are very different. The magnitude of the coefficients with a low access rating to canal water were found to be statistically significantly different from zero, but the number of farmers were too few to be confident that the rating was generating an effect of different magnitude than those with medium, high and very high access. The precision of the estimates for moderate and good access to government tubewells were equivalent.

These findings indicate that level/category is not important within source. Thus combinations of sources were developed in which each source or combination forms a separate irrigation system. Then hypotheses were formulated regarding the impact of each individual irrigation source as well as combinations thereof, on total factor productivity (TFP). The impacts of the different irrigation systems upon TFP were then tested by means of a second production function model (II). In this manner the individual effects of irrigations sources and their combinations were captured in a second production function (Model II). These effects could not be incorporated in Model I because this model assumes that access to a combination of irrigation sources have an additive effect on rice productivity.

Canal water in combination with private tubewell water was found to be the most efficient irrigation combination and yielded the highest total factor productivity. Hence it was assigned a TFP index of 1.0 and all other irrigation systems were compared to it. Canal water was the single-most efficient irrigation source while private tubewells were intermediate in efficiency between canal water and government tubewells. Canal water alone was 0.91 times and private tubewells alone were 0.85 times as efficient as the (base) combination of canal water and private tubewells.

Government tubewells were hypothesized to have the lowest total factor productivity among the irrigation systems considered. Farmers with combinations of all irrigation sources (canal water, private and government tubewells) had an estimated total factor productivity index of 0.79 compared to an index of 1.00 for canal water and private tubewells. The combination of canal water and government tubewells particularly yielded lesser total factor productivity than any other irrigation system containing canal water. Thus farmers with irrigation systems consisting of government tubewells in combination with one or more other sources have a lower total factor productivity than farmers who avail of separate or combined irrigation systems with access to canal water and/or private tubewells.

The magnitude of the precision of the estimates measuring the impact of differences in the TFPs of irrigation systems in Model II were evaluated through pair-wise comparisons of the differences in the standard errors relative to differences in the estimated parameter coefficients. Pair-wise differences in the standard errors of irrigation systems with only canal water and only private tubewells, were low as were differences in the TFP between them. These findings indicate that these two systems appeared to be drawn from the same population. Similar results indicate that irrigation systems defined only by the use of canal water or private tubewells are drawn from the same population as systems containing both canal water and private tubewells.

In contrast, the null hypotheses that irrigation systems defined by private tubewells and canal water as opposed to systems defined by private tubewells and government tubewells came from the same population was rejected at the 90% level. Irrigation systems consisting of canal water and government tubewells together and in combination with private tubewells, also had low standard errors. The null hypothesis that these two systems are drawn from the same population was also rejected with a high level of statistical confidence lending credibility to previous findings that all three irrigation systems including government tubewells are drawn from a different underlying population than the four systems which do not contain them.

8.6.2 Research and Policy Recommendations

Results from this study indicate that the efficiency of water usage of rice-growing farmers is not the same across seven irrigation systems defined by three irrigation sources (canal water, private tubewells and Government tubewells) and their combinations. Such results differ from a previous study done by International Irrigation Management Institute (IIMI), which indicates that farmers who grow wheat, are equally efficient in using water. However, rice-farmers in this study are dependent on seven irrigation systems as compared to three such systems (canal water, private tubewells and their combination) in the IIMI study.

There were two major findings in this section. The first finding was that combinations of certain irrigation, sources, particularly those involving canal water alone or in combination with private tubewells exhibit greater efficacy than others, while combinations involving Government tubewells had poorer than average efficiency. Both of these two key findings need to be investigated further.

The first key finding concerns the efficacy of canal water, alone and in combination with private tubewells. Nearly 90% of the sample comprises of farmers growing less than or subsistence levels of rice acreage. Hence the majority of this sample consists of farmers who are utilizing canal-water with great efficiency; as they may not want to or be able to afford to buy a private tubewell. The characteristics of farmers using the different systems need to be investigated further to gain additional insights regarding the superior efficiency of these systems. The second key question is why government tubewells are so inefficient relative to other irrigation sources for the rice crop. There are three possible reasons: (1) government tubewells were found to be old and ill-maintained; (2) there are issues of governance involved because the local irrigation field workers have been causing moderate obstruction to the operation of tubewell water; and (3) water from government tubewells was found to be saline and unsuitable for irrigation. In fact rice is a salt-sensitive crop, as compared to other crops, such as wheat which have much higher salt-tolerance. The detrimental effect of salinization due to this water source may cause salt-stress particularly on land which is already moderately saline. But water from private tubewells may also be saline as continued use of both private and government tubewells over the years has increased the level of the water table, resulting in drainage problems, seepage of salt into the water and salinization of land. Hence research regarding (3) may also be useful in diagnosing the reasons as to why private tubewells are not so productive as canal water. Information regarding the quality of water from government tubewells and the soil type of land is available, and can be utilized to investigate such questions further.

Hence it appears that Government should encourage investment by farmers in private tubewells; and offer them incentives to do so. At the same time it should increase its investment in the provision of canal water to farmers. However, the issues behind the poor functioning of Government tubewells should also be explored. One alternative is to close down public tubewells.

8.7 Impact of Production Inputs on Rice Output

The factors of production are critical to the amount of rice output produced. Inputs of land and labor in particular are intensively used for rice production, due to rising population pressure. Hence hypotheses were formulated regarding these two inputs, in particular. The first (null) hypothesis was that output elasticity of rice with regard to land is positive.

The application of irrigation water also requires a constant stream of labor (approximated here by labor stock) to apply water to rice throughout the crop's growth cycle. Hence the second null hypothesis was that the elasticity of output with respect to labor rises. As output is measured as total rice revenue (i.e via higher output quantities) with constant prices of inputs and outputs, a positive elasticity of output with respect to labor denotes that labor is still a scarce factor of production, so that the share of income to labor also rises.

These hypotheses were tested for, by means of the same Cobb-Douglas production models used to test the irrigation models. The production function of rice is primarily determined by the quantity of inputs used, although conditioning agents such as the availability of various types of irrigation infrastructure, as well as good access to input/output markets and the industrial town are important.

The production function for rice was originally estimated for 127 farmers. As a result of careful outlier analysis the sample of rice farmers was decreased to 113. Methods used for outlier analysis included visual data screening, examination of regression residuals and regression coefficients of farms which exerted unduly high leverage (DFBETA analysis). The results of outlier analysis consisted of dropping from the sample those farms which were flooded, atypical farms and farms which contained implausible and illogical rates and levels of substitution among inputs and outputs. To identify which farms did not appear to have expected relationships (e.g low yield, but high inputs per acre), the values of the relevant variables were compared to those of the median yield, yield per acre, own and other inputs' average products and inputs per acre (standardized inputs).

Variables representing the output and inputs of the rice crop were aggregated to the farm level and often modified to obtain the most appropriate measures. Rice physical product was reduced to monetary terms by adding up the revenue from different IRRI and Basmati rice varieties. Land acreage devoted to rice was adjusted downward to account for the decrease in output potential due to the average amount of rice farmland affected by soil salinity, water-logging and drainage. The stock of labor available for the rice enterprise was obtained by summing up male, female and reported child labor, derived as a residual after accounting for their off-farm labor activities. This measure of aggregate labor was then modified by multiplying by an adjustment factor consisting of the percentage of farm area cropped to rice.

Purchased Inputs consisted of total costs incurred on fertilizer, manures, pesticides and zinc applications. The total cost incurred on each of these inputs was obtained, by multiplying the per acre cost by the number of acres to which the input was applied. The cost of manure included any labor costs incurred in its application and spreading.

The derivation of the horsepower measure first entailed the standardization of tractors and bullocks to common horsepower units. Relevant tractors and bullocks horsepower units were then multiplied by the number of passes made by each of these two techniques, to obtain actual usage. Horsepower hours per acre were assumed to be constant. Aggregate horsepower was also multiplied by the same adjustment factor as labor.

Seed was measured by the total amount of rice seed actually uprooted and transplanted to the rice field from the nursery. The biologically-feasible upper limit was set on seed rate per acre.

8.7.1 Results

Results from both production models indicate that among the five input variables, only land and seed coefficients had impacts of some magnitude on the elasticity of output as represented by input coefficient estimates. Elasticity of output with respect to land and seed were of a high magnitude particularly in model I. Both of these estimates were precise as they exhibited comparatively low standard errors.

The seed variable appeared to be picking up the effect(s) of (a) missing variable(s). The remaining bundle of inputs all had low or near-zero coefficients which are not statistically significant at all. Hence these results indicate that salinity-adjusted land acreage and irrigation systems consisting of canal water, private tubewells and their combination are particularly important in determining total factor productivity for rice.

The major drawback to both of the production models was that in spite of careful outlier analysis and care in constructing variables, collinearity among inputs such as land, seed and purchased inputs, was quite high. Hence it was difficult to separate out the effect of the parameter coefficients. Moreover, the seed, labor and horsepower variables were measured with serious error. In spite of quality adjustments made to these variables, the measurement error does not appear to have decreased sufficiently to yield meaningful coefficient estimates for these variables.

8.7.2 Directions for Future Research

Additional research needs to be done to obtain improved measures of inputs such as labor and horsepower which are incorrectly measured. Only then can more meaningful and robust estimates of these variables /measures of the elasticities of output be obtained from the Cobb-Douglas functional form. Additional sample information which has not been used indicates that many sample farmers hire out piece-rate contract labor to undertake certain rice operations, a reason why family and hired labor does not equal the actual flow of services to the rice activity. An improved measure of horsepower may require that the assumption of constant horsepower hours per acre be dropped, because tractors use a higher amount of horsepower to plough one acre as compared to bullocks. It may be harder to reduce collinearity among variables without throwing out key observations. However, with an improved data set it may also be possible to use a higher order functional form (such as the translogarithmic model) to capture variable elasticities of output and changes in the shapes of the isoquants.

An improved data set may also yield improved estimates for irrigation variables. Hence it may enable the investigation of more refined questions regarding canal water irrigation. The canal water index, as described previously is formed by adding up a location-specific index to the water-availability index. The location-specific index arises due to the inherent nature of this water resource, as farmers near the head of the water-course have more water than farmers further downstream. The water-availability index defines levels of canal water access by the extent to which obstructions in the supply of this source affect actual usage. Such obstructions depend on (1) how far the canal is from the head of the water-course, and (2) whether the canal-water flow is impeded by (a) upstream farmers blocking water further downstream, and (to a lesser extent) (b) by silting and sedimentation of the canal water-course, due to its being unpaved or inadequately maintained. Meaningful estimates of the separate indices measuring these phenomena will yield estimates of the effects of such constraints on the efficiency of rice. However the question also arises as to why upstream farmers block water for others and do not fear punishment/ reprisals/litigation etc; as well as why are. water-courses not properly maintained. The underlying causes may be the inadequate design and incentives within the current irrigation system, in which monitoring and maintenance activities are not checked upon. Hence these issues should also be investigated.

8.7.3 Policy Recommendations

The results of Sections 8.6. and 8.7 only present estimates regarding the productivity of factors in rice cropping. Previous ANOVA results provide evidence that farmers have diversified to horticultural crops and fodder (livestock) crops. Hence conclusions as to whether this change in crop mix changes the total productivity of the cropping system cannot be drawn. Additional research requires to be done as to how the decline in productivity shifts the cropping pattern between crops, and the extent to which total productivity increases.

8.8 Impact of Infrastructure

Closer access to the market and industrial towns affected the efficiency of rice output. Their effects are specifically tested for.

8.8.1 Impact of Market Town

Closer access to the market town is expected to impact rice productivity through two effects: (1) enhancement of the information-processing skills of farmers which increases their chances of learning new techniques and adopting new crops/technology; and (2) increase in total factor (revenue) productivity through changes in expected prices.

The alternative hypothesis was that closer access to the market town increases total factor productivity in the rice crop, as farmers use a given bundle of resources more efficiently and incur higher revenues and lower costs. Findings indicated that the null hypothesis that the market town did not affect the efficiency of input use in rice production, was rejected at the 90% level; access to the market town is systematically related to variation in output. However, the magnitude of variation could not be decomposed into the individual price and information-processing effects.

8.8.1 Impact of Industrial Town

The industrial town is included in the production function to validate the hypothesis that access to the industrial town does not directly affect the efficiency of resource use within the rice crop. But this hypothesis is ambiguous. Access to the industrial town increases profitability (and revenues) obtained from growing high-value labor-intensive cash crops including rice, thereby reinforcing the price effect exerted by close access to the market town. Results indicated that the null hypothesis is valid. Hence the differences in land-labor proportions which increased access is expected to encourage, appears to be captured by variable proportions in inputs estimated in the production function; leaving the efficiency of resource use within the rice crop production function unaffected.

A joint hypothesis was also tested for: increased access to both the industrial and market towns increases revenue-generated total productivity of rice. However, the null hypothesis regarding this combined price effect failed to be rejected at the 90% level of statistical significance. This result was unanticipated as the price effect was expected to be captured by both the market and industrial town indices. As the market town alone is statistically significant at the 90% level, the market town may have 'picked up' both market information and price effects. The industrial town does not seem to have captured such expected price effects.

8.8.2 Policy Recommendations and Future Research

Results regarding access to the market town corroborate its importance to farmers. They justify private and public investment in the setting up of secondary and linkage markets. Additional research may be warranted whereby both the price and 'access' effects of the market and industrial town indices may be more specifically modelled in a simultaneously determined system.

APPENDIX I

APPENDIX I: SURVEY INSTRUMENTS

I.A Village Profile: COMMERCIAL, ADMINISTRATIVE, INSTITUTIONAL & SOCIAL INFRASTRUCTURE IN THE RICE-WHEAT PRODUCTION ZONE OF PUNJAB, 1992.

(Filled in from **one or more knowledgeable farmers, numberdar or headman** of village).

i) Interviewer:______________________________ ii) Date ________________.

iii) Checked by:_____________________________ iv) Date ________________.

v) Village: Name:____.

vi) Tehsil: _________________________ vii) District ____________________.

viii) Mandi Affiliation_________________ ix) More/Less Accessible________.

x) Village Location (describe) ____.

xi) Chief Respondent: Name ____.

xii) Work ______________________. xiii) Social Status _______________.

xiv) Number of Households in Village ______________.

1. <u>GENERAL TRANSPORTATION METHODS</u>

1.1 a) Do you have GTS __________ Train _________ available in your village.

1.1 b) What type of private transport is available in your village

1. __________ 2. __________ 3. ____________.

1.2 A) What is the distance to the nearest bus-stop ____________ (kms).

(If distance is not zero, ask Question 1.2 B, regarding methods of transport and then for each method of transport ask Question 1.2 C) & D) about Time spent and Fare incurred and fill in the following **Table).**

1.2 B) Transport Type	________	________	________	________
1.2 C) Time Spent	________	________	________	________
1.2 D) Fare Incurred	________	________	________	________
1.2 E) Others(Specify)	________	________	________	________

2. **ACCESS TO ROADS, COMMERCIAL & OTHER FACILITIES**

2.1 (Ask Questions 2.1 column-wise with respect to each place and fill in the table).

Name of Place	Distance from vlge/bstop-kms (A)	Location (B)	Method of Transport (C)	One-way Fare/ trip(Rs) (D)	Freq/day (from_ to_) (E)	Time taken (F)
1) Near: Tehsil Town	______	______	______	______	______	______
2) Nearest Distrt Town	______	______	______	______	______	______
3) Nearest Mandi	______	______	______	______	______	______
4) Nearest Town	______	______	______	______	______	______
5) Nearest Indust Town	______	______	______	______	______	______
6) Union Council	______	______	______	______	______	______
7) Procurement Center	______	______	______	______	______	______
8) Seed-depot	______	______	______	______	______	______
9) Fertiliser depot	______	______	______	______	______	______
10) Rice-mill	______	______	______	______	______	______
11) Flour-mill	______	______	______	______	______	______
12) Agri Ext Official	______	______	______	______	______	______
13) Ag: Res: Instit:						
i) Faisalabad	______	______	______	______	______	______
ii) Kala Shah Kaku	______	______	______	______	______	______
14) Nearest Bank	______	______	______	______	______	______
15) Nearest Workshop	______	______	______	______	______	______
16) Nearest Main road	______	______				

Condition of Road (Write out correct answer): i) Pucca/kutcha/bricked ______ .
ii) Very Good, Good, Fair, Poor, V Poor ________.

17) Nearest link road	______	______				

Condition of Road (Write out correct answer): i) Pucca/kutcha/bricked ______,
ii) Very Good, Good, Fair, Poor, V Poor ________.

18) Railway Station	______	______	______	______	______	______
19) Public Call Office	______	______	______	______	______	______
20) Post Office	______	______	______	______	______	______
21) Boys Primary School	______	______	______	______	______	______
22) Boys Sec School	______	______	______	______	______	______
23) Girls Primary School	______	______	______	______	______	______
24) Girls Sec School	______	______	______	______	______	______
25) Police thana	______	______	______	______	______	______
26) Health Clinic	______	______	______	______	______	______
27) Social Welfare Cter	______	______	______	______	______	______
(Function:Handicraft/adult literacy//health ________)						
28) Veterinary Center	______	______	______	______	______	______
29) Water User's Assoc.	______	______	______	______	______	______
30) Other (specify)	______	______	______	______	______	______

4. IRRIGATION AND POWER

4.1 Do you have electricity in the village. Yes/no _____.

4.1 a) Since how long did you have it? (Years)_____.

4.2 What are the major sources of irrigation in the village.

A) Perennial Canal: _____ B) Seasonal Canal ___________.

C) Private Tubewells _____ i) Since when installed _______.

D) Government Tubewells (nos): ________ i) Date of Installation ____.

ii) If Yes to Govt tubewells, how many were operational during:

Rabi 91-92: ___. If nonoperational give reason _________________________.

Kharif - 92:Y/N ___. If nonoperational, give reason _____________________.

Did loadshedding occur during: Rabi 91-92: Y/N ___. Kharif -92: Y/N ___.

Months in Rabi _______________. Average no hrs daily __________.

Months in Kharif _______________. Average no hours daily ________.

4.3 What is the location of the village with respect to the water channel.

i) Head ___ ii) Middle ___ iii) Tail ____. Distance from Rajwa ____ kms.

4.4 Is the water-course pucca (=1) or kutcha (=2) ________.

4.5 Did you have any constraint in getting canal water during:

4.5.1 Rabi 91-92, Yes/No___. If yes, Reason: i)__________ii)___________.

4.5.2 Kharif 92, Yes/No ___. If yes, Reason: i)__________ii)___________.

4.5.3 If yes, in what months, on average, has your water been cut off, at critical times times during: i) Rabi 91-92___________________________.

ii) Kharif 92___________________________.

5. MACHINERY/TRANSPORT MODE/PRIVATE VEHICLES INVENTORY

5.1 What are the total number of the following machines/tubewells in the village:

i) Private tubewells	_____,	ii) Govt tubewells	_____,	iii) Tractors	_______,
iv) Threshers	_____,	v) Tractor trolleys	_____,		
vi) Donkey/mule-carts	_____,	vii) Bullock-carts	_____,		
viii) Self-propelled Combines	_____,	ix) Tractor-dr: Combine	_____,		
x) Reapers	_____,	xi) Wheat drills	_____,		
xii) Rotavator	_____,	xiii) Tractor plough	_____,		
xiv) Mouldboard Plough	_____,	xv) Private cars	_____,		
xvi) Disc Plough	_____	xvi) Others (Sp)	_____.		

5.2 What is the rate for the following machines:

A)	Tractor: Dry Ploughing-rate	______	Rs /ac.	**B)** Dry Planking-rate	____	Rs /ac.
C)	Wet Ploughing-rate	______	Rs /ac.	**D)** Wet Planking-rate	____	Rs /ac.
E)	Thresher Rate	______	Prod/ac.	**F)** Combine Rate	____	Rs /ac.
G)	Daily wage rate	______.				

6. COMMODITY TRANSPORTATION COSTS

6.1 (Ask Q 6.1 column-wise with regard to each commodity transported and fill in the following Table).

	Transport Mode Commonly-used						
	Bullock-carts	Rate /md	Donkey-cart	Rate/md	Tractor Trolley	Rate/ md	Other (Sp) rate/md
Seed		______	_____	_____	_______	_____	_____
Fertiliser		______	_____	_____	_______	_____	_____
Produce (Grain)		______	_____	_____	_______	_____	_____
(Straw)		______	_____	_____	_______	_____	_____

7. INPUT-OUTPUT DISPOSAL

Pricing/Marketing of Agricultural Produce

7.1 (Ask Question 7.1 for each output listed, with respect to the following Table).

VILLAGE PRICES

Crop Name/Season Harvest	Before Harvest	Harvest (May 15-June 15)	Before Harvest
Wheat (Rabi 91-92)			
Grain (Rs 40/kg)	__________	__________	
Straw (Rs /40 kg)	__________	__________	
Rice - (Kharif 92)			
Grain (Rs /40kg)	__________	__________	
Paddy (Rs /40kg)	__________	__________	
Straw (Rs/40 kg)	__________	__________	

7.2. (Ask Q 7.2 column-wise with respect to disposal of surplus of various crops and fill in the following Table).

Marketable Surplus of Crops in Village	Person/Agency to whom sold: Beopari	Arthi	V. Shop-keeper	Village Consumer	Others (Specify)
Rice Grain	_____	_____	_____	_____	_______
Rice Paddy	_____	_____	_____	_____	_______
Wheat Grain	_____	_____	_____	_____	_______
Wheat Bhoosa	_____	_____	_____	_____	_______
Milk	_____	_____	_____	_____	_______
Ghee	_____	_____	_____	_____	_______
Other Crop (sp)	_____	_____	_____	_____	_______

7.3 INPUT SUPPLY SYSTEM

7.3 (Ask Question 7.3 regarding inputs (Seed, Fertiliser and Pesticides used by villagers, with **respect to the following Table):**

INPUT USED (Cash/Credit)	**INPUT OBTAINED FROM:** Govt Depot	Beopari	Arthi	V. Shop-keeper	Other Agent	Cost (Specify)	Remarks (Rs/unit)
A) Wheat Seed	______	_____	_____	______	________	________	________
Rice Seed	______	_____	_____	______	________	________	________
B) Fertiliser							
1) Urea	______	_____	_____	______	________	________	________
2) DAP	______	_____	_____	______	________	________	________
3) FYM	______	_____	_____	______	________	________	________
4) Zinc	______	_____	_____	______	________	________	________
5) Other (Sp)	______	_____	_____	______	________	_________	________

7.3.1 From Rabi 91-92 to the present, did the villagers have a problem in obtaining:

1) Seed. Y/N __. If yes, Problem: Quantity _____ Quality _______.
Any Other ____.

2) Fertiliser Y/N __. If Y, Problem: Quantity _____ Quality _____.
Any Other______.

3) Pesticide Y/N ___. If Y, Problem: Quantity _____ Quality _____.

Any Other______.

8. LABOR CONSTRAINT.

8.1 Did farmers face any labor shortage for farm operations during

i) Rabi 1991-92 (Y/N) ___________ ii) Kharif 1992 (Y/N) _________.

8.2 Fill in the Table regarding labor operations with respect to labor used etc:

	LABOR USED (Family/exchange/contract/hired)	M/F/C[1]	WAGE/ACRE	REMARKS
Wheat: Harvesting				
a) Manual i) Cutting	____________________________	______	_________	___
ii) Threshing	____________________________	______	_________	___
Rice:				
a) Transplanting	____________________________	______	_________	___
b) Harvesting i) Cutting	____________________________	______	_________	___
ii) Thresher	____________________________	______	_________	___
Other Farming Operation in Village				
	____________________________	______	_________	___

8.3 Did **farmers** in the village do **seasonal off-farm work** during:
Rabi 91- 92, Y/N ___ and Kharif 92. Y/N ____.

8.3.1 If yes, Type of job:

1 ____________ Rate/day _________ Months available _________. Place______.

2.____________ Rate/day _________ Months available _________. Place______.

8.4 Is permanent off-farm work available in or nearby the village. Y/N___. If yes, what
type of job: 1.____________ Rate/mth___________ Place _________

---

[1] M=male, F=female, C=child

2.____________ Rate/mth __________ Place ________

3.____________ Rate/mth __________ Place ________

9. INPUT FINANCING

9.1 Did you borrow from the Bank. Y/N _____.

If so, from which bank _______________.

9.1.1 For what purpose: 1. ________ 2. ________ 3. ________.

9.2 Did you borrow from non-institutional sources. Y/N ______.

9.2.1 From which sources: 1. ________ 2. ________ 3. ________.

9.2.2 For what purpose: 1. ________ 2. ________ 3. ________.

10. EXTENSION AGENTS

10.1 Where is the nearest extension worker located _______________.

Is he EADA _____, A.O _____, F.A _____, Beldar _____. Others ______.

Which type of farmer does he visit ___________________________.

How often does he visit them _________________________.

11. RESEARCH LINKAGES

11.1 Is there any demonstration plot in or near the village. Y/N _____.

11.2 If yes, Crop - Wheat _____ (nos) Rice _____________(nos).

11.3 Do farmers visit the Research Station:

At KSK- rice Y/N _____. How often _________. Benefit Obtained ________.

At Faisalabad - wheat Y/N _____. How often _____. Benefit Obtained ______.

12. EDUCATION

12.1 Which of the following (in nos) are there in the village.

i) Male teachers ______, ii) Female teachers ______________,
iii) Govt Servants (Resident)______, iv) Matriculates ______________,
v) Graduates ______, vi) Agri Graduates ______________,
vii) Progressive Farmers ______, vii) Govt Servants (Non-resident) ______________.

I.B: Guidelines for Village Questionairre

Q. i & ii) The enumerator should write his name and fill in the date.

Q iii & iv) are to be filled by the supervisor.

Q v)-x) The information in these questions concern village name and other particulars. The enumerator should already know this information by the time he reaches the village, so that he can fill it in, easily. Question x) regarding village location fixes the location in his mind to prepare him for Question 2.

Questions xi) - xiii), regarding the name, work and social status of the farmer are the first questions he should ask and fill in.

1. GENERAL TRANSPORTATION METHODS

Q 1.1 i) The two types of commonly-available public (Govt) transport are already written down. Just mark down whichever type of transport is available in the village.

Q 1.1 ii) However for private transport, you have to ask about the the different types of private transport available and write down the answers (3 spaces are provided). Common types of transport are tonga, suzuki etc. Be sure to include ALL transport types used to reach the bus-stop, including walking or cycling.

Q 1.2 A) This question asks the distance to the nearest bus-stop.
Q 1.2 B)-D) Brief instructions are given in the brackets in order to fill in the given table. The specific questions to be asked are as follows.

1.2 B) By which **method of transport** do you reach the nearest general bus-stop.
1.2 C) How much **time** does it take to reach the nearest bus-stop.
1.2 D) What is the **fare** incurred.

Thus Q 1.2 B) logically follows from Q 1.2 A) by asking the different methods of transport used to reach the nearest bus-stop. Each method should be written down in one space in the first row.

Q 1.2 C)-D) Then for each mode of transport taken to get to this bus-stop, ask the time taken and the fare incurred to reach it, and fill in this information in the second, and third rows respectively. Repeat for each mode of transport.

If walking is a mode of transport, you **must** write it,. However, for cost or fare for walking, please write NA = Not Applicable.

Q 1.2 E) This fourth row is meant to note down any distinctive (or different) feature in the village. For example, if the bus-stop is not in this village, but in the next village, write down the name of that village.

Q 2.1 Read the 6 sub-questions which have to be answered with respect to each place. Each place corresponds to one row. When asking the questions, use the form given with respect to the nearest district town. For example:

A) How far is the bus-stop from the **nearest district town.**
B) **Name** the nearest district town.
C) By which **method of travel** do you get there.
D) What is the **one- way fare per trip.**
E) How **frequently** does this transport come and during what time of the day:
(from ___ to ___).
F) How much **time** does this transport take to reach the nearest district.

Q 2.1 A) The distances to certain places such as nearest mandi, industrial town, district town etc will be readily known to the farmer respondent. However, he may not remember (or know) the distance to such places as the Agricultural Research Institute (at Faisalabad), so easily, as this place may not linked to the village or the nearest town by a directly connecting road. The farmer will find out the distance by adding up the distance to intermediate connecting-points, or towns, and the enumerator and other respondents can help him in this exercise. The enumerator should also note down the steps involved in reaching those places which are reached in this roundabout fashion. Please use the space left at the bottom for such notes. Write down the Serial Number (S. No), and place so that the place can be correctly identified.

Q 2.1 B) Name of Location refers to the name of the town, in which the 'Place' is located. The 'Place' can be a seed-depot or other commercial facility or it can be district, or mandi town etc. If it is a road, please write the name of the road e.g G.T road, Warburton-Nankana road etc.

Q 2.1 C) If various 'methods of travel' or types of transport are taken to reach that destination, you should write them all out e.g: walk+bus+suzuki.

Q 2.1.E) Note down the frequency of each transport type but also write down the timing of the buses.

For example. 1) Every fifteen minutes (from 8 a.m til 10 p.m)
OR 2) 2 times a day (morning and afternoon).

Q 2.1 F) Write down the time taken in the same order in which the types of transport are written, for example if C) is walk+bus+suzuki.
Then the time taken (in hrs) may be: 1 + 1/3 + 1/2

Use easily-understood short forms such as: walk = w, tonga = t.

Q 2.1 14) Bank. Write down the name of the Bank e.g ADBP, NBP etc.
Q 2.1 16) & 17. Please be Careful here. Some villages connect directly to the main road, so the distance to the link road is not applicable=NA. Other villages may connect to the main road through a link road, passing through the village, so the distance to the link road is 0 kms.

Remember to fill in the sub-question: the distance the road is kutcha or pucca, if applicable.

Q 2.1 19) In 'Others (Specify)', write down any other

Q. 3 This question is similar to Question 2. 6 sub-questions again have to be answered, with respect to each service. Each service corresponds to one row, so that answers are filled in row-wise. Again, the form given in the example should be closely followed.

For example for service i):

A) Is there a P.C.O available in the village.
B) If not, where is it located.
C) At what distance from the village.
D) What type (or mode) of transport do you use to get there.
E) What is the fare per trip.
F) How much time does it take to get there.

Q 3. If the service is available in the village, then columns B) through E) should be marked NA = Not Applicable.

Only if the service is available outside the village, should questions B) through E) be asked, and columns B) through E) be filled in, in the table.

Q 3. 3), 6). If there is no masjid school for boys and /or girls, and respondents do not know where the next school is, you may write 'do not know'. However, try to obtain answers for all these services.

Q 3. 11) For the Social Welfare Center, note down what its function is, in the space provided directly underneath the question. The function can be simply handicrafts(=HC), adult literacy (= AL), or Health (= H), or any combination thereof (e.g HC/AL/H). Use only short forms for convenience.

Sometimes, in answering questions, the respondent tells you the time since a facility has been available. It is helpful to make a note of it. Please use the space left at the bottom for such notes. Write down the Serial Number (S. No), and 'name of service' so that the service can be correctly identified.

Q 4 The questions in this section are quite straightforward.

Q 4.2 Mark or tick the answers which apply.

Q 4.4 The water channel is the main nallah.

Q 4.5 A) & B) When answering the 2 sub-question regarding the percentage and distance of farms near to and far away from the rajwa, the farmer first tells you the location of the water-course(s) in the village. So please keep the shape and size (or the map) of the village in mind. You may draw a map of the village for the purpose.

Q 4.6, 4.7 Farmers particularly like to list their problems as asked in these question.

Q 5.1 regarding availability of different agricultural machinery and modes of transport has to be answered by the farmer counting all the numbers of available machinery etc, in the village. Under the heading, "Others", you may specify, more than one type of machinery or transportation method. Examples are bicycles and motor-cycles.

Q 5.2 Please write down the rates for the different machines.

Q 6 concerns the costs of transporting seed, fertiliser etc by 3 different methods. Tick or mark Yes against the concerned answer and write down the rate/bag.

Q 7.1 A Table question. The Before Harvest period specified denotes one month prior to harvest. During Harvest denotes the 2 weeks during and immediately following harvest.
First find out the before harvest prices for wheat and fill them in. Then do the same for rice.

Q 7.2 Write Y or tick the person or agency to whom the marketable surplus of each crop is sold. If the surplus is sold to any agency not listed, please list it under the heading of the last column (Others - Specify). Marketable surpplus of a crop not listed should be listed in the last row of the first column, against other crop.

Questions with respect to Fertiliser are listed in Q 7.3 below. The type of information requested includes the following:

a) Which type of fertilisers are available in the village?
b) Where are they available from?
c) How sure are you of their quality?

Q 7.3 This is another Table question. Please follow the following procedure:
First mark off the each input used by the villagers on wheat and rice.
Then ask the farmer, the source (or seller) of the fertiliser, and mark the relevant column.
If he obtains the fertiliser in cash fill in the space under the heading cash.
If he obtains the fertiliser in credit fill in the space under 'Credit'.
Any fertiliser not covered in this list should be specified under others.
Follow the same procedure for seed, each type of fertiliser and pesticides used by the villagers.

Q. 8.1 This question first asks whether people in the village, faced labor shortage during the 2 crop seasons.

Q 8.2 Then it asks which operations there was a shortage in, and what type of labor was used to overcome that shortage.
In writing down type of labor, please write all that apply.
E.g If Family and exchange labor are used, and they consist of Males and Females, write F+E and M+F.
Labor categories are defined as:
Hired labor - labor which is permanently or temporarily hired by the farmer.
Contract labor means labor which has been contracted only for the particular job.
Exchange labor is self-explanatory.
The term M/F/C is such that M = male F = female and C=child.

Q 8.3 asks if, kind of seasonal off-farm work available, where, rate, and months available.
If the answer to Q 8.3 is No, stop. If it is yes, continue.
Do likewise for Q 8.4.
In general, the months available for seasonal work are January to March for the Rabi crop.
Please note that in certain villages, farmers may not do seasonal off-farm work at all.

Q 8.4 asks if, where and kind of off-farm permanent work available to farmers.

I.C Farm-household Questionairre: AGRICULTURAL PRODUCTION IN THE RICE WHEAT PRODUCTION ZONE OF PUNJAB

Interviewer ____________________ Sample No ____________ Date ________

Checked By: ____________________ Date:________________.

1 IDENTIFICATION

Farmer's Name _______________. S/O _________________ Caste _______.

Farmer Category: Small/Large ___________. Village ______________ Tehsil_____.

2. CHARACTERISTICS OF FARMER AND FARM

2.1 Farmers Education: Years of Schooling ________, Age ________(yrs)

Involvement in farming: full-time _______, part-time _________ .

2.2 Main Source of Farm Income (rank highest 1,2,3, lowest).

i) crops _________ ii) livestock ______,

iii) fruit & vegetable production __________________.

v) Off-farm work _________ vi) Others _________.

Relative share of crop/off-farm income in total income:

Rice (%) _________ wheat (%) _________

Off-farm income (%) _________ other (%) _________

3 Farm Area

3.1 Farm Size (ac): Owned _______ plus Rented-in _______ less Rented-Out_______,

Operational Holding _______.

4 Tenancy Terms:

4.1 Tenancy: Owner ______ , Share tenant _______, Lease tenant _______,

owner cum share tenant ______, owner cum lease tenant _______.

4.2 Terms of Share Tenancy:

Percent share of Output: Rice-92: Grain________% Residues________%

Wheat-91-92: Grain________% Residues________%

4.2.1 Percent Share of Inputs:

Rice-92: Seed_____ Fert_____ Irr_____ Ps _____ Pl_____ Other_____.

Wheat-91-92: Seed_____ Fert_____ Irr_____ Ps _____ Pl_____ Other____.

4.3 Rent or Lease (Rs or prod/ac): Rabi-91-92 ______, Kharif-92_____, Annual_____.

5. FARM LOCATION

5.1 Distance of farm from the i) village ________ km ii) pucca road _______ km

iii) mandi ________ km

6. FARM TRANSPORTATION (nos)

Bullock-cart _______ (nos) Donkey/mule-cart ________ (nos)

Tractor trolley _______ (nos) Motorcycle ________ (nos)

Motor car _______ (nos). Others ________.

7. Farm Implements (nos)

Wheat Seed drill____ Spray-Pump ____ Mouldboard Ploug___
Ridger ____ Thresher ____ Combine ___
Rotavator ____ Cultivator ____ Bullock-plough ___
Disc Plough ____ Fodder chopper: Bullocks ____ Hand ____ Electric ____. Other(specify) ____.

8 Family Size and Education

Total Family size______ nos, Adult: Male____ nos, Educated_____nos
Female ______ nos, Educated _____ nos.
Children: Male Nos _____, Class _____, _____, _____, _____, Non-schoolgoing _____.
Female Nos _____, Class _____, _____, _____, _____, Non-school-going_____.

9. Farm Labour

9.1 Family Labour: Full Time _____ nos, Part Time_____nos,
Permanent Hired Labour _____ nos.

9.2 Wages Grain: Rice _____ mds, Wheat _____ mds.
Cash _____ Rs. Other _____ /Yr.

9.3 Constraints in getting Permanent Hired Labour: 1 _______ 2 _______ 3 ______.

9.4 Family Adult Labor Activity

	S.No	Working			Not working	Others	
		On-Farm	Off-Farm	Both	(student/aged)	Student+farmwork	
Male.	1	____	______	____	_______	_______	_____
	2	____	______	____	_______	_______	_____
Female	1	____	______	____	_______	_______	_____
	2	____	______	____	______	_______	_____

FARM CHARACTERISTICS

10. Power Source:

10.1 Bullock _____ Tractor _______ Bullock & Tractor _______
10.2. If tractor, is it owned ____ or hired_____,
10.3 Horsepower _____ Year of purchase_____, Type _______.

11. IRRIGATION SOURCE

11.1 Major source of irrigation
Canal _____ T.well _______ Canal & Tubewell _____.
Tubewell (nos): Owned_____, Hired _______ Share (%) ______ Gov't ______, Landlord ______.
If owned, Installation Year _____, Water outlet size _____ inches,
Diesel (Tractor-driven) _____, Diesel (Engine-driven) _____, or Electrified_______.
Canal: perennial _____ or seasonal ____ .

11.2 Where does the farm lie with respect to the rajwa. Head / Middle /Tail_____.

11.3 Are you satisfied with existing irrigation sources for:
Quantity _____(Y/N). If not, Months with shortage _________________________.
Reasons i) _________ ii) ________________
Quality _____(Y/N). If not, reasons: 1 ____________ 2 ___________________.

12 Livestock Composition (nos):

Buff. Milk______ Buff. Dry______ Buff.Y stock (M)_____ B.Young(F)_______

Cow Milk ______ Cow Dry ______ Cow. Y Stock (M)_____ C.Young(F)_______

Sheep ______ Goat ______ Horse _____ Donkey _______

Poultry ______

13 Land Type (with respect to Operational Holding):

Total Parcels according to land type _______ nos.

Land Types of parcel: 1 ______ 2 __________ 3 _________ 4 __________
Code: Halki Mera=1, Dermaini Mera=2, Bhari Mera=3, Clayee=4, W.logged=5, Saline=6.

Parcel Size (ac): 1 ______ 2 __________ 3 _________ 4 __________

Distance from Road: 1 ______ 2 __________ 3 _________ 4 __________

Cropping Pattern: 1 ______ 2 __________ 3 _________ 4 __________
or Rotation:

14 CROPPING PATTERN (with respect to Operational Holding)

14.1 Which crops did you grow during last two seasons.

RABI 91/92			KHARIF -91			
CROP	AREA (acres)	GR PROD or YLD/AC (maunds)	CROP		AREA (acres)	GR PROD [or if not YLD/AC] (maunds)
Wheat	_______	_______	Rice	_____	_______	_____
Rapeseed & mustd	_______	_______	Maize	_____	_______	_____
Sunflower	_______	_______	Sorghum	_____	_______	_____
Vegetables	_______	_______	Millet	_____	_______	_____
Gram	_______	_______	Sesamum	_____	_______	_____
Lentils	_______	_______	Mongbean	_____	_______	_____
Berseem	_______	_______	S. Cane	_____	_______	_____
Vegetables	_______	_______	Other Crop (Sp)		_______	_____
Other Crop (specify)	____	_______	Fallow	_____	_______	_____

Reason for Fallowing:
1 ____________(ac)
2 ____________(ac)
3 ____________(ac)

Reason for Fallowing:
1 ____________(ac)
2 ____________(ac)

15 RICE-WHEAT VARIETIES

Rice: Varieties Name: 1. __________ 2__________ 3____________
Area (ac): 1. __________ 2__________ 3____________
Production 1. __________ 2__________ 3____________

Wheat: Variety's Name: 1. __________ 2__________ 3____________
Area (ac): 1. __________ 2__________ 3____________
Production: 1. __________ 2__________ 3____________

16. RICE-WHEAT PRODUCTION PRACTICES	**Wheat-91-92**	**Rice-K-92**
RICE - NURSERY RAISING		
Total area (Kanal/Merla)	__________	__________
Nursery Planting Date	__________	__________
Seed Rate (kgs/kanal/merla)	__________	__________
Seed Source (Possible answers: own, fellow farmer, Research(KSK), Arthi, seed depot)	__________	__________
Seed Treatment (Y/N)	__________	__________
Chemical Name	__________	__________
Chemical Cost	__________	__________

Dry Ploughing (nos)	________	________
Dry Planking (nos)	________	________
Wet Ploughing (nos)	________	________
Wet Planking (nos)	________	________
FYM (cart/donkey/trolley-load/ac)	________	________
Total Irrigations (nos)	________	________
Nursery Treatment due to insects/pests (Yes=1, No=2)	________	________
If Yes, Chemical Name	________	________
Chemical cost (Rs./unit area)	________	________
Fertilizer Application Quantity/Type	________	________

LAND PREPARATION-RICE AND WHEAT

Dry ploughing days (nos/ac.)	B____T____	B____T____
Rate (Rs/ac)	________	________
Dry Planking (nos)	B____T____	B____T____
Rate (Rs/ac)	________	________
Wet Ploughing (nos/ac)	B____T____	B____T____
Rate (Rs/ac)	________	________
Wet Planking (nos/ac)	B____T____	B____T____
Rate (Rs/ac)	________	________
Other Operation (Specify)	________	________
-- Cost (Rs/ac)	________	________

RICE NURSERY TRANSPLANTING

Uprooted area (merla/ac) ________

Nursery Removal Labor (Family/hired/contract/exchange) ________
If family/or exchange, Uprooting time Mandays/ac(& manhrs/day ________
If hired/or contract labor, Uprooting wages (Rs/ac) ________
Nursery Transplanting labour (Family/hired/contract/exchange) ________
If family/or exchange, Transplanting time (Mandays/ac(& manhrs/day ________
If hired/or contract labor, Uprooting wages (Rs/ac) ________

Wheat-91-92 Rice-92

WHEAT PLANTING

Seed rate (kgs/ac)
Seed Price (Rs/40kg)
Seed Source
(Answers: own, fellow farmer, Research St, Arthi, seed depot)
Transportation cost (Rs/40kg).
Sowing Date

FERTILISER APPLICATION

Fertiliser: Source (agent)
Basal Dose (bags/acre): Urea
DAP
NP
SSP
Other (sp)
Price/bag of encircled Fertiliser Type:
Urea/DAP/NP/SSP

Top Dose (Bags/acre):Urea
DAP
NP
SSP
Other (sp)
Price/bag of encircled Fertiliser Type:
Urea/DAP/NP/SSP

Broadcost time (manhours/ac)

Number top doses applied
Transport Cost/bag

Zinc Application

No of acres applied. (ac)
Dose (nos of bags/ac)
Price/bag
Source (=seed sources + following sources:

FYM APPLICATION

Number of acres applied (nos)
Labor-type (Family/hired/contract/exchange)
Quantity applied (nos of carts/Trolley)
If own/exchange labor, loading/Unloading (mhrs/tr)
If hired/contract, Rate (Rs/trolley or Cart)
Spreading Time (Manhours/acre)
FYM Prices (Rs/trolley)

WEEDING Management

Level of weed infestation
(none, little, moderate, severe)
Weeding Method (none, Manual, Chemical, Mechanical)
Area Covered by each method (Manl/Mech/Cheml)
If Manual/Mech Weeding (manhours/ac)
If Chemical: Name
Cost (Rs/ac)
Type of labor used (Family/hired/exchange)

Insect Pest Management (if applicable)

Insecticide Name ____ ____

Source (Village-shop, Arthi, mandi-shop, depot, Other) ____ ____

Cost (Rs/ac) ____ ____

Application labour time (manhours/ac) ____ ____

Spray machine (owned=1, hired=2) ____ ____

If hired, Machine hiring rate (Rs/ac) ____ ____

Rice and Wheat Rodent Management Wheat-91-92 Rice-92

Damage caused by rats (mds/ac) ____ ____

Method used for rodent control

Code: Traps=1, Watering=2, Smoking=3, Manual=4, Poison=5, Prayer, Cat? ____ ____

Cost Incurred (Rs/ac) ____ ____

Irrigation Management

Total number of irrigation ____ ____

Irrigation Time (hours/ac) ____ ____

If applicable, Rental Tubewell water rate (Rs/hr) ____ ____

Irrigation constraints 1____ 2____

1____ 2____

Rice and Wheat Harvesting/ Threshing

Harvesting starting (Month/Week 1 2 3 4) ____ ____

Harvesting ended (days after harvest start) ____ ____

Area Harvested by:

Combine (ac) ____ ____

Combine (rate/acre) ____ ____

Manual (ac) ____ ____

Harvesting Labour (Own, Exchange, Hired) ____ ____

If own, number of mandays worked ____ ____

If hired or contract, harvesting wages/acre

Wheat Threshing Labour (Own, Exchange, Hired) ____ ____

If own, number of mandays worked ____ ____

If hired or contract, threshing wages/acre ____ ____

Consumption of Produce ____ ____

Marketing Agent used ____ ____

(a=arthi, b=beopari, vs=village shop, others(sp))

Transport Cost incurred/mode of transport ____ ____

Variety/Price/md ____/____ ____/____

Variety/Price/md: ____/____ ____/____

Variety-Wise Quantity sold ____/____ ____/____

Variety-wise Qauntity sold ____/____ ____/____

Straw (Rs/acre) ____ ____

(indicate whether sold)

Marketing: Commission ____ ____

Octroi ____ ____

Others ____ ____

Major Marketing Constraints: 1 ____ 1 ____

Major Transportation Constraints: 1 ____ 1 ____

2 ____ 2 ____

Agricultural Credit

1. Did you need agricultural credit during: Rabi 1991-92 Yes/No ____
   Kharif-92, Yes/No ____
2. Medium-term loan needed: Y/N____, obtained ____.

Purpose of loan (A) **Source (B)** **Terms of Repayment (C1):Cash/kind** **Interest Rate (C2):Time intervals**

Constraints faced in obtaining loan.

Appendix II

APPENDIX II CLUSTER ANALYSIS

Table II.A Rank and Cluster Attributes of Distance to Market/Industrial Towns for 28 Sample Villages by Ward's Method

Rank and Cluster Attributes of

INDUSTRIAL TOWN

Cluster Number	Frequency Value within Rank	Rank	Village Number	Distance (kms)	Cluster	Frequency of Rank	Rank	Number Ranking	Ranking
1	1	1	15.0	2.0	1	1	1	11.0	7.00
1	2	2	1.0	3.00	1	1	2	4.0	8.00
1	2	2	11.0	3.00	1	1	3	12.0	9.00
2	2	4	9.0	5.00	2	2	4	3.0	10.00
2	2	4	21.0	5.00	2	2	4	18.0	10.00
2	4	6	5.0	6.00	2	2	6	20.0	12.00
2	4	6	13.0	6.00	2	2	6	26.0	12.00
2	4	6	14.0	6.00	2	1	8	10.0	15.00
3	4	6	27.0	6.00	3	1	9	24.0	20.00
3	1	10	4.0	8.00	3	1	10	9.0	21.00
3	6	11	12.0	9.00	3	1	11	5.0	23.00
3	3	12	2.0	10.00	3	1	12	15.0	24.00
3	3	12	3.0	10.00	3	1	13	14.0	28.00
3	3	12	18.0	10.00	3	1	14	23.0	31.00
4	1	15	25.0	11.50	4	1	15	6.0	32.00
4	4	16	8.0	12.00	4	1	16	13.0	35.00
5	4	16	19.0	12.00	5	1	17	7.0	36.00
5	4	16	20.0	12.00	5	2	18	27.0	40.00
5	4	16	26.0	12.00	5	2	18	28.0	40.00
6	1	20	10.0	15.00	6	1	20	22.0	43.00
6	1	21	6.0	16.00	6	1	21	2.0	52.00
6	2	22	16.0	17.00	6	1	22	21.0	55.00
6	2	22	23.0	17.00	6	1	23	1.0	58.00
6	1	24	22.0	18.00	6	2	24	8.0	68.00
7	2	25	24.0	20.00	7	2	24	19.0	68.00
7	2	25	28.0	20.00	7	1	26	16.0	70.00
7	1	27	7.0	21.00	7	1	27	17.0	83.00
8	1	28	17.0	37.00	8	1	28	25.0	111.50

Table II.B Clustering Distance to Market/Industrial Towns for 28 Sample Villages by Ward's Method

	Distance to Market Town								Distance to Industrial Town							
Cluster Nos	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8	No 1	No 2	No 3	No 4	No 5	No 6	No 7	No 8
3	10	8	1						8	12	8					
4	9	10	8	1					7	12	8	1				
5	9	10	5	3	1				3	12	8	4	1			
6	3	10	6	5	3	1			3	8	4	8	4	1		
7	3	5	6	5	3	5	1		3	8	4	8	3	1	1	
8	3	5	6	2	3	5	3	1	3	8	4	5	3	1	3	1

II.A Cluster Techniques

The differing numbers of clusters into which the hierarchical and non-hierarchichal (seed) clustering methods divided up the villages were examined. The objective was to determine whether the villages were grouped in a meaningful fashion, such that different clusters of villages represented different levels of infrastructure and the number of clusters best illustrated varying levels of infrastructure for the data set.

II.B Clustering Methods

There are five hierarchical methods which use Euclidean distance, available in SPSS. They consist of two types of average linkage methods, Ward, centroid and median methods. The average linkage between groups method (known as BAVERAGE in SPSS) defines the distance between clusters as the average of the distances between all pairs of cases in which each member of the pair is from each of the clusters. The WAVERAGE method, known as the average linkage within groups (and a variant of BAVERAGE), combines clusters in such a way that the average distance between all cases in the resulting cluster (i.e within-cluster variation) is as small as possible.

Ward's method uses actual distances (or sum of squares) of variables to maximize between-cluster variability while minimizing within-cluster variability. At each stage of clustering, within-cluster sum-of-squares is minimized over all partitions obtainable by combining two clusters from the previous stage.

The centroid method measures the distance between two clusters as the Euclidean distance between the means. A new centroid or mean is computed every time a new individual or group of individuals is added to an existing cluster. The median method is a variant of the centroid method, in which the two clusters being combined are weighted equally in the computation of the centroid regardless of the number of cases in each cluster.

The non-hierarchical clustering procedure is represented in SPSS by the the QUICK CLUSTER procedure which selects seed points randomly from all the observations, and clusters them according to initial cluster centers, which it then updates.

Clustering Method Used

The different hierarchical clustering methods were first used on the variable, distance to the bus-stop (the first key indicator). In using the clustering process, it was essential to recognize that the variable (distance to bus-stop) followed a left-sided and bi-modal statistical distribution, with extreme values located at the tail-end. Hence, normalized values needed to be used for final clustering.

The BAVERAGE method (average linkage between groups) was initially used as it was the default method. Results obtained are explained descriptively. BAVERAGE was able to separate out the nine villages with highest access to the bus-stop (which had zero unweighted distances) into a separate (first) category by means of five clusters. However, the weighted distances of these villages separated to form the first cluster only by further sub-division into six clusters. BAVERAGE also consistently separated out the least inaccessible four villages (nos 7,17,22, and 28), or those furthest away from the bus-stop, into the furthermost categories depending on the number of clusters. With a grouping of five clusters, these villages remain in clusters three to five; but with a larger sub-division (into eight clusters), they form clusters five through eight. These groupings are not totally satisfactory. While village 28 is clearly an outlier, villages 7, 17 and 22 consist of extreme values (defined as values three standard deviations away from the mean), and need to be placed in the group of least accessible villages). Moreover, the BAVERAGE method was unable to separate the middle block of villages into sub-groups because it uses the average distances of variables to minimize information between groups.

Unfortunately, experimentation with the Centroid and Median methods yielded similar or more obscure results than those obtained from the BAVERAGE method.

Hence the WAVERAGE method (average linkage within groups) which minimizes average Euclidean distance within clusters was utilized. After successive clustering, the WAVERAGE method proceeded to separate the last four villages into clusters six, seven and eight, so that extreme values are in cluster six, while outliers are in clusters seven and eight (this is not so clear for cluster seven). However, it was unable to separate out differences among the middle block of villages even when the number of clusters was successively increased from three to eight. The WAVERAGE method still has the drawback that it uses maximizes average instead of actual distances as part of its clustering algorithm.

Only Ward's method was able to distinguish between the various categories of high, medium and lower level of infrastructure among the middle block of villages. This method classified the twelve to fifteen middle block of villages (at least 50% of the sample) into two, three or four clusters, depending on whether the number of clusters was five, six or seven. With normalized (or weighted) distances, the middle block of villages are divided into two, three, four or five clusters out of a total number of eight clusters. Thus, the villages in clusters two, three and four can be interpreted to have high, medium and lower medium levels of infrastructure, while cluster five (together with cluster six) includes lesser accessible villages. Clusters seven and eight include outliers. However, as there are only two villages in cluster four, they are paired with cluster five and six (each having three and one villages), and if necessary the last two clusters namely, seven and eight (which have outlying values), to form the least accessible villages.

Ward's method was able to yield the best results because it uses actual distances (or sum of squares) of variables to maximize both between cluster variability and minimize within-cluster variability. Ward's method, biased to form clusters with a small and uniform number of observations within each cluster, appears to be best suited to this data set.

In comparision with the non-hierarchichal seed clustering procedure, the categorical distinctions in Ward's method were more clear-cut, particularly regarding the middle block of villages. Hence this method was chosen.

II.C Village Profiles

'Kot Lahndas' (Village 1)

Introduction

The first two villages sampled are centered around Nankana Sahib (NNS), a large market-town and the (administrative) tehsil head-quarters. The town is a cultural center with a temple (the largest in Pakistan) founded by the founder of the Sikhs and is a place of pilgrimage for Sikhs. It has a population of 300,000. However, Nankana tehsil in general, is a fairly sparsely-populated area.

Access to Infrastructural Services

Kot Lahndas is urban-based, located 3 kms south-west of Nankana Sahib. It compares favorably with other villages regarding its access to infrastructural services.

As one of six villages located on a main road (district road), K. Lahndas also has a bus-stop in the village, a key indicator of accessibility to transport services. Transport does not appear to be a problem in this village. Commercial forms of transport used to reach NNS include both buses and horse-carts. Fifty percent of households also own a bicycle.

Kot Lahndas has the third nearest marketing center and light engineering workshop for agricultural machinery, with the nearest input distribution center for seed and fertiliser within the sample. The village ranks seventh in its access to the bank, and eleventh in access to veterinary services.

Kot Lahndas has quite good access to most administrative services. While the village is 58 kms away from the district town (compared to the sample average of 58 kms), it is also closest in proximity to the tehsil town (also NNS) among all 28 villages.

But the village is located further away from the Union Council, at the median[1] distance of 6 kms. It has the highest village access to the police post, 3 kms distant.

Both types of communications infrastructrure i.e telephone and Post Office are located at a distance of half a kilometer in the adjoining village.

K. Lahndas is among the majority of villages which have a primary school for both girls and boys within the village. It has the median distance to the boys secondary schools. It ranks eighth in access to the girls secondary school, and has the median distance to health services, all of which are 3 kms distant.

Electricity and Irrigation

The village was electrified ten years ago. but electricity is turned off regularly (known as load-shedding) during the critical months of June (for summer crops) and December (for winter crops). Although the village is located 2 kms from the head of the water-course, larger farmers located upstream[2] block the water for downstream farmers during those rabi and kharif months in which they face a shortage (generally June and December). Although the Government tubewell available in the village was installed in 1968, it is presently non-functional. The machinery is very old and the motor is burnt. Furthermore, the local irrigation officials do not co-operate with the villagers in order to repair the Government tubewell.

Agriculture

Wheat and rice grains, paddy, vegetables and chilles are the main crops. They are sold to the commission agent in NNS. Farmers themselves appeared to have good information about market prices, which approximate the prices in NNS. Input

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[1] Many infrastructural services such as educational and health services are provided on a universal basis by the Government. Other agricultural support services such as veterinary and extension services, were also found to be available on a decentralized basis, as this is an agricultural area. Sometimes even outlying areas had good access to these services. Thus the appropriate statistic to measure such access was found to be the median, which was generally less than the mean. In such circumstances the median , which was often less than the mean. On the other hand, commercial infrastructural facilities were normally concentrated in areas of high population densities. Generally the access of any one village to infrastructural services depended on the spatial location of the village relative to such areas (unless a village itself had high population density). For such infrastructural services the appropriate statistic for comparison across villages is the mean (refer to Chapter 4.3.2.D).

[2] 'Larger' farmers are perceived as farmers who have more land and more local social and political consequence.

dealers located at the nearby market in NNS, travel to the village to buy milk and wheat straw.

There is often shortage of fertiliser, so that farmers have to pay higher prices than Government fixed prices. Pesticide prices were also percieved to be higher than those fixed by the Government. Both fertilizer and pesticides were often adulterated.

There was no labor shortage during periods of high demand for critical crop operations.

Technology

Most of the farmers in the village appear to be small farmers. At first glance, the level of technology in the village did not appear to be very high because there are only five tractors and as many private tubewells. However, there is an active rental market for wheat and rice ploughing. Rental rates appear quite modest. Some harvesting operations also appear to be mechanised e.g wheat threshing. Donkey and mule-carts (totalling 15 in number), form the main form of transport for produce, along with five tractor-trolleys.

The extension agent, 3 kms distant, visits progressive farmers in the village, fairly regularly, twice a month[3]. The Rice and Wheat Research Institutes are nearly equi-distant from the village (at 70 kms to 88 kms away). Farmers do not visit these Research Institutes[4] at all.

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[3] While this conforms with standard operating procedures currently followed by the extension services, such procedures are not followed in all villages.

[4] Very few farmers in the sample villages visited the Research Institutes. Hence mention will be made of them, only in those villages in which farmers visited the Institutes.

'Ladhuana' (Village 2)

Access to Infrastructural Services

Ladhuana is located 10 kms due east of NNS, to the north-east of Kot Lahndas. The village has a population of 245 households.

While both villages derive many infrastructural services from NNS, Ladhuana has lower access to many services than Kot Lahndas. The main road is one kilmeter away from Ladhuana. It takes ten minutes to reach the bus-stop there, and an additional ten minutes to reach NNS by bus and horse-cart. Private transport consists of 35 bicycles.

Ladhuana has the median distances to the agricultural marketing center, input distribution centers for seed and fertiliser, and the light engineering work-shop for agricultural machinery. However, banking services (also 10kms distant) are relatively further away with 60% of the villages having nearer access to this source.

Ladhuana ranks fifth in access to the tehsil town (NNS) in the sample. The village also ranks tenth in distance both to the district town and the Union Council. However it takes one and and one-half hours to reach the Union Council because it is only accessible on foot. Ladhuana has the median distance to the police post.

The village ranks fourth from the bottom in its access to veterinary services located in NNS.

Ladhuana ranks sixth and tenth in access to the Wheat and Rice Research Institutes, 70 kms and 88 kms distant.

The village is one of nine which have postal services. It ranks sixteenth in access to telephone services.

Ladhuana has primary schooling for both sexes. It ranks twentieth and sixteenth in access to the boys' and girls secondary schools. Both educational services are 10 kms distant compared to their respective median distances of 3 kms and 6 kms respectively. Ladhuana is among the top 33% of sample villages in its access to the girls' secondary school, but it ranks among the bottom in access to health services.

Electricity and Irrigation

Electricity in the village is turned off for three to four hours regularly for six months. The three Government tubewells available in the village are out-of-order.

The village is located 2 kms from the middle of the water-course. However, in actuality, it has no access to irrigation at all. It is not only further away from canal irrigation sources than K. Lahndas, but larger farmers in the area have succeeded in blocking the water for other farmers for the past four years. The three Government tubewells available in the village are out-of-order.

Agriculture

Wheat grain and fodder, and berseem fodder are the main crops. The input dealer[5] sells grain, milk, clarified butter and fodders including wheat fodder. Farmers do have to pay higher seed and fertilizer prices than the price fixed by the Government. Fertilizer was often adulterated.

A type of contract labor (known as 'changar'labor[6]) appears to be used with regard to wheat and rice harvesting operations. There is no labor shortage during periods of high demand for critical crop operations.

Technology

Villagers reported only two progressive farmers and a low level of improved technology in the village: two each of tractors and threshers. However, these figures do not describe grass-roots institutional development. Ten progressively-inclined farmers in the village have formed a Committee and meet weekly with the extension agent to discuss agricultural problems and exchange information. The extension agent who lives in the village has also planted rice and wheat demonstration plots there.

There is also a rental market for wheat and rice ploughing, and threshing, which (in common with K.Lahndas) has rather modest rental rates. Some harvesting operations also appear to be mechanised e.g wheat threshing[7].

Two tractor-trolleys, ten horse and six mule-carts are the main forms of transport for produce.

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[5] The input dealer who in this village comes from NNS (but in some cases is from the village) picks up the crop directly from farmers' fields, thereby saving them marketing costs (cost of transport, fees of the commission agent etc).

[6] 'Changar' labor consists both of landless and other non-farming labor such as artisans etc. Normally the whole family works and gets paid on a piece-rate basis.

[7] The rental market for tractors, may be located fairly near, in the adjoining villages, or near the work-shop for repairing machinery, located 10 kms away.

'Kothiala Virkan' (Village 3)

Access to Infrastructural Facilities

Kothiala Virkan is located 2 kms off of the Muridke-Sheikhupura road west north-west of Muridke, a large market town and industrial metropolis, second only to Gujranwala. K. Virkan derives a number of services from within the village because of its comparatively large population of 4936 people living in an average household size of 6.4 people,

The road to the bus-stop, located two kilmeters away, is quite bumpy. It can be reached by walking in twenty-five minutes, and by horse-cart in fifteen minutes. Muridke is eight kms further away. Twenty horse-carriages provide commercial transport. There are also approximately twenty bicycles in the village.

K. Virkan has good access to two of three administrative services. It is among the lowest 25% of sample villages regarding access to the tehsil town, Ferozewala, but ranks sixth in access to the district headquarters, Sheikhupura located 28 kms away. This village, one of nine with a Union Council, has the median distance of 10 kms to a police post.

K. Virkan has the sample median distance to the nearest agricultural market, input distribution center for seed and fertiliser and the light engineering work-shop for agricultural machinery. However, the village ranks among the lower 40% of the sample in its (comparatively poorer) access to banking services. It is also one of five villages having a veterinary center.

Likewise the village is one of nine with postal services. However, telephone services are located in Muridke, 10 kms away with only 42% of the sample villages located further away.

K. Virkan does have primary schooling services for both sexes. It is one of only two villages to have a boys' secondary school. Village access to the girls' secondary school, 16 kms away is higher than the median of 10 kms. Health services are available within this village (as in five other villages).

Electricity and Irrigation

The village has been electrified for 20 years. K. Virkan is 10 kms short of the tail-end of the water-course, and only half of the village has access to canal-water. Canal-water is cut off during June and July. About 25 privately-owned tubewells make up for the lack of water.

Agriculture

Wheat grain, wheat fodder and other fodders, namely: berseem, gram and oats are the main crops grown in the village (in order of importance). About 60% of wheat grain is taken to the market but berseem and the other fodders are not traded. However, milk is the sixth most important marketable crop, indicating that integrated cattle farming is important.

The input dealer trades in milk and some paddy, as well as other crops for smaller farmers. The commission agent trades in wheat grain, and vegetables (potatoes and peas). The larger farmers prefer to use the services of the commission agent. The village shopkeeper deals in wheat straw and paddy. Wheat grain is used as a medium of exchange both by the villagers and the shop-keeper in mutual transactions.

Farmers use their own rice and wheat seed. Although they are aware of the prices of fresh seed, they consider it to be expensive and of poor and 'weak' quality. Private dealers charge higher prices (than Government-fixed prices), only for fertilizer sold on credit. Fertilizer and to a greater extent, pesticides are often adulterated.

Technology

There are eight progressive farmers in the village with a commensurate level of technology: eight tractors, threshers and tractor-trolleys. The extension agent located in Muridke, appears to visit only the (progressively-inclined) farmers in the village. While some farmers appeared to be unaware of the agents visits to the village, the extension agency has planted rice and wheat demonstration plots in the village indicating a certain amount of activity.

Some farmers visit the Rice Research Institute, to obtain rice seed in April. While the village ranks third in access to this facility, an agricultural graduate from Kothiala Virkan also works there. However, farmers do not visit the Wheat Research Institute 127 kms distant.

There is a rental market for wheat and rice tillage and wheat threshing. Twenty donkey-carts, 100 mule-carts and eight tractor-trolleys are the main form of transport for produce.

'Kohri' (Village 4)

Access to Infrastructural Services

Kohri is centered around Muridke market, 8 kms distant. It is also one of six villages located on a main road, and the only village located on a major highway: namely, the main Grand Trunk road connecting Lahore to Rawalpindi. The village is small consisting of 325 households.

Kohri obtains most of its infrastructural services from Muridke. Muridke is nine kilometers away and takes as many minutes to reach by bus due to the short distance involved. Buses appear to be the major form of transport.

Kohri ranks tenth in distance to the marketing town and input distribution centers for seed and fertiliser and thirteenth in such access to the light engineering work-shop.

The bank is comparatively further away. Kohri lies within the lower 40% of sample villages in access to credit services.

Kohri has only average or poor access to Government administrative services. The distance to the district town 58 kms away, is slightly greater than the sample mean of 54 kms. Kohri ranks twelfth in distance to Ferozewala, 28 kms away. Kohri is in the bottom 25% of sample villages regarding distance to the Union Council, 6 kms distant, although the U.C is easily accessible by wagon (0.5 hours) and walking (0.75 hours). Kohri ranks eight in its access to the police post.

The village is also within the bottom 25% of the sample regarding its comparative access to the veterinary center.

The village has its own post office. Telephone services are located 8 kms away, greater than the median of 6 kms.

Kohri has primary schooling services for both sexes. It ranks third in its access to the boys' secondary school 2 kms distant, but fifteenth in its access to the girls' secondary school, 8 kms away. Access to health services also 8 kms distant is much higher than the median of 3 kms.

Electricity and Irrigation

The village has been electrified for 19 years. Due to its location within an industrial area, Kohri benefits from uninterrupted electric supply. Electricity is only turned off for one hour every day during December or January. There are four Government tubewells in the village, all of which are operational. However, the village is located 2 kms from the tail end of the water-course. As canal water is seasonal in nature, villagers experience water shortage during February and March.

Agriculture

Wheat grain and fodder, rice paddy, and milk are the main crops. The commission agent is the main marketing agent for all crops, except wheat straw which villagers exchange among themselves.

Farmers perceive that prices of fertilizer and pesticides are high. A greater problem is that, fertilizer and to a greater extent, pesticides are often adulterated.

Technology

There are twenty progressive farmers in the village but the level of improved technology in the village is not commensurate with this number, namely; eleven tractors and five threshers. There were four bullock-ploughs in use in the village.

Although the extension agent is located in Muridke, (and Kohri lies among the bottom third of sample villages regarding access to extension services), he visits the (progressively-inclined) farmers as well as some selected others, in the village. The extension agency has also planted rice and wheat demonstration plots.

Kohri is the second nearest village to the Rice Research Institute. Farmers in this village actually travel both to the Wheat and Rice Research Centers (113 kms and (15 kms) distant, in order to obtain seeds for wheat and rice respectively.

The rental market for farm operations is very similar to K. Virkan. There is a rental market for wheat and rice ploughing and planking. Wheat and rice threshing appear to be mostly done by hand, although combine harvesting is available.

There are a total of 20 donkey/mule-carts and three horse carts which should be the main forms of transport. However, the farmers only use the tractor-trolleys (11 in number) for transportation for fertilizer and grains.

'Kirto Pindori' (Village 5)

Access to Infrastructural Services

Kirto Pindori (Vilno 5), is located on the Muridke-Narowal Road to the north-east of Gujranwala market, and the north-south Grand Trunk road.

The village population consists of 400 households. K. Pindori is 2 kms away from the bus-stop, accessible both by horse-carriage (a 15 minute journey), and on foot (a 30 minute journey). There are 20 such horse-carriages, which transport the villagers both to the bus-stop, and often onward to Narang, the nearest market town. Other private means of transport in the village consist of 50 bicycles and about 20 motor-cycles.

Distribution of many commercial and other services (e.g telephone, security) for the village are concentrated in Narang, the nearest town and marketing center.

Kirto ranks fifth and sixth among sample villages in distance to the nearest input distribution center and market town respectively. Its comparative ranking regarding access to the nearest light engineering work-shop for agricultural machinery and the bank is lower, but still within the upper 33% of the sample.

K. Pindori is one of five villages which has a veterinary center within it.

Access to two out of three Government administrative services is comparatively good. Both the union council and district town (Sheikhupura) are located at the mean and median sample distances (4 kms and 54 kms respectively). The tehsil town (Ferozewala) is 39 kms distant, making K. Pindori rank within the bottom 15% of the sample in access to this service. It ranks fifth in access to the police post, 6 kms distant (and well below the median of 10 kms).

The village ranks fourth in distance to the Rice Research Institute 29 kms away, while the Wheat Research Institute is 153 kms distant.

K. Pindori is one of nine villages with postal services within it. But the village has the median distance of 6 kms with regard to telephone services.

The village has very good educational facilities. It has primary schooling services for boys and girls. It is one of only two villages to have a boys secondary school and also one of three villages to have a girls secondary school. There are 13 male and 17 female teachers in the village.

In common with five other villages, K. Pindori has a health clinic.

Electricity and Irrigation

The village has been electrified for eighteen years. Even so, villagers complained that electricity is regularly cut during winter for four hours and during summer for two hours, and the tubewell operator does not give them water so that actual access to water is more limited than it appears to be. The middle of the water-course passes through the village. However, the water course is a seasonal one (flowing only in summer), and villagers complain that the water channels are narrow and the water level is low. Irrigation water is critically short in June. But water is supplemented by nine of twelve operational Government tubewells, and 16 private tubewells which have been built from 1985 onwards.

Agriculture

Wheat and berseem grain are the main crops, grown for the market. The village dealer who buys directly from farmers is preferred over the commission agent. Villagers sell both wheat and berseem grain, in addition to wheat straw and milk to such dealers. The villagers sell some wheat grain and rice paddy to the commission agent too, who pays them low prices (presumably because he has lent them money). Clarified butter is bartered or exchanged among villagers themselves.

Farmers normally use their own seed for wheat and rice. They do buy wheat seed from the Government depot and progressive farmers. Farmers' complaint was that the seed was not available on time. Farmers obtained fertilizer from the commission agent at black market prices. The supply of fertilizer was irregular and it was not available in timely fashion. Pesticides were reported to be adulterated.

Many farmers engage 'changar' labor for major crop operations.

Technology

There are 20 progressive farmers in the village with varying types and levels of improved technology viz: 32 tractors, five threshers, and 16 privately-owned tubewells. There was no traditional tillage technology. Donkey and mule carts tractor trolleys (about four and 15 in number) were the main forms of transport for produce.

The extension agent located in the village often visits the large 'progressive' farmers. He has set up two demonstration plots each, of rice and wheat in the village.

'Chak 6/58' (Village 6)

Access to Infrastructural Services

Chak 6/58 is located in district Sheikhupura to the south-west of Nankana Sahib. The village is 5 kms off of a major district road connecting the two market towns of Bucheke and Syedwala. Chak 6/58 has a population of 1412 people living within households containing an average of 5.8 people.

This village is located 5 kms from the bus-stop, itself at a crossroad, near a larger village, Bara Ghar. It takes one hour to reach the bus-stop on foot. The road to the village is very good having been built within the past few years. However, the villagers still appear to feel a sense of isolation, due to the lack of available transport facilities. Villagers do own some private transport (fifteen to twenty bicycles and one motor-cycle). There is no commercial transport such as horse-carriages, etc except transport used to move grains etc.

Most commercial services are obtained from Bucheke, 16 kms distant and 1.5 hours away. Chak 6/58 ranks among the lower 33% of villages regarding distance to the nearest marketing, input distribution center and light engineering facilities for agricultural machinery. Such access is well below the respective median distances to these services (10.5 kms, 10 kms and 10 kms). The bank, 5 kms distant, is comparatively nearer and less than the median of 6 kms. The village ranks last in access to the veterinary center 32 kms away.

Chak 6/58 also ranks relatively low in its access to all Government administrative services. It ranks eighteenth in its access to Nankana Sahib, 32 kms away. The village is 8 kms and 88 kms distant from the Union Council and district town respectively (and higher than the sample medians of 4.4 and 54 kms). However, the village is third nearest to the police post, whose distance is half of the sample median.

The village ranks fifth in access to the Wheat Research Institute but is further away from the Rice Research Institute. As in most villages, farmers do not utilize their services at all.

Village access to postal and telephone services (5 kms and 16 kms distant respectively), is in the bottom 25% of sample villages.

The village has primary schooling for both girls and boys. Village access to the boys and the girls secondary schools, 5 kms and 16 kms distant was sixteenth and twenty-first within the sample. About 60% of sample villages had better access to health services than Chak No 6/58.

Electricity and Irrigation

The village has been electrified for fifteen years but electricity goes off regularly from December to February for about four to six hours daily, and in July and August for one to two hours daily. The village is located 2 kms from the tail-end of the perennial water-course, and there is water constraint throughout the winter. However, farmers upstream have blocked the canal, so that during July and August, water can only flow through the canal for four hours daily. The four Government tubewells are operational for only three months in each season, leading to acute shortage during April and May.

Agriculture

Chak Number 6/58 has 1,882 acres of arable land. Wheat and rice grain are the main marketable crops. There are a variety of marketing channels available in the village. Wheat and rice were marketed both by the village dealer and the commission agent, although berseem and wheat fodders were exchanged by farmers among themselves. Clarified butter was exchanged among villagers. Milk is collected and sold by the dealer outside the village.

Although farmers normally use their own seed for wheat and rice, they buy wheat seed from the Government depot and progressive farmers. Farmers complain that seed from the Government depot is impure and unavailable on time. Farmers obtained fertilizer from the commission agent at black- market prices, above those fixed by the Government. The supply of fertilizer was irregular and it was unavailable in timely fashion. They did not report any complaints regarding pesticides, but probably did not use them either.

Technology

There are five progressive farmers in the village with varying types and levels of improved technology, namely: six tractors, six threshers, and nineteen privately-owned tubewells. No bullock-ploughs were used.

There was a rental market for wheat and rice ploughing. Wheat threshers and combines were also available on hire. Five tractor-trolleys and three donkey/mule-carts serve to transport produce.

The extension agent is located in Bucheke, 16 kms distant. He only visits the progressive farmers once a year.

'Chaindpur Sharif' (Village 7)

Access to Infrastructural Services

Chaindpur Sharif is situated due south of Nankana Sahib. Chaindpur has a population of 3183 people living within an average household size of six people.

The village is 11 kms away from the bus-stop, (at Kot Fazal), which connects the west-east district road from Bucheke to More Khunda. It ranks second last among sample villages in distance to the bus-stop. It takes one to one and one-half hours to cover this distance by suzuki pickup or horse-carriage due to the poor condition of the road: it winds tortuously in keeping with the hilly contour and topography of the area. Three horse-carriages and as many suzuki vans ply this route. Private modes of transport: namely, 50 bicycles and ten motor-cycles supplement them.

Although the village is equidistant from the two towns of More Khunda and Bucheke (both 21 kms distant), villagers define More Khunda as the nearest town and marketing center. Village access to the marketing town is appreciably higher than the median of 10.5 kms, and ranks second to last in the sample.

Chaindpur Sharif ranks among the bottom 10% of villages regarding distance to the nearest input distribution center and workshop for agricultural machinery. The distance of 21 kms is well below the median distances of 10 kms to both of these services. It is the furthest away of all villages regarding access to the bank, 21 kms distant.

This village is one of five with veterinary facilities located within it.

Chaindpur has low access to two out of three administrative services. The village ranks twentieth in access to the tehsil town, located 36 kms distant, and appreciably higher than the mean and median of 24 kms. Village access to the district town is within the bottom 10% of the sample. However, the union council is located within the village. Chaindpur has the third-highest access to the police post, 5 kms distant.

The village ranks fourth in access to the Wheat Research Institute, 76 kms distant, and is relatively nearer than the Rice Research Institute, 90 kms away.

It is one of nine villages which has a Post Office within it. It is furthest within the sample regarding access to telephone services located 21 kms away.

The village has primary schooling for both sexes. It ranks among the lowest 15% of sample villages regarding secondary schooling for boys and girls, which are 18 kms and 21 kms distant.

Electricity and Irrigation

The village has been electrified for twelve years. Electricity is regularly cut during winter for six hours and during June, July and August for three hours, limiting access to tubewell water.

The middle of the water-course passes through the village, which is also situated on the northern bank of the Ravi River. However, the water course has silted up, as farmers at the head of the water-course have blocked the canal. Thus there is a shortage of water in the winter months, as well as in the summer months of June, July and August. Water for irrigation is supplemented by three operational tubewells; a fourth tubewell is nonoperational.

Agriculture

Chaindpur Sharif contains 4804 acres of arable land. Wheat and rice are the main crops. Rice grain and paddy are sold exclusively to the commission agent, while wheat grain is handled both by the commission agent and the input dealer. Wheat fodder is bought directly at the farm-gate by the input dealer, for sale in Lahore.

Farmers are satisfied with the quality of the wheat and rice seed, which they buy from the supply depot. Farmers buy fertilizer from the commission agent. While farmers did not complain about fertilizer prices, they reported facing shortage in its supply. Both fertilizer and pesticides are adulterated.

Technology

There are three progressive farmers in the village with varying types and levels of improved technology, namely: ten tractors, eight threshers, and four privately-owned tubewells. There were no bullocks.

The extension agent is located within the village and visits both the progressive farmers as well as other farmers whenever they ask him.

There is a rental market for land preparation of rice and wheat. Some harvesting operations also appear to be mechanised e.g wheat threshing. Combines are also available. Tractor trolleys and horse-carts (ten and three in number) are the main forms of transport for produce.

'Jatri' (Village 8)

Access to Infrastructural Services:

Jatri is located on a north-south district road linking More Khunda to a town in the neighbouring district of Kasur (Bhai Peru). The population of 1899 is living in households containing an average of 5.9 people.

It is one of six villages to be located on a road as well as a bus-stop. Villagers complement travel by bus with other private means of transport, namely: 30 bicycles, and two motorcycles. Jatri fares below the mean or median in distance to a number of services. However, transport to these destinations is readily available, so that reaching them is faster than the distance may indicate.

The nearest town of More Khunda (12 kms away) provides many of the services (commercial, social, health and educational) for this village. Jatri ranks sixteenth in its access to the nearest marketing center, light engineering work-shop for agricultural machinery and input distribution center for seed and fertiliser. The police post, located 16 kms away from the village is also higher than the median distance of 10 kms.

This village has relatively poor access to the nearest bank, as the distance of 12 kms is double that of the sample median.

Jatri ranks among the lower 40% of villages regarding access to Government administrative services. The village ties for eighteenth place with Kirto Pindori (Village number 5) regarding access to the tehsil town of Nankana Sahib, 32 kms away. The Union Council and the district town are 7 kms and 68 kms distant and much higher than the respective mean and median distances of 4.4 kms and 54 kms.

The village ranks twentieth in the sample, in its access to the veterinary center 7 kms away.

Jatri is one of nine villages with postal services within it. However, telephone services are available 12 kms away.

There are boys and a girls schools within the village, with seven male teachers and one female teacher. The village ranks in the bottom 33% of the sample regarding access to the boys' and girls' secondary schools both 12 kms distant. Health services available in the same town place the village second to last within the sample.

Electricity and Irrigation

The village has been electrified for 22 years. However, the electricity is regularly cut off for 4 hours from December to February and for one and one-half hours from August to September.

Two government tubewells were installed in the village in 1968 but they are currently, non-operational. The village is 5 kms from the tail-end of the water-course, so that it gets no irrigation water. Villagers have invested in 14 tubewells.

Agriculture

The village consists of 1505 acres of arable land. The main crop is rice grain and paddy. The main marketing agents for rice are both the input dealer and the commission agent. Wheat and rice seed are obtained from the commission agent and the progressive farmers.

While farmers complained of shortage and adulteration of fertilizer, they said they did not have any constraint in obtaining pesticides. However they may not be using them at all.

There was labor shortage during both crop seasons for critical rice, wheat and sugar-cane farm operations.

Technology

There was only one progressive farmer. There were ten tractors, five threshers and fourteen tubewells, critically important in this rainfed area. There was only one pair of bullock-carts in the village.

Access to village extension services were relatively greater than the median distance of 5 kms; but the extension agent visited farmers twice a month. There were no rice or wheat demonstration plots in the village.

This village has the third-highest access to the Wheat Research Institute (75 kms distant. Distance to the Rice Research Institute, 100 kms away, is comparatively higher. Progressive farmers within the village visited both of these Institutes once in three months.

There was a rental market for both wheat and rice (or dry and wet) ploughing and planking respectively. Transportation for fertilizer and grains, was provided by twelve donkey/ mule-carts and seven tractor-trolleys.

'Chak No 369/G.B' (Village 9).

Access to Infrastructural Services

Chak No 369/G.B is located to the north-west of Nankana Sahib. Village population consists of 5000 people living in 200 households. (recheck).

The bus-stop 5 kms away, is on the nearest link and main road connecting Nankana Sahib to Jaranwala. It takes one hour to traverse this road on foot. There is no commercial transport in the village. Apart from walking, villagers use other privately-owned transport modes such as bicycles (90) and motor-cycles (two) for travel.

The nearest town of Gungapur, 2 kms away, enables Chak No 369/G.B to have the highest access to bank services. While Gungapur is fifteen minutes away on foot, it offers a limited number of infrastructural services.

Chak No 369/G.B ranks among the first six villages in its access to the agricultural marketing center, light engineering work-shop for agricultural machinery and input distribution centers for seed and fertilizer, all located in Buchina, 5 kms distant. But the village has relatively less than median access (4 kms) to the veterinary center, also located there.

Chak No 369/G.B has fair access to only one of three Government administrative services. It ranks eleventh in its access to the tehsil town located 16 kms away. Approximately 80% of sample villages have closer access to the district town, 72 kms distant. The village ranks sixteenth in the sample regarding distance to the union council. Access to the police post (16 kms distant), is appreciably higher than the sample median of 10.5 kms.

Due to its northerly location on the border between Faisalabad and Sheikhupura, near the Jaranwala-Faisalabad road, this village is closest in distance to the Wheat Research Institute (65kms). The Rice Research Institute is further away (95 kms).

The village ranks twelfth in the sample in its access to postal services, available 1.5 kms away. However Chak 369/G.B is comparatively nearer in its access to telephone services (fourth), available from the same place (Gungapur).

Schooling services for both girls and boys are available in the village. The male to female teacher ratio is 9:3. Both the boys and girls secondary schools are in Nankana Sahib (16 kms away), placing the village among the bottom 25% of the sample in such sample access.

The village ranks eight in its relative ranking to health services, 2 kms distant.

Electricity and Irrigation

The village has been electrified for twenty years. During 1992 there was constant loadshedding for 24 hours throughout the year. Although there are two Government tubewells, they have been out-of-order for two years. The village is at the head of the water-course, but the water-channels are broken. These two problems give rise to severe water constraint. During winter, critical months of shortage of water are March and April, while there is a shortage throughout the summer.

Agriculture

The main crops in the village are tobacco, wheat, both grain and fodder, berseem fodder, and milk. These crops are marketed by the input-dealer. Vegetables and berseem grain are marketed through the commission agent. Rice is sown very little and tobacco is the main cash crop.

Farmers use their own seed for wheat and rice. Although they expressed a preference in obtaining seed from the Wheat Research Institute (WRI) at Faisalabad, they said the distance was prohibitive. Farmers did not report any constraint with regard to obtaining fertilizer and pesticides.

There is labor shortage for critical farm operations (in both seasons) associated with berseem, wheat and tobacco. Labor is required for tobacco harvesting, which is done by hand. Other operations are normally done by the farmers and their families, due to the high supervision costs incurred, if the work is done by hired or contracted labor.

Technology

There are ten progressive farmers in the village, but there is little improved technology, namely: two tractors, one thresher, and seven private tubewells. However, there are two bullock-carts. Tobacco is a labor and management-intensive crop in this village, and it appears that farmers do not use improved technology for this reason.

The extension agent is located at Nankana Sahib and visits only the progressive farmers. There are no rice and wheat demonstration plots in the village.

There is a rental market for the preparation of land for wheat, berseem and rice There are two tractor-trolleys and five donkey carts available for transportation of produce in the village.

'Bhammanwala' (Village 10)

Access to Infrastructural Services

Bhammanwala is located north-east of Gujranwala market, off of a district road connecting Gujranwala to Sialkot. It is located 2 kms downstream from the Nandipur headworks at the Upper Chenab Canal. The nearest bus-stop is 2 kms away. It takes 25 minutes to reach on foot[8]. There were two suzuki pickups in the village. The quantity of private transport modes could not be fully ascertained, but there were four motor-cycles in the village.

The village population of 1297 people live in an average household size of 7.2 people.

Many commercial and other services are concentrated in the nearest town of Gujranwala City, 15 kms away. Bhamunwala ranks nineteenth and twentieth with regard to access to the main marketing and input distribution center located there.

Bhammanwala ranks first in distance to the bank (together with six other villages), and the light engineering work-shop for agricultural machinery, both located 2 kms away.

The veterinary center is within the lower 40% of the sample. Located 5 kms away, it is greater than the median distance of 4 kms.

The tehsil and district towns are both in Gujranwala city, 15 kms away. The tehsil and the district town rank tenth and fifth among sample villages and are less than their respective mean (and median) values of 24 and 54 kms. Both the Union Council and the police post are relatively much further away. Located 8 kms and 15 kms distant, these services are available further than their respective median distances of 4 kms and 10 kms.

The village ranks among the upper 50% of the sample in its access to the Rice Research Institute, (74 kms distant) and among the lower 50% in such access to the Wheat Research Institute (194 kms).

While Bhammanwala has the median distance to Postal services, 2 kms distant, it ranks among the bottom 25% of the sample in access to the telephone services 15 kms away.

While there is a primary school for boys in the village, the girls primary school is located 3 kms away in a neighbouring village, as are the secondary schools for boys and girls. Bhammanwala ranks higher in its access to the girls secondary school (eighth) than to the boys secondary school (tenth). Health services available 6 kms away, are higher than the median of 4.6 kms.

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[8] Walking in fact is the most common mode of transport to reach the bus-stop.

Electricity and Irrigation

The village has been electrified for twelve years, but electricity is regularly cut off for three to four hours throughout the year. There are no government tubewells in the village. The village is at the head of the water-course (the upper Chenab Canal), which is seasonal. Thus during winter the village does not have publicly-provided irrigation water. Villagers have invested in twenty-five tubewells. During the summer villagers did not experience water shortage as the rains were good.

Agriculture

The village comprises an area of 662 arable acres. There are two main groups of crops namely: rice paddy and wheat grain as well as wheat fodder anda milk. The grains are marketed through the commission agent while fodder and milk are sold to the village dealer.

Villagers primarily use their own rice seed for planting. Wheat seed is bought from the commission agent, if necessary. Farmers perceptions are that the prices of fertilizer are too high, while pesticides are adulterated.

There was labor shortage during both the wheat and rice seasons. Family and hired labor, as well as changar labor, hired on contract basis, did critical farm operations.

Technology

There are fifteen progressive farmers in the village. There are six tractors, three threshers and two reapers in the village. Bullocks are not used for land preparation.

The extension agent is located at Aroop, 6 kms away, and visits the progressive farmers once a week. There are no rice or wheat demonstration plots.

There are twelve donkey and mule-carts, four tractor trolleys and two suzuki vans used for transportation of fertilizer and grains.

'Gaggar Ke' (Village 11)

Access to Infrastructural Services

Gaggar Ke is located east of Gujranwala market on the Gujranwala-Pasrur Road. The bus-stop is 1 km from the village and takes 15 minutes to traverse on foot.

The population of the village consists of 1548 people who live in an average household size of 6.7 people.

Gaggar Ke ranks ninth in access to the nearest town, Gujranwala city, located at a distance of 7 kms. Villagers get some (though not all) commercial and marketing services from there.

Gaggar Ke ranks second in its access to the nearest agricultural marketing center located in Talwandi Musa Khel, 3 kms away. The village also ranks eighth in distance to the nearest input distribution center for seed and fertiliser, located in Gujranwala. Gaggar Ke ranks within the upper 25% of sample villages in its access to the light engineering work-shop for agricultural machinery (5 kms distant), the veterinary center and the bank (both 3 kms distant).

Access to administrative services is very good. The village has the highest and third-highest access to the district and tehsil towns located in Gujranwala. Gaggar Ke is one of six villages which has a Union Council within it. Security services (7 kms away) are available at less than the median distance of 10.5 kms.

Gaggar Ke is one of nine villages to have postal services. However, it ranks ninth within sample villages in access to telephone services located 3 kms away.

There are primary schooling services for both sexes, with three male and three female teachers within the village. Gaggar Ke ranks tenth with five other villages in distance to the boys' secondary schools, 3 kms away. Gaggar Ke ranks eighth in its access to the girls' secondary school, to which it has relatively better access. However, about 75% of the sample, has better health services (7 kms distant) available.

Electricity and Irrigation

The village has been electrified for 18 years, but the electricity in the village is cut off for three hours daily throughout the year. There are no government tubewells available. The village is located 0.75 kms from the head of the water-course, which is a seasonal one. There is water constraint in July, August and September, and there is no water during the winter months. Farmers have invested in 27 to 30 tubewells within the village.

Agriculture

Gaggar Ke consists of 701 acres of arable land. Rice and wheat grain are sold by the dealer and commission agent and exchanged among the villagers themselves. Wheat fodder and milk is bought by the dealer while rice paddy is traded by the dealer and the commission agent.

While 10% of the farmers buy wheat seed from the Seed Corporation, others buy it from the dealer or save seed from their previous harvest. Farmers use their own rice seed or buy it from the commission agent. Fertilizer is obtained from the commission agent. Farmers did not have any problems regarding pesticides.

There is labor constraint in both cropping seasons. There is a labor shortage during periods of high demand for critical crop operations. Family, hired and contract labor all work on wheat and rice harvesting operations, and labor is readily hired at a daily wage of Rs 50 per day within the village.

Technology

There are only four progressive farmers in the village with a commensurate level of improved technology: four tractors, two threshers and 30 private tubewells. There are two bullock-carts. Combine harvesting is available on rent.

The extension agent is located at Gujranwala and comes once a week to visit only the progressive farmers. There are no rice and wheat demonstration plots in the village.

There is a rental market for wheat and rice ploughing, and threshing.

Horse and donkey and mule-carts (five and eleven respectively) are the main forms of transport for produce. There are also two tractor-trolleys and two suzuki-vans available for this purpose.

'**Kot Qazi**' (Village 12)

Access to Infrastructural Services

Kot Qazi is located 9 miles due west of Gujranwala on the Gujranwala-Hafizabad road. It is one of nine villages located on a bus-line.

The population of the village consists of 766 people living in an average household size of 5.8 people.

The nearest town is Gujranwala metropolis located 9 kms away. The village ranks among the upper 40% of the sample in access to the nearest agricultural marketing center and input distribution center for seed and fertiliser, 7 kms away. Distances to these services are well below their respective medians of 10.5 kms and 10 kms. The village ranks in the lower 25% of the sample regarding access to veterinary services, 8 kms distant and twice the median value of 4 kms.

The village has the highest village access to the light engineering work-shop for agricultural machinery and the bank, 2 kms away.

Access to two out of three administrative services is very good. Gujranwala is the relevant district and tehsil town. Hence the village ranks second and fourth with regard to access to these services. Kot Qazi ranks second to last in its access to the Union Council 8 kms away. The village also ranks eighth in its access to security services 8 kms distant.

Postal and telephone services available 1 km and 2 kms distant, are less than their respective sample medians of 2 and 6 kms.

There are primary schooling services for both sexes, with 3 male and 3 female teachers within the village. Access to the boys and girls secondary schools 2 kms away is comparatively good. The village ranks fourth and fifth in access to both of these services. However, it ranks within the bottom 25% of the sample, in its access to health services, 8 kms distant and comparatively much higher than the median of 3 kms.

Electricity and Irrigation

The village has been electrified for 30 years. There are no government tubewells available. The village is located 1 km from the middle of the water-course, which is perennial in nature. There is a water constraint in both seasons, as the original canal system was built to irrigate one-half of the area. Critical months of water shortage are November, December, June and July. Farmers have invested in 13 tubewells within the village.

Agriculture

Arable village land area is 1006 acres. Rice and wheat grain and vegetables are sold by the commission agent while wheat fodder and milk are sold by the dealer. Both of these marketing agents trade rice paddy.

Farmers use rice and wheat seed from the previous year's crop. They felt that seed from the Government depot was impure. Prices of fertilizer and pesticides were perceived as being too high. Both fertilizers and seeds are adulterated.

There is no labor constraint in either of the cropping seasons, as there is enough labor in the village. There is a labor shortage during periods of high demand for critical crop operations.

Technology

There are six progressive farmers in the village with a commensurate level of improved technology: three tractors and one thresher. There were no bullock-ploughs used. Combine harvesting is available on rent.

K. Qazi ranks fourth in its access to the extension agent located in a neighbouring village, 2 kms away. He comes once or twice a month. He visits with every farmer, and discusses all their agricultural problems. There is one rice and wheat demonstration plot in the village.

Kot Qazi ranks tenth in its access to the Rice Research Institute, 70 kms distant. While the Wheat Research Institute is further away (170 kms), researchers from this institute visited the village during the past year.

There is a rental market for wheat and rice ploughing, and threshing. Donkey and mule-carts, horse-carts and tractor-trolleys (two, three and seven respectively) are the main forms of transport for produce.

'Dehnsar Bala' (Village 13)

Access to Infrastructural Services

Dehnsar Bala is located east of Gujranwala on the Mianwali Bangla and Sadoke road. It is one of nine villages located on a bus-line. Although the road is a narrow brick one, it is in relatively good condition. Commercial transport consists solely of buses which pass by the village every three hours during the day-time. There is little private transport (ten bicycles and three motor-cycles).

The population of Dehnsar Bala consists of 1201 people living in an average household size of 7.7 people.

The nearest town of Mianwali Bangla (6 kms away) provides most of the infrastructural services for this village. Dehnsar Bala ranks among the upper 30% of the sample in its access to the agricultural marketing center, input distribution center for seed and fertiliser and the light engineering work-shop for agricultural machinery. Distance to these services 6 kms away, are well below their respective medians of 10.5 kms and 10 kms. The village has the median distance, of 6 kms to the bank.

Dehnsar Bala ranks sixth in its access to veterinary services available at Dehnsar Paen, a larger village located 1 km down the hill.

This village has good access to two of three administrative services. It ranks seventh in access to Gujranwala the nearest district town, 35 kms away. However, the village is in the bottom 25% of the sample, regarding its access to the tehsil town (Kamoke) relatively further away (40 kms). Kot Qazi is one of six villages having a Union Council within it. It ranks tenth in its access to security services, 9 kms distant.

Dehnsar Bala ranks (seventh) in its access to the Rice Research Institute, 65 kms distant. The Wheat Research Institute is much further away (190 kms).

The village ranks third and eleventh in its access to postal and telephone services. Both services located 1 km distant, are much less than the respective median distances of 2 kms and 6 kms.

Primary boys and girls schooling services within the village employ three male and two female teachers. Dehnsar Bala ranks third and fourth in its access to the boys and girls secondary schools located 1 kms distant. Health services are also located in Dehnsar Paen.

Electricity and Irrigation

The village has only been electrified since the past four years. During the winter months the electricity is cut off for three to four hours, while during the summer, it is cut off for two hours. There are no government tubewells available. The village is located 0.5 km from the head of the water-course, which is seasonal in nature. The village is served by three water-channels. There is critical shortage of water during June and July. During the past 27 years, village farmers have invested in as many tubewells.

Agriculture

Arable land within the village consists of 908 acres. Barter trade is the predominant form of exchange within the village. While consumers appear to trade in all the commodities produced here, the surplus of wheat grain is sold to the commission agent and excess wheat fodder and milk is sold to the dealers. Villagers trade exclusively in rice grain and vegetables among themselves.

Farmers use rice and wheat seed from the previous year's crop. They felt that seed obtained from the Government depot was both expensive and poor in quality. Fertilizer and pesticides were perceived as being adulterated.

There is no labor constraint in either of the cropping seasons.

Technology

There are three progressive farmers in the village with some improved technology: seven tractors, four threshers and two reapers. Combine harvesting is available on rent.

The extension agent, located in the neighbouring village, visits with every farmer once a week. He discusses the farmers' agricultural practices in detail. There is one rice and wheat demonstration plot in the village.

There is a rental market for wheat and rice ploughing, and threshing. Donkey/mule-carts and tractor-trolleys (five and seven respectively) are the main forms of transport for produce.

'Kot Rattan' (Village 14)

Access to Infrastructural Services

Kot Rattan is located to the north-east of Hafizabad on the east-west Rasulnagar-Wazirabad road. It is 3 kms from the bus-stop. The road to the bus-stop is a dirt road, in fair condition, accessible every one-half hour by horse-carriage, or one hour by walking. Buses pass by every three hours during the day-time. There are also five horse-carriages in the village. Private modes of transport are not plentiful; ten bicycles and three motor-cycles.

The population of the village consists of 1215 people living in an average household size of 6.7 people.

Many infrastructural commercial and decentralized services are provided by the nearest town of Jam ke Chatta (6 kms away). For example, the railway line passes through this town, and is used quite frequently to go to further-off locations (e.g Wazirabad) instead of the bus. Jam ke Chatta is also the nearest agricultural marketing center and input distribution center for seed and fertiliser. The village ranks among the upper 20% of the sample in its access to these two services.

The village ranks ninth in its access to the light engineering work-shop for agricultural machinery. It has the median value to the bank.

Village access to veterinary and security services is eighteenth in the sample. Distances to these services equal 6 kms and 14 kms, and are higher than the respective sample medians of 4 kms and 10 kms.

Access to administrative services is below average. Gujranwala the district town is 56 kms distant, slightly above the mean distance of 54 kms. The tehsil town of Wazirabad, 28 kms distant, is above the median of 24 kms. Access to the Union Council (6 kms), places the village in the bottom 33% of the sample.

Likwise both the Rice and the Wheat Research Institutes are also relatively far away (114 kms and 166 kms), positioning the village within the lowest 33% of the sample.

Kot Rattan is one of nine villages which has a post office within it. It ranks twelfth in its access to telephone services, 6 kms away.

There are primary schooling services for both sexes. The village is one of only three, in which the girls secondary school is located in the village. However, as the boys secondary school is 6 kms away in Jam ke Chatta. Hence Kot Rattan ranks sixteenth in sample access to the boys secondary school. There are six female teachers, compared to three male teachers. K Rattan is one of nine villages with health services available within the village.

Electricity and Irrigation

The village has only been electrified during the past six years. There are no government tubewells available. The village is located at the tail-end of the water-course, which is seasonal in nature. Water is constrained during the summer and critically short from July to September. During the past 30 years, village farmers have also invested in 25 tubewells.

Agriculture

The village area is 2099 acres. Wheat grain and rice paddy are sold by the commission agent and the village dealer, while rice grain, wheat fodder and milk are sold by the commission agent. Sugar-cane is sold directly to the sugar-mills.

Farmers normally obtain rice and wheat seed from their own previous crop, or from a fellow farmer. They also obtain rice seed from the commission agent but felt that it was expensive and its quality was not good. Farmers perceived fertilizer and pesticides to be adulterated. They also said that prices of both these two inputs were too high.

There is a labor constraint in both of the cropping seasons. Labor is not mobile at all in the village. Villagers do not go out of the village to work even during the off-farming season.

Technology

There are seven progressive farmers in the village with some improved technology: six tractors, two threshers and one reaper. Combine harvesting is available on rent.

The extension agent, located in Jamke Chatta, meets selected farmers (only one or two) once in two weeks. There are no rice or wheat demonstration plots in the village.

There is a rental market for wheat and rice ploughing (machinery) and harvesting (contract labor). Donkey and mule-carts and tractor-trolleys (four of each respectively) are the main forms of transport for produce.

'Bara Pind' (Village 15)

Access to Infrastructural Services

Bara Pind is located to the north-east of Hafizabad off of the (west-east) Pindi Bhatian-Wazirabad road. It is 2 kms south of the nearest bus-stop. As the road to the bus-stop is paved and in good condition, it is negotiated in one-half hour on foot. Two horse-carriages (also used to transport produce) supplement the bus which passes by the road every one-half hour during the day-time. Private modes of transport include: eight bicycles and four motor-cycles.

The population of the village consists of 851 people living in an average household size of 6.1 people.

Bara Pind has the highest village access to the agricultural marketing center, input distribution center for seed and fertiliser, light engineering work-shop for agricultural machinery and the bank, 2 kms away. The village ranks seventh in its access to veterinary services, located in the same area.

Access to administrative services is fairly good. The village ranks tenth in access to the district town (or city) of Gujranwala, 52 kms distant. The tehsil town of Wazirabad is 24 kms distance from the village and is equal to the sample mean and median values. Ram ke Chatta has good access to the Union Council, 2 kms away; it has the median value in its access to the security services 10 kms away.

Both the Rice and the Wheat Research Institutes are relatively far away (110 kms and 162 kms), placing the village within the bottom 33% of the sample.

Bara Pind ranks second and fifth in its access to the postal and telephone services, 2 kms and 6 kms distant.

There are primary schooling services for boys and girls within the village. Bara Pind ranks fifth in sample access both to the boys and the girls secondary schools, 2 kms away. It is one of nine villages with health services available.

Electricity and Irrigation

The village has been electrified for the past 22 years. There are no government tubewells available. The village is located 1 kms from the the tail-end of the (seasonal) water-course. Although water is constrained throughout the year, canal-water is critically short from July to September. During the past 32 years, village farmers have also invested in 25 tubewells.

Agriculture

The village area consists of 892 acres of arable land. Farmers sell their main cash crops of rice paddy and wheat grain to the (market) commission agent as well as the dealer. However the dealer is the sole trader for rice grain and agricultural bye-products (wheat fodder and milk). Sugar-cane is sold directly to the sugar-mills.

Farmers normally obtain rice and wheat seed from their own previous crop or from the commission agent. They often bought fertilizer from the commission agent both in cash and on credit. However, they felt that these inputs were too expensive. Farmers also complained about the adulteration and shortage in supply of fertilizer and pesticides.

There is a labor constraint for agricultural operations regarding wheat and rice in both of the cropping seasons.

Technology

There are ten progressive farmers in the village with some improved technology: four tractors and one thresher.

The extension agent, located in Jamke Chatta, visits the progressive farmers once in a month. There are no rice or wheat demonstration plots in the village.

There is a rental market for wheat and rice ploughing (machinery) and combines. Donkey and mule-carts and tractor-trolleys (four and two of each respectively) are the main mode for transporting produce to the market.

'Ramke Chatta' (Village 16)

Access to Infrastructural Services

Ramke Chatta is located on the (north-south) road connecting Hafizabad with Qadirabad. It is one of nine villages on a bus-line. Buses pass by the road every three hours during the day-time. The road passing through the village, though paved, is in very poor condition, and needs extensive repairs. Ramke Chatta resembles a small town in population, and in spite of the poor road, has extensive links with other villages.

The population of the village consists of 4675 people living in an average household size of 6.8 people. Village inhabitants own 60 bicycles and ten motor-cycles. Seventeen horse-carriages supplement the bus as commercial modes of transport.

Ramke Chatta ranks in the bottom 25% of the sample regarding access to the nearest agricultural marketing center, light engineering work-shop for agricultural machinery, the input distribution center for seed and fertiliser and the bank. These services are all concentrated in the large market town of Hafizabad located 17 kms away from the village.

Ramke Chatta has veterinary services available within it, as do four other villages.

Access to administrative services is variable. The village lies within the bottom 33% of the sample regarding access to the district city of Gujranwala, 70 kms away. Ramke Chatta ranks twelfth with respect to access to the tehsil town (Hafizabad), 17 kms distant. The village is one of six to have a Union Council within it. While the village ranks second in distance to the police post 4 kms away, it takes an hour to reach it (on foot or by horse-carriage).

Ramke Chatta is one of nine villages to have a post office. Its access to telephone services (17 kms) is less than the sample median of 10 kms, placing it in the bottom 33% of the sample.

There are primary schooling services for boys and girls in Ramke Chatta. But the village has better access to the girls secondary school than to the boys secondary school, as it is one of only three villages to have this facility. However, the girls secondary school is co-educational. Seventeen male and seven female teachers staff the primary and secondary schools. The village has median ranking regarding access to the boys secondary school, 3 kms distant. Ramke Chatta is one of six villages with health services available in it.

Electricity and Irrigation

The village has been electrified for the past 15 years. There are no government tubewells available. The village is located 0.5 kms from the the tail-end of the (seasonal) water-course. During the summer, there was no water-shortage because the rains were good. In the past 30 years, village farmers have also invested in 50 tubewells.

Agriculture

The village area consists of 4,386 acres of arable land. Farmers sell their produce directly to the village dealer. Marketable crops within the village include wheat grain, rice paddy, wheat fodder and milk. Farmers sell sugar-cane directly to the sugar-mills. There is a small rice-mill (or sheller) in the village.

Farmers normally obtain rice and wheat seed from their own previous crop, on credit from the commission agent or in cash from the Government Depot. Farmers buy fertilizer both on cash and credit from the commission agent. They complain about the high prices of fertilizer and pesticides, as well as shortage in the market supply of these two inputs. Both fertilizer and pesticides are often adulterated.

There is no labor constraint in either of the cropping seasons. The demand for labor for agricultural operations within the village is very high from April to May and October to December. Work for wages (at Rs 40 per day), as well as contract work is readily available.

Technology

There are 11 progressive farmers in the village with some improved technology: 15 tractors, 13 threshers and three reapers.

This is one of four villages, which has an extension agent within it. He often visits farmers within the village. There are two rice and two wheat demonstration plots in the village.

There is a rental market for wheat and rice ploughing (tractors). Combine harvesting is available at a relatively moderate rent. Donkey or mule-carts and tractor-trolleys (five and fifteen of each respectively) are the main forms of transport for produce.

'Saakhi' (Village 17).

Access to Infrastructural Services

Saakhi is located 21 kms south west of Hafizabad, off of the Hafizabad-Pindi Bhatian road. The village ranks twenty-fifth in access to the bus-stop, located at a distance of 8 kms (at Rasulpur). It takes two hours to reach the bus-stop, on foot and one and one-quarter hours by horse-carriage. The road is unpaved and in very poor condition (with large cracks and crags), particularly in the rainy season.

The population of the village consists of 2,035 people living in an average household size of seven people. There is little privately-owned transport, namely: six cycles and two motor-cycles; and four horse-carriages which ply commercially. Villagers supplement this tranport by using the transportation modes for produce for themselves too.

Saakhi is far (often the furthest) from both commercial and decentralized public services. It is furthest from the agricultural marketing center, input distribution centers for seed and fertilizer and light engineering work-shop for agricultural machinery. These services are all located in Hafizabad, 37 kms away. Saakhi ranks sixteenth in sample access to the bank, 8 kms distant.

Saakhi has the median sample distance for access to veterinary services, 4 kms away.

Access to administrative services is relatively poor. The village ranks within the bottom 25% of the sample regarding access to the district city of Gujranwala (83 kms distant) and the tehsil town of Hafizabad (37 kms). It ranks sixteenth with respect to the Union Council, 5 kms away and is furthest in access from the police post.

While Saakhi is equidistant from both the Rice and Wheat Research Institutes (111 kms distant), it ranks ninth in its access to the Wheat Institute.

Village access to postal and telephone services is very poor. The post office is located at a distance of 8 kms from the village, four times the median value of 2 kms. Saakhi is furthest in distance to telephone services, 38 kms away.

There is only primary schooling available for boys. The girls primary and secondary schools, as well as the boys secondary school are located 8 kms away from the village. Village access to the girls primary school ranks within the bottom 15% of the sample. The village ranks nineteenth in access to the boys secondary school and is the furthest from the girls secondary school, 37 kms away. Health services located 4 kms away from the village, place Saakhi slightly above the median distance of 3 kms.

Electricity and Irrigation

The village has been electrified for the past four years. There are five government tubewells in the village. However, they do not operate around the clock. In the winter season they operate for eight hours and during the summer for four hours. The village is located in the middle of the water-course. Canal water has been cut during the critical months of March, December, June, July and August. During the past 16 years, village farmers have also invested in 20 to 22 tubewells.

Agriculture

The village area consists of 1,869 acres of arable land. Villagers do not sell their produce to the market commission agent, although they buy rice grain from him. They sell wheat grain, sugar-cane, fodder and milk to the dealer, who buys the crops at the farm-gate. Village consumers exchange rice paddy among themselves. Farmers also sell sugar-cane directly to the mill at Jalalpur.

Farmers normally obtain rice and wheat seed from their own previous crop, the commission agent or the Government Depot. Farmers buy fertilizer from the commission agent or licensed agents. They complain about the shortage of fertilizer and its bad quality. They do not use pesticides.

There is a labor constraint for the summer crops. Labor is locked into the village, and does not migrate outside, even during the agriculturally slack seasons. Work is readily available within the village during the summer at the daily wage-rate of Rs 35 per day.

Technology

There are six progressive farmers in the village with a commensurate level of technology: seven tractors and five threshers.

There is a rental market for wheat and rice ploughing (tractors). There are 20 to 22 donkey and mule-carts and four tractor-trolleys in the village, which serve to transport produce (and people).

Although the extension agent is located 10 kms away from the village, he goes there one or two times a month, and is ready to exchange information with farmers he meets in the village square. There are no demonstration plots of rice or wheat in the village.

'Chiani Hajran' (Village 18).

Access to Infrastructural Services

Chiani Hajran is located on the Hafizabad-Varni Qataran Road. It is one of nine villages on a bus-line. The road passing by the village is paved and in good condition. There is little privately-owned transport: namely, six cycles and two motor-cycles. Three horse-carriages ply commercially.

The population of the village consists of 1,093 people living in an average household size of 6.5 people.

Chiani Hajran has medium access to commercial services which it obtains from Hafizabad the nearest town, 10 kms away. For example, the village ranks twelfth in its access to the agricultural marketing center. It also has the median value for access to the input distribution centers for seed and fertilizer and light engineering work-shop for agricultural machinery. However, the village ranks eighteenth in distance to the bank. It is also one of six villages with veterinary services.

Overall access to administrative and police services is fairly good. Although the village ranks within the lower 40% of the sample regarding access to the district city of Gujranwala (64 kms), it is closer to the tehsil town (Hafizabad) and the Union Council. It ranks fifth and seventh in access to these two services 10 kms and 2 kms away. The village has the median distance of 10 kms to the police post.

The village ranks within the bottom 25% and lower 50% of the sample, regarding access to the Rice and Wheat Research Institutes.

Chiani Hajran ranks close to the median distance regarding access to postal services. Comparable access to telephone services is slightly poorer; within the lower 50% of the sample.

Primary schooling for boys and girls is available within the village. Kot Chiana ranks fourth in access to the boys secondary school (2 kms distant), and sixteenth in access to the Girls Secondary School (10 kms distant). Village access to health services, 2 kms away, place it tenth in the sample.

Electricity and Irrigation

The village has been electrified for the past ten years. There are no government tubewells in the village. The village is in the middle of the water-course, which is seasonal in nature. There is no canal water in the winter, and water is cut off during the summer months of June, July and August. During the past 30 years, farmers have invested in 50 tubewells to irrigate their lands.

Agriculture

The village area consists of 549 acres of arable land. Farmers sell paddy, rice and wheat grains to the market commission agent. Wheat fodder, milk and sugar-cane is sold directly to the dealers and the sugar-mills.

Farmers normally obtain rice and wheat seed from their own previous crop or from the commission agent on cash and on credit. They complained of the adulteration of fertilizer and pesticides, in particular DAP urea which had stones in it.

There is a rental market for wheat and rice ploughing (tractors). Harvesting by combine is also available. There are five donkey and mule-carts and 15 tractor-trolleys which provide transportation for produce.

There is an extreme shortage of labor for agricultural operations in rice, wheat and sugar-cane during both cropping seasons. Work is readily available within the village during these times, at the daily wage-rate of Rs 40 per day.

Technology

The villagers' perception was that there were no progressive farmers in the village, as they were all small farmers. However, there was a good level of improved technology available in the village: 20 tractors, 20 threshers and six reapers.

The extension agent is located 2 kms away. The extension agent visits farmers once a month. The extension agency has planted one or two demonstration plots of rice and wheat in the village.

'Kot Chinna' (Village 19).

Access to Infrastructural Services

Kot Chinna is located 1.5 kms from the Pindi- Bhatian Hafizabad road on the subsidiary feeder (Kaola Tarar) road. It is one of nine villages situated on a bus-line. The road is paved and in good condition, but villagers have to take the local bus to the main road, and then change buses, in order to go to the nearest town of Hafizabad. Local buses pass by every 45 minutes during the day. There is also one horse-carriage available. There is little privately-owned transport, namely: five cycles and two motor-cycles.

The population of the village consists of 394 households with an average household size of six people.

Kot Chinna ranks sixteenth in sample access to the nearest town and agricultural marketing center (Hafizabad), 12 kms distant. The village ranks fifteenth and eighteenth in access to the input distribution centers for seed and fertilizer and light engineering work-shop for agricultural machinery, also located there.

Kot Chinna ranks seventh in access to veterinary services. Along with six other villages, it is the nearest to the bank, also 2 kms distant.

Access to administrative services is variable. The village ranks within the lowest 40% of the sample regarding access to the district city of Gujranwala (68 kms distant). Kot Chiana ranks seventh and twelfth in access to the tehsil town (Hafizabad) and the Union Council, 4 kms away. Village access to the police post (22 kms distant) is third to last within the sample.

Kot Chinna ranks tenth in sample access to the Wheat Research Institute (110 kms distant). Access to the Rice Research Institute, 128 kms distant is relatively much worse.

While the village has median access to the post office, it ranks sixth in access to telephone services (both 2 kms away).

Available primary schooling for boys and girls in the village, is staffed by five male and four female teachers. The village ranks fourth and twelfth in distance to the boys and girls secondary school located 2 kms and 4 kms away. The village ranks eighth in sample access to health services, 2 kms distant.

Electricity and Irrigation

The village has been electrified for the past 28 years. Two government tubewells have been operational during this time. However, water is not always readily available, as electricity is cut off, for one to four hours daily. Farmers have also invested in 30 tubewells. Although the village is at the head of the water-course (itself perennial and half-paved), water is blocked by farmers relatively further upstream. Hence villagers complain of water shortage in canal-water.

Agriculture

The village area constitutes 287 acres. Villagers engage in barter trade (clarified butter and rice grain) among themselves. They also exchange rice paddy and wheat grain, but sell the surplus (from these two main crops) to the commission agent. The dealer buys surplus straw and milk for sale outside the village, but villagers also trade in wheat straw. Vegetables are sold to the commission agent.

Farmers normally obtain rice and wheat seed from their own previous crop. The commission agent is their source of obtaining fertilizer and pesticides both in cash and credit. They complain about the bad quality and adulteration of pesticides, but had no other complaints regarding input useage.

There is labor shortage only during winter. This shortage arises because labor goes to the cities to earn extra money at this time. Farmers use contract and exchange[9] labor in addition to family labor.

Technology

There is only one progressive farmer in the village. However, there is proportionally more improved technology available: eight tractors, six threshers and two reapers.

The extension agent is located 5 kms away. He visits the village once a month. The extension agency has not planted any demonstration plots of rice and wheat in the village.

There is a rental market for wheat and rice ploughing (tractors) and combine harvesting (available at relatively moderate rates). Modes for transportation of produce include four donkey and mule-carts and six tractor-trolleys in the village.

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[9] Exchange labor is an informal arrangement. One farming household sends out one or more of its able-bodied laborers to another farming household when the latter face a labor constraint, and vice versa.

'Amoke' (Village 20).

Access to Infrastructural Services

Although centered around Muridke market, Amoke is located 2 kms to the west of the (main) Sheikhupura-Gujranwala road. The bus-stop is located on this main road. The link road to the bus-stop on the main road is paved and in good condition. It takes one-half hour to reach the bus-stop from the village on foot and ten minutes by horse-carriage.

The population of the village consists of 3,076 people living in an average household size of 6.5 people.

Amoke relies on the nearest town of Sheikhupura (an industrial metropolis), 12 kms distant, for a number of services. Amoke ranks sixteenth, fifteenth and eighteenth in its access to the agricultural marketing center, input distribution center for seed and fertilizer and light engineering work-shop for agricultural machinery. This village is also one of six villages located closest to the bank.

Amoke ranks seventh in its access to veterinary services (2 kms distant).

Access to Government administrative services is relatively good. The village ranks third and seventh in access to the district and tehsil town (Sheikhupura) respectively. Amoke ranks sixteenth in its access to both the Union Council and police services, 5 kms and 12 kms distant.

Amoke is located relatively closer to the Rice Research Institute (66 kms) than to the Wheat Research Institute, located at the sample median distance (114 kms).

Amoke is one of nine villages which has postal services within it. It is also the only village which has telephone services available.

Primary schooling for both boys and girls is staffed by eight male and three female teachers. The village ranks fourth and fifth in its access to the boys and girls secondary school, located at a distance of 2 kms. Amoke is one of six villages with health services within it.

Electricity and Irrigation

The village has been electrified for the past ten years. Electricity is cut off for an average amount of three hours daily in the winter, and five hours daily in the summer, which aggravates the water constraint (see below).

There are no government tubewells in the village. The village is 2.5 kms from the middle of the water-course, which is a perennial one. However, the canal water is cut off by the village headman, during the months of June, July and August, so that villagers complain of a water constraint in these months. Villagers have invested in 175 private tubewells (the highest within the sample) since 1972.

Agriculture

The village area consists of 3,237 acres of arable land. Farmers sell rice paddy, vegetables and wheat grain, the main cash crops to the commission agent. There is a market for clarified butter, wheat straw and milk in the village, although the dealer buys surplus quantities of the latter two commodities for sale, in Sheikhupura.

Farmers normally set aside rice and wheat seed from their own previous crop, in addition to obtaining wheat seed from the Government depot. They obtain fertilizer and pesticides from licensed shops and from the commission agent on credit. They complain about the shortage of DAP fertilizer and Padhan (a granular insecticide) in the market. Both fertilizers and pesticides are adulterated.

Farmers do not go out of the village for seasonal work. Vegetables are grown extensively in Amoke; with a resulting demand for female (and child labor). There is also demand for male and female labor for rice uprooting, transplanting and harvesting operations.

Technology

There is a rental market for ploughing and threshing machines including combine harvesters. Tillage rates for rice are very high. Produce and fertilizer is transported using 15 donkey and mule-carts and 15 tractor trolleys.

There are four progressive farmers in Amoke. However, there is proportionally more improved technology available in the village: 20 tractors, seven threshers, three reapers and one ridger.

The extension agent visits selected (progressive) farmers once or twice a week. He is located 5 kms away. However, the extension agency has not set up any demonstration plots of rice and wheat in the village.

'Kot Sadu Ram' (Village 21)

Access to Infrastructural Services

Kot Sadu Ram is located on the Nankana Sahib-Buchina Road. It is one of nine villages on a bus-line. The road passing by the village is paved and in good condition. There is some privately-owned transport in the village, namely 40 cycles and five motor-cycles.

Kot Sadu Ram obtains nearly all its infrastructural services from Nankana Sahib, which is 5 kms distant. It ranks third, fourth and sixth in access to the nearest input distribution centers for seed and fertilizer, agricultural marketing center and the light engineering work-shop for agricultural machinery. The village ranks tenth in access to the bank and sixteenth in distance to veterinary services.

Access to administrative services is fair. Kot Sadu Ram approximates the median and mean distance to the district city of Sheikhupura (55 kms). While the village ranks second in sample access to the tehsil town, it ranks sixteenth in such access to the Union Council. Regardless both services are located at Nankana Sahib. The village ranks third in access to the police post.

Kot Sadu Ram is second-nearest to the Wheat Research Institute (70 kms distant) among sample villages. The Rice Research Institute is relatively further away (85 kms).

Both postal and telephone services are 5 kms away. However, the village ranks twenty-first in access to the post office and eleventh in such access to telephone services.

Primary schools for boys and girls are available within the village. Secondary school education and health services are in Nankana Sahib. The village ranks thirteenth and fifteenth in its access to the girls and boys secondary school.

Electricity and Irrigation

The village has been electrified for the past ten years. Farmers cannot run their electric tubewells part of the time as electricity is cut off for four hours from December to March and for one to two hours from July to August (see below).

The three government tubewells in the village are non-operational because they are out-of-order. The village extends from the head of the perennial water-course to 2 kms away from it. There is a water constraint in the village, as the government tubewells are non-operational and the system of canals is cut off for four hours in January, and for eight hours during June, July and August. During the past eight years, farmers have invested in 26 tubewells.

Agriculture

Farmers sell their main cash crops of rice grain, paddy and wheat grain to both the commission agent and market dealers. However, the dealer is the sole marketing agent for wheat fodder, milk and clarified butter.

Farmers normally obtain rice and wheat seed from their own previous crop or from the commission agent. They complain of the untimeliness of seed availability, bags of seed being underweight and of mixed quality, resulting in poor germination of wheat, berseem and vegetables. Farmers' constraints also include untimeliness in the availability of fertilizer and the poor quality of DAP and urea fertilizer. Pesticides are sold beyond their expiration dates in the market.

There is a rental market for land preparation and rice tillage. Combine harvesting is not available. There are 20 donkey and mule-carts for transporting agricultural produce and fertilizer.

There is a labor constraint during both cropping seasons. There is ready demand for male, female and child labor within the village for critical farming operations, regarding wheat and rice. The daily wage rate within the village is Rs 40.

Technology

There are four progressive farmers in the village. However, there is little improved technology available in the village: two tractors and one thresher. There is also one pair of bullock-carts in the village.

The extension agent visits the progressive farmers in the village once in six months. He has also set up one demonstration plot each of rice and wheat in the village.

'Pir Kot' (Village 22)

Access to Infrastructural Services

Pir Kot is located off-shore from the junction of the Qadirabad link canal which connects the River Chenab to the Ravi River. It is 10 kms from the Lahore-Jaranwala road.

The village populatiom consists of 943 people living within an average household size of 6.6 people.

Pir Kot ranks twenty-second in its access to the bus-stop 10 kms away. As the road to the bus-stop is in very poor condition with paved (3 kms) and unpaved (7 kms) portions, it takes two hours to reach the bus-stop on foot or by horse-carriage. Private transport available in the village consist of 15 bicycles and four motor-cycles. They are supplemented by five horse-carriages which ply commercially.

Pir Kot ranks in the bottom 20% of the sample regarding its access to the marketing center, the input distribution center for seed and fertiliser and the light engineering work-shop for agricultural machinery, all located in the market town of Faizabad (18 kms distant). The village ranks in the bottom 10% of the sample regarding its access to the bank and veterinary center, also available there.

Access to administrative services is fair. Pir Kot ranks ninth in access to the district town (Sheikhupura), 50 kms distant. However, the village is furthest away from the tehsil town of Nankana Sahib (43 kms). The village has the median distance of 4 kms to the Union Council. It also lies within the bottom 25% of the sample regarding distance to the police post, 18 kms away.

The village ranks sixth and tenth in its access to the Rice and Wheat Research Institutes, 48 kms and 110 kms distant.

Pir Kot has nearly uniformly poor access to additional infrastructural services available from Faizabad. Thus Pir Kot is second and fifth from the bottom in its access to the Post Office and telephone services, respectively. In spite of having primary schooling for boys and girls, Pir Kot still ranks in the bottom 15% of the sample in its access to secondary school education for girls and boys. However, the village has median access to health services, 4 kms away.

Electricity and Irrigation

The village was electrified seven years ago. The electricity in the village was turned off for six hours daily from December to February and from June to August, thereby affecting the operation of the tubewells. Four Government tubewells have been installed since 1968. Two of them were operational during the winter, and only one was operational during the summer. The transformer was defective and the motors were burnt in the remaining tubewells. The village is located 0.5 kms from the head of the water-course, which is perennial. There is no constraint at all in water availability, given the village location at the head of the main water-course. There is only one privately-owned tubewell in the village. It was installed fours year ago.

Agriculture

The village consists of 957 acres of arable land. Rice is grown on 80% of the area, within Pir Kot. Given that the commission agent is the main marketing agent for grains (rice and wheat) and paddy, the villagers feel that the poor access to marketing and transportation facilities are a major constraint to their agricultural operations. The village dealer sells other crops, namely: wheat straw, milk and clarified butter.

Farmers use their own wheat and rice seed. They also buy wheat seed (and fertilizer) from the commission agent, and rice seed from the Government depot. They pay cash for all inputs. Farmers complained about the quality of fertilizer as well as the shortage in fertilizer (particularly DAP) in the market. They had no complaints about pesticides.

There is a labor constraint for critical farming operation during both cropping seasons, when there is a market for contract labor (consisting of poorer families in the village). These laborers often claim a large sum of money in advance, before they work. Labor is locked within the village and is immobile.

Technology

There are five progressive farmers in the village, with some improved technology: fourteen tractors, five threshers and four reapers. The extension agent (or Field Assistant) located in Faizabad, never comes to the village. Hence there are no rice and wheat demonstration plots there.

The rental market for wheat and rice ploughing, threshing and combine harvesting is localized, with rather modest rental rates.

Ten tractor-trolleys form the main modes of transport for produce. They are supplemented by three donkey carts. Transportation costs are very high.

'Ghazi Kakkan' (Village 23)

Access to Infrastructural Services

Ghazi Kakkan lies to the south-east of Gujranwala market. It is located 22 kms due east of the Grand Trunk Road on the road from Narang to Kala Khatai. Ghazi Kakkan is located on the west bank of the Ravi River.

The village populatiom consists of 1,173 people living within an average household size of 6.2 people.

Ghazi Kakkan ranks second in its access to the bus-stop, 1 km away. The road to the bus-stop is unpaved but in good condition and is easily reached within ten to 15 minutes. The local bus passes by the village, every two to three hours during the day-time. However the villagers complain that they require much more frequent transport. There is no commercial transport in the village, although some people do have bicycles.

Ghazi Kakkan has relatively poor access to a number of commercial and marketing services. Thus the village ranks in the bottom 25% of the sample in its access to the input distribution centers for seed and fertiliser, the agricultural marketing center and the bank. These services are located in Narang, 17 kms away. Ghazi Kakkan ranks second to last in its access to the light engineering work-shop for agricultural machinery, located 31 kms away, in Shahdra.

The village ranks nearer eighth in access to the veterinary center, 2 kms distant.

Access to administrative services is fair. Ghazi Kakkan ranks eighteenth in access to the district town of Sheikhupura, 59 kms distant. The village has the median distance of 24 kms regarding its access to the tehsil town of Ferozewala. The Union Council is also accessible from the village at the median distance of 4 kms. The village ranks second to last in its access to the police post, located at a distance of 24 kms.

The village has better access to the Rice Research Institute, 43 kms away, than to the Wheat Research Institute, (159 kms distant).

While both postal and telephone services are located 2.50 kms away, the village ranks eighth and eighteenth in such access to these two services.

Ghazi Kakkan has relatively poor access to educational facilities. The nearest primary schooling facilities are in Lubanwala (a neighbouring village) 2.5 kms away. Secondary schools for boys and girls are located in Shahdra 31 kms distant. The village also ranks eleventh in access to health services, located at a distance of 2.5 kms.

Electricity and Irrigation

The village has been electrified for 11 years. Electricity in the village is turned off for three to four hours daily from December to February and from May to June, thereby affecting tubewell operation adversely. Two Government tubewells were installed in 1965. During the two cropping seasons in 1992, only one tubewell was operational, because the other one broke down a year ago, and repairs typically take a long time. Villagers have also invested in 13 private tubewells since 1983. The village is located 0.5 kms from the head of a major water-course which is perennial in nature. There is little constraint in water availability.

Agriculture

The village consists of 1,822 acres of arable land. Rice and wheat are the main village crops. Farmers take rice paddy, wheat grain and straw to the commission agent in the market or an outside dealer collects the crop (in trucks), directly from the farm-gate. Milk is sold by a local dealer while milk products (e.g butter) are exchanged within the village.

Farmers use their own wheat and rice seed. Progressive farmers also buy wheat seed from the Government depot and rice seed from the Rice Research Institute. Fertilizer is bought from the government or licensed agents in the market, but only the commission agent sells the input on credit. Farmers complain about the shortage of DAP in the market but have no complaints regarding pesticides.

There is a labor constraint for critical farming operations particularly during the summer season, when sugar-cane and vegetables are grown in addition to rice. There is a market for contract labor (consisting of the poorer families).

Technology

There are five progressive farmers in the village, with little improved technology: ten tractors, one reaper and two instruments of primary tillage (one rotavator and one disc plough). The extension agent (or Field Assistant) comes to the village occasionally, but has not planted rice and wheat demonstration plots there.

The rental market for wheat and rice ploughing, threshing and combine harvesting is localized. Combine harvesting is available. Ten tractor-trolleys are the main modes of transport for produce, together with a suzuki van.

'Chak No 49' (Village 24).

Access to Infrastructural Services

Chak No 49 is located south-east of Muridke market. The road to the village branches due east of off the G.T Road at a distance of 10 kms south of Muridke. The distance of 2 kms from the village to the bus-stop is only in fair condition but is easily traversed in 15 minutes on foot (due to a short-cut) and 10 minutes by horse-carriage.

The bus runs every one and one-half hours from dawn to dusk. There is no commercial transport to the bus-stop.

Chak No 49 has a population of 789 inhabitants who live in an average household size of 6.6 people.

The village obtains about half of its services from Muridke (20 kms distant), with most of the remaining services obtained from various neighbouring villages. Chak No 49 ranks in the bottom 15% of the sample in access to the marketing town, input distribution center for seed and fertiliser, the light engineering work-shop for agricultural machinery and the bank, all of which are at Muridke. Village access to the bank is third to last within the sample.

Chak No 49 ranks tenth in access to the veterinary center, 4 kms away in Mubarak Pura. It takes 1.5 hours to reach Mubarak Pura. Village access to this service ranks within the bottom 15% of the sample.

This village has fairly good access to administrative services. It ranks tenth and thirteenth in its access to the district and tehsil towns. It has median access to the Union Council (4 kms distant). However, Chak No 49 ranks among the bottom 15% of the sample in access to the police post, 19 kms distant.

Chak No 49 is the village nearest to the Rice Research Institute (13 kms). But access to the Wheat Research Institute (162 kms distant) is further than the mean of 130 kms.

The village is comparatively much nearer to the Post Office (4 kms) than to the telephone (20 kms).

Chak No 49 is the only village which has no primary schooling for either boys or girls. The boys primary school is 4 kms distant. Girls primary schooling and secondary schooling facilities for both sexes are available in Muridke, about 20 kms distant. The village ranks in the bottom 25% of the sample, in access to these facilities.

The village ranks fifteenth in its access to health services 4 kms distant,

Electricity and Irrigation

The village has been electrified for 10 years. Electrical power is regularly turned off (by WAPDA) during February, March, September and October for four hours regularly. The village is located in the middle of a minor water-course which is seasonal in nature. However it is served by two water channels, located at a distance of 1 km and 1.5 km from the village. There are two functional Government tube-wells, out of a total of four such tube-wells in the village. Villagers suffer from a shortage of water from June to August. Their major complaint consists of the cutting off (and diversion) of water by upstream villagers, and the periodic cutting off of electrical power by the Water and Power Development Authority (WAPDA).

Agriculture

The village consists of 996 acres of arable land. Wheat grain and paddy are the main cash crops. They are marketed by the commission agent and the village input dealer. The latter goes to sell the milk surplus in Muridke regularly. Clarified butter is traded within the village itself.

Farmers use their own wheat seed or obtain it from the commission agent in Muridke. However, they often buy rice seed from the Rice Research Station. Farmers obtain fertilizer from the commission agent but complain that it is too expensive and weighs less than the required amount of 50 kgs. Another complaint is that pesticides are less than the standard weight.

There is a labor shortage for critical summer crop (rice) operations.

Technology

There are two progressive farmers in the village with a modest amount of improved technology available: five tractors and three threshers. The extension agent (or Field Assistant) meets the progressive farmers once or twice a year. The extension agency has not planted any rice and wheat demonstration plots here. However, crop scientists from the Rice Research Institute have visited the village to give technical advice to the farmers.

There is a also rental market for wheat and rice ploughing, and threshing. Combine harvesting is not available at all. Donkey /mule-carts and tractor-trolleys (about three and five in number respectively), are the main form of transport for produce.

'Rakh Chak Khali' (Village 25).

Access to Infrastructural Services

Rakh Chak Khali is about 2.5 kms south of the district road connecting Pindi Bhatian and Sukheky. The village is located on this district road, which is to the south of the nearest market town of Hafizabad. It takes one hour to reach the bus-stop (2.5 kms away) both on foot and by horse-carriage due to the rough condition of the road (consisting of both brick and unpaved portions).

The bus runs every half hour, 24 hours a day. Four horse-carriages provide transport, to and from the bus-stop. There is little private transport to supplement these two transport modes: just three motor-cycles and six bicycles.

There are approximately 500 to 600 inhabitants within the village.

Rakh Chak Khali obtains many of its services (unless stated otherwise) from Sukheke, the nearest marketing town, 11.5 kms away. The village ranks fifteenth in sample access to marketing facilities and has the median ranking for the input distribution center for seed and fertiliser. Village access to the light engineering work-shop for agricultural machinery lies within the lower 40% of the sample.

The village ranks within the lower 25% of the sample with respect to access to the bank. It ranks third to last in access to veterinary services.

Rakh Chak Khali is one of six villages which has a Union Council within it. However, its access to other administrative services is very poor. The village ranks second to last and last in sample access to the tehsil town of Hafizabad (41.5 kms) and the district city of Gujranwala (111 kms distant). However, Rakh Chak Khali ranks comparatively higher (fifteenth) with regard to access to the police post, 11.5 kms away.

While this village ranks second to last among all villages in access to the Rice Research Institute, 152.5 kms distant, it ranks eighth in access to the Wheat Research Institute located at a distance of 102.5 kms.

Rakh Chak Khali ranks third to last in access to the Post Office, 11.5 kms away, while it ranks higher nineteenth in such access to telephone services located in Muridke, 10 kms distant.

Rakh Chak Khali has primary schooling services for both sexes. Both secondary schools for boys and girls and the health clinic are located in Sukhekhy. The village ranks twenty-first and nineteenth in access to the boys and girls secondary schools respectively. Village ranking is among the bottom 15% of the sample regarding access to the health services.

Electricity and Irrigation

The village has been electrified since 1986. Electricity in the village was turned off for four hours daily only during December 1991. Three Government tubewells have been available in the village, since 1961. However, during the 1991-92 crop year, only two such tubewells were operational, as one was out-of-order due to an electrical fault. While Rakh Chakh Khali is located 5 kms from the tail-end of the water-course, canal water is totally cut-off, so that the village has no access to irrigation at all.

Agriculture

The village comprises 307 acres of arable land. Wheat grain and rice paddy are the main marketable crops. They are sold to the commission agent (in Gujranwala). However, the village dealer buys milk and clarified butter to sell within Gujranwala. Farmers exchange wheat fodder among themselves. Vegetables are traded through the village shop-keeper as well as among the villagers themselves.

Farmers obtain seed from their own previous crop and from the commission agent. Their complaints include short supply in, and high prices of fertilizer, which they obtain on credit from the commission agent. They have no complaint regarding pesticides.

There is a labor shortage for critical wheat, rice and vegetable crop operations. There is work available within the village for Rs 50/- day. Villagers do not normally go out of the village to seek work.

Technology

There are four progressive farmers in the village with some improved technology: five tractors and three threshers. There is also one bullock-cart. The extension agent (or Field Assistant) meets the progressive farmers three times a week. However, the extension agency has not planted any rice and wheat demonstration plots here.

There is a also rental market for wheat and rice ploughing, and threshing. Combine harvesting is available at relatively modest rental rates. Two donkey cum mule-carts and three tractor-trolleys are the main modes of transport for produce.

'Kot Baqir' (Village 26).

Access to Infrastructural Services

Kot Baqir lies south-west of Gujranwala market. It is 2 kms away from a bus-stop on the Gujranwala-Sheikhupura road. The road to the bus-stop is easily-traversed in 15 minutes on foot (due to a short-cut) and in ten minutes by horse-carriage (of which there are two in number). The bus is conveniently available at all times. There is little complementary private transport: three motor-cycles and eight bicycles.

Kot Baqir is a small village. It has a population of 705 inhabitants who live in an average household size of 6.4 people.

Kot Baqir obtains nearly all of its services from two urban locations: Gujranwala city (12 kms) and Maraliwala (3 kms distant). The village approximates median values in its access to the nearest market marketing town, and input distribution center for seed and fertiliser. Kot Baqir ranks fourth in access to the light engineering work-shop for agricultural machinery and the bank, both located in Maraliwala.

Village access to the veterinary center is equal to the sample median of 4 kms.

Kot Baqir has comparatively good access to administrative services. It ranks third and seventh in sample access to the district and tehsil town (both in Gujranwala) and tenth is such access to the Union Council (in Maraliwala). The village ranks sixteenth in relative access to the police post 12 kms distant.

The village is closer in access (twelfth) to the Rice Research Institute (72 kms distant), than to the Wheat Research Institute (162 kms away).

The village ranks ninth and nineteenth in access to telephone services and postal services, both of which are 3 kms away.

Kot Baqir has primary schooling services for both sexes. It has median access to the boys' secondary school and health services, 3 kms distant. Village access to the girls' secondary school, also 3 kms away is relatively better (eighth).

Electricity and Irrigation

The village has been electrified for 12 years. The electricity was turned off (by the Water and Power Development Authority or WAPDA) regularly, during Rabi 1992 for four hours. The village has no access to any form of canal water or Government tube-wells.

Agriculture

The village consists of 549 acres of arable land. Wheat grain, rice paddy, vegetables and wheat straw are the main crops. Farmers sell wheat grain and paddy to the commission agent. The input dealer buys milk and wheat straw for onward sale to Gujranwala.

Farmers either use their own rice and wheat seed or obtain it from each other. The village shopkeeper and commission agent supply fertilizer on cash and credit respectively. Farmers complain about the shortage and high prices of fertilizer. Both fertilizer and pesticides are adulterated.

There is a labor shortage for critical wheat, rice and vegetable crop operations.

Technology

There are four progressive farmers in the village with only a modest amount of improved technology, namely: three tractors and threshers. There is also one bullock-cart. The extension agent (or Field Assistant) travels 3 kms to meet the progressive farmers once a week. However, the extension agency has not planted any rice and wheat demonstration plots here.

There is also a rental market for wheat and rice ploughing and threshing. Combine harvesting is available at relatively modest rental rates. Donkey and mule-carts and tractor-trolleys (eight and three respectively) are the main mode of transport for produce.

'Kuri Kot' (Village 27)

Access to Infrastructural Services

Kuri Kot lies to the south-east of Gujranwala market. The road from the village to the nearest bus-stop in Wando (6 kms distant) is unpaved, and in poor condition, so that it takes one and one-half hours to reach it on foot, and one-half hour by horse-carriage. Four horse-carriages provide transport, to and from the bus-stop. Villagers also own 25 bicycles.

The population of the village consists of 892 inhabitants living in an average household size of 4.63.

Kuri Kot obtains commercial, credit, animal and human health, extension, security and telecommunciations services from Wando.

The village ranks sixth in distance to both marketing facilities and the input distribution center for seed and fertiliser and ninth in such access to the light engineering work-shop for agricultural machinery.

The village has the sample median value regarding distance to the bank. It ranks eighteenth in access to veterinary services.

Kuri Kot is relatively far away from most administrative services. The village ranks twentieth in access to the tehsil town of Kamoke and the Union Council. Their respective distances of 36 kms and 6 kms are greater than the corresponding median distances of 24 kms and 4 kms. Kuri Kot ranks fifth and eight in distance to the district town (Gujranwala), and security services, 40 kms and 6 kms away respectively.

While the village ranks eighth in access to the Rice Research Institute, 66 kms away, it is furthest away from the Wheat Research Institute (210 kms) away.

The village has the median value with regard to access to telephone services, but lies within the bottom 25% of the sample in access to postal services, although both services are 3 kms distant.

Kuri Kot has primary schooling services for both sexes. Both secondary schools for boys and girls and the health clinc are located in Wando. While it has the median value for access to the girls secondary school, the village ranks seventeenth and twentieth in access to the boys secondary school and health services.

Electricity and Irrigation

While the village has been electrified for ten years, electricity is cut off (by WAPDA) regularly for three hours during December and June. The village has no Government tubewells and neither does it have any access to canal water. However, farmers have invested in 34 tubewells during the last 30 years.

Agriculture

The village has 1,129 acres of arable land. Wheat grain and rice paddy generate a marketable surplus. They are sold to the commission agent (in Gujranwala). There is a local village market for milk and wheat straw. However the dealer buys surplus quantities of this produce for sale in Wando. Villagers also deal in clarified butter.

Farmers obtain wheat and rice seed from their own previous crop. They also buy rice seed from the dealer. Farmers complain of the high prices, short supply and the poor quality of fertilizer, which they obtain from the commission agent. They also object to the shortage in market supply of pesticides as well as their poor quality.

There is a labor shortage for critical wheat and rice crop operations because labor can easily find work in the city. Work is available within the village for Rs 40/-day.

Technology

There are four progressive farmers in the village with some improved technology: seven tractors and three threshers. The extension agent (or field assistant) meets the progressive farmers once in two weeks. However, the extension agency has not planted any rice and wheat demonstration plots here.

There is a rental market for wheat and rice ploughing, and threshing. Combine harvesting is available. Donkey and mule-carts and tractor-trolleys (about three and seven respectively), are the main form of transport for produce.

'Pir Kot' (Village 28)

Access to Infrastructural Services

Pir Kot is located north-west of Hafizabad market. It is the sample village furthest from the bus-stop, which is 20 kms away in Vanike, the nearest town. Although the road is paved and in fairly good condition, it takes two hours to reach the bus-stop by horse-carriage. Villagers own five bicycles in addition to five horse-carriages, the commercial means of transport.

The population of the village consists of 943 inhabitants living in an average household size of 6.6.

Pir Kot obtains most of its services from Vanike, 20 kms away. Hence its relative access to many services (commercial, administrative, etc) is very poor. The village ranks among the bottom 15% of the sample regarding its access to the marketing facilities, input distribution center for seed and fertiliser, light engineering work-shop for agricultural machinery and veterinary services.

Pir Kot also ranks third from last in sample access to the nearest bank, and the veterinary center, in Vanike.

Access from the village to all the administrative services is uniformly poor. Pir Kot ranks last in sample access to the the Union Council. The village is the second to last in access to the district town (Gujranwala, 94 kms distant). Pir Kot ranks twenty-fifth in access to the tehsil town and the police post, 40 kms and 20 kms distant.

While Pir Kot is furthest away from the Rice Research Institute, 160 kms away, it is relatively nearer to the Wheat Research Institute (180 kms).

Pir Pot is also furthest away in its access to the postal services. Access to telephone services is only slightly better.

Pir Kot only has primary schooling services for boys. Such schooling for girls in addition to secondary schools for boys and girls and the health clinic are in Vanike. Although Pir Kot ranks twenty-third in access to the secondary school for girls, it has even worse access to the boys secondary school to which it ranks last in the sample. The village is also furthest in access to the health services.

Electricity and Irrigation

The village has been electrified only since the past few months. Nevertheless, electricity is cut off (by WAPDA) regularly for three to four hours daily. The village has no Government tubewells. Nor does it have any access to canal water as there is no water-course in the area. However, farmers have invested in ten tubewells since 1988.

Agriculture

The village has 957 acres of arable land. Farmers sell surplus rice grain, paddy, wheat grain and straw in Vanike to the commission agent.

Farmers obtain wheat and rice seed only from their own previous crop. They buy fertilizer from the commission agent both on cash and credit. Farmers complain about the prices and short supply of both fertilizer and pesticides.

Family and village labor is hired during critical wheat and rice crop operations, during which there is labor shortage. Village wage rates are the lowest in the sample. Labor is immobile and does not travel outisde the village.

Technology

There are no progressive farmers in the village and there is little improved technology: two tractors and one thresher. The extension agent (or Field Assistant) has never visited the village, nor has the extension agency planted any demonstration plots here.

The rental market for wheat and rice ploughing is relatively very expensive. Rental threshing harvesting by combine is also available. One donkey-cart and four horse-carriages are the main forms of transport for produce, and transport is relatively expensive. There are also two tractor-trolleys available.

APPENDIX III

APPENDIX III: BINOMIAL PROBABILITY OF OFF-FRAM EMPLOYMENT

Methodology

The hypothesis that greater access to all infrastructural services (or the key indicator, the off-farm labor market) leads to greater opportunities for off-farm employment is itself based on an underlying premise. This premise or hypothesis is that the probability of acquiring off-farm employment in more accessible infrastructurally developed areas is different from the probability of obtaining such employment in lesser infrastructurally-developed areas. The two-step process whereby this underlying assumption is specified and tested for, is described next.

The null and alternative hypotheses are initially stated in verbal terms:

H_o: Higher overall access to infrastructure has no effect on the probability of obtaining off-farm employment.

H_1: Higher overall access to infrastructure has a positive effect on the probability of acquiring off-farm employment

The measure used to denote off-farm employment is obtained by counting the numbers of individuals in a household who work off the farm and giving a weight of unity (or 1) to each of these households. A household is considered to be engaged in off-farm employment if at least one person is engaged in off-farm employment:

For the j'th farm-household: $OFF\_E = \Sigma_{i=1 \text{ to } n} (OFFM\_E)$

where OFF_E = the off-farm employment level of the j'th farm-household and i=1..n, the number of individuals in a farm-household.

After defining the measure of off-farm employment, the two hypotheses are re-stated in analytical form as:

H_o: $Pr\ (OFF\_E)^H = Pr\ (OFF\_E)^L$ AND

H_1: $Pr\ (OFF\_E)^H = Pr\ (OFF\_E)^L$,

where superscripts H and L = High and Low infrastructural villages,

$Pr\ (OFF\_E)^H_j$ = Probability of the j'th farm-household working off-farm in a high-access village.

$Pr\ (OFF\_E)_{Lj}$ = Probability of the j'th farm-household working off-farm in a low-access village. (Note: $0 =< Pr\ (OFF\_E)_j =< 1$ for both high and low-access villages).

In this form, the null hypothesis asserts that the probability of adult males of the farm-household obtaining employment within the high access villages is the same as their probability of obtaining employment in the low-access villages. In order to operationalize and test this hypothesis, the probability of obtaining off-farm employment has to be initially computed for the high access villages.

Households in both the high and low access villages are assumed to follow an underlying binomial distribution as both villages and households within them have been randomly chosen within a multi-stage sampling procedure. The number of farm households engaged in off-farm employment in high access villages is computed by means of the following formula in which the individual farm-household probability (given by the first formula on Page) are summed over j households:

$$\Sigma_{j=1 \text{ to } k} (OFF\_E)^{H} = \Sigma_{j} \Sigma_{i} (OFFM\_E)^{H}$$

where j = 1..k are the number of households.

The resulting statistic obtained is an estimate of the probability for obtaining off-farm employment within the underlying population of high-access villages. Similarly the probability (signifying opportunity) for getting off-farm employment in lesser accessible infrastructurally developed villages is found to be at least 0.36. These odds ratio are statistically significant at the 0.05 level. Hence the null hypothesis that the level or proportion of households engaged in off-farm activity is the same across high and low access villages has to be rejected. It is also inferred that the proportion of off-farm employment of farm households is significantly affected by their infrastructural access.

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