Wheat Harvest Technology in Punjab's Rice Wheat Zone: Combines, Laborers and the Cost of Harvest Delay

Melinda Smale
Agricultural Economist

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Khalida Perveen, Rural Sociologist
M. Shafiq-ur-Rehman, Agricultural Economist
Maqsood Ahmed Hussain, Agricultural Economist
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Executive Summary

Combine-users in Punjab's rice-wheat zone tend to be large owner-operators who harvest a total of over 20 hectares in either wheat or rice. Although a slightly higher proportion combine rice, those who combine wheat hand-harvest a smaller percentage of their total crop area. In wheat, the percentage of crop area hand-harvested is likely to depend on animal herd sizes, since most combine-users previously sold wheat straw and now meet their dry fodder needs by hand-harvesting some area. By comparison, the proportion of rice area that is hand-harvested may reflect the crop's varietal composition and the wetness of the farmers' fields. The relationship of varietal composition, field condition, and rice area combined merits further research attention.

At present, imperfect information in the custom combine market probably dominates these decision-making criteria. Many farmers stated that they would have combined a larger area if they had known of or had obtained combine services earlier. In Indian Punjab, Laxminaryan et al. also found that the majority of combine-users hand-harvested some acreage, both because they needed wheat straw for fodder and "they experienced difficulties and uncertainties in obtaining the services of the combine"(p.82).

The youth of the industry and the high cost to companies of "advertising" their services, or establishing and maintaining close contact with their clients, undoubtedly contributes to some contractual difficulties. Most combine-users had only one or two years of experience renting combines, and knew little about the machine itself or the companies from which they hired the combine. Most contracts were verbal. About half of the farmers were informed of combine availability by company representatives, and about half were informed by other farmers.

Despite any difficulties in communicating with the companies, farmers estimated that, on the average, combines arrived only 3 days after rice crop maturity and 5 days after wheat crop maturity. A number of farmers experienced no delays because their contracts were negotiated in the fields when combines arrived in the area. Farmers recalled that in hand-harvesting wheat, over the three years preceding the shift in technology, they waited a comparable period for contracted laborers to begin harvesting their fields. Although initial delays may be similar, the difference in average harvest duration with the two technologies is dramatic. For these large farmers, combines cleared the wheat fields 8 days after crop maturity, including delays. Hand-harvesting the same fields, laborers did not complete cutting and threshing until 28 days after crop maturity.

Yield comparisons indicate that, as a consequence of shattering losses associated with long harvest duration, farmers' wheat returns increased by over 10 percent when they shifted technologies. At current rental and wage rates, with yield

increases, farmers gain net revenues when combining wheat, despite the loss of wheat straw sales. Although average yield increases associated with combining were even higher in rice, these were partially offset by lower prices received for broken rice. At current wage and rental rates, farmers lost net revenue when combining rice. The slight loss in rice revenues may be offset by timely planting of wheat, or if the farmer combines both crops, by the gains in wheat revenues. Further research should investigate the comparative harvesting costs for rice more thoroughly.

Hand-harvesters operating over 10 hectares (potential combine-users) also tended to be owner-operators who themselves contracted and supervised harvest laborers. Most of them paid heavily in grain, straw, and other in-kind payments for wheat harvest labor. Although they tended to contract labor well before crop maturity, a large proportion of them experienced both pre-harvest labor delays and delays during the harvest, when laborers sometimes left their fields to work for other farmers.

The estimates provided by hand-harvesters confirm the substantial costs of harvest delay. Based on a three-year average and farmers' recall, a large hand-harvester in the rice-wheat zone can expect a 10 to 12 percent yield loss in years of longer delays. In 1986, laborers cleared the fields of these large farmers an average of 27 days after crop maturity. At "crop maturity," the average moisture content of the wheat was only 10.5 percent, which is dry by agronomists' standards. Given the dryness of the crop, and the increased rainfall probabilities associated with prolonged harvest duration, yield losses are not surprising.

As compared to the custom combine market, the harvest labor market appears personal in nature. Despite increased labor mobility and commercialization in Gujranwala District, the locus of the wheat harvest labor market seems to remain the village and nearby villages. Eighty-five percent of the farmers hired labor from their village of residence. Farmers tended to know most of the laborers they hired, and most laborers claimed the village where they were harvesting as both their residence and their home. Many of the laborers hired from outside the farmers' villages lived in nearby villages. Certain exceptions were discovered, such as several farmers who hired contract labor teams through the local grain merchant, and transported them to the farm by tractor trolley. These cases are probably atypical. Unlike the conditions described for Sind (Seager) and for Indian Punjab (Singh and Laxminaryan) migrant labor is not a recognizable feature of the Gujranwala wheat harvest, with the possible exception of village residents working in nearby towns who return home for the harvest, and are more properly termed "commuters."

The personal nature of labor contract arrangements recalls the more traditional and customary market conditions described in the 1970's literature. On the other hand, as suggested by Elahi,

seypi laborers were markedly absent. Only two or three laborers described themselves as seypi and reported seypi receipts among their income sources. Although a sizeable subgroup of laborers reported tailoring, weaving or sewing as a major source of non-agricultural income, the largest percentage worked in heavy manual jobs, driving or equipment operation. Some of them may belong to the artisan and social labor groups described in the literature, but their current sources of income no longer identify them with distinctive occupational groups. About 50 percent reported that their occupations differed from that of their fathers. These results suggest that, as in other countries in South Asia, high agricultural growth rates may gradually obscure the socio-occupational hierarchy that often characterizes traditional village settings (Binswanger and Rosenzweig).

Wheat harvest laborers in the rice-wheat zone can be described as "landless." Although 20 percent of them had access to land through ownership or sharecropping agreements, for all laborers, the average area owned and shared was under a half of a hectare. About one quarter of the laborers reported that, although they were laborers, their fathers had been farmers. This slight evidence suggests that a certain proportion of the laborers come from families who have been only recently dispossessed.

Another striking characteristic of the market for wheat harvest laborers in the rice-wheat zone, unlike that described for some areas in India (Singh, Ryan and Ghodake), is the predominance of men among harvesters and the apparent absence of wage differentials between men and women. In 1986 and 1987, more than four out of every five cutters were men. Laborers were often relatives or friends who worked as a team, and members of one team each reported the same wage in maunds per acre. Quality differentials, if they exist, may be expressed in total harvest earnings. With payment in maunds per acre, a worker who cuts a greater area per day, but cuts the same number of days as the others in the team, presumably earns more in a harvest season. In some of the other tasks reported by laborers, such as hoeing and vegetable picking, wage differentials were observable between men and women although the total number of cases were few. Unlike in wheat and rice harvesting, laborers hoeing and picking are paid on a daily basis. Possible wage differentials for these tasks, and what they express, should be investigated further.

Wheat harvest laborers are heavily dependent on the harvest as a source of annual income. The average hired laborer earns enough during one harvest to meet the subsistence wheat needs of 2.8 persons for a year. In the average laborer household, 2.9 persons participate in the wheat harvest, and their earnings cover the annual wheat needs of their eight-person household. Ninety-five percent of the laborers claimed wheat harvesting as their most important source of agricultural income during rabi, and eighty-five percent reported that wheat harvesting was the single most important source of income in that season. In monetary equivalent, the wheat harvesting wage compares favorably with the average daily wage in non-agricultural occupations.

In either season, over half of the laborers had at least one source of income that was not related to crop or livestock production. Employment ranged from 9-11 days in the least active months to 26 days in the most active months. Seasonal peaks in employment appear to correspond to the agricultural cycle, and employment is highest during the wheat harvest, rice transplanting, and rice harvest The troughs in annual employment therefore correspond to periods during which laborers seek non-agricultural jobs. Most laborers reported that income from agricultural tasks was more important than non-agricultural income. Other than wheat harvesting, the major source of agricultural income was rice harvesting. Loss of both rice and wheat income would undoubtedly threaten the capacity of these households to meet their grain consumption needs.

Although non-agricultural wages were relatively high, the large seasonal swings in employment suggest that daily wage levels should not be used to estimate annual income for these laborers. Whether laborers can earn enough additional cash to purchase the wheat they now earn in kind is debatable. Informally, laborers stated that they preferred to cut their own wheat supply rather than purchase it because they are not certain to find or retain a job in town.

Thus these results imply a clear tradeoff between equity and efficiency in the market for combine harvesting. Use of combines by large farmers results in yield savings of over 10 percent in both rice and wheat, although these gains are reduced somewhat when lower rice quality and loss of wheat straw are taken into account. Timely planting of the next crop, particularly in the turnaround from rice to wheat, may also add to efficiency gains. At the same time, each large combine operating in wheat directly affects the wheat consumption of some 780 persons; the harvest laborers on whom these people depend are unlikely to have reliable alternative income sources.

A fuller range of harvest technologies, such as smaller, locally manufactured combines, improved reapers, or whole crop harvesters would spread efficiency gains to farmers with smaller plots to harvest and at the same time have more positive effects on employment, to the extent they depend on local manufacture. Development of these technologies has been hampered by the present rental rates for large combines, which probably do not reflect world market purchase prices or actual opportunity costs of capital.

Finally, losses because of harvest delays can also be reduced in the longer run through the development of wheat varieties more resistant to shattering. Varietal improvement can benefit a wider range of farmers than those who are the main beneficiaries of combine harvesting.

Introduction

Background

Incentives for Harvest Mechanization

With fixed selling prices, profitability in wheat farming is highly correlated with yield. Punjab's wheat farmers now produce at an estimated 60 to 70 percent of their yield potential, and the majority have adopted semi-dwarf varieties and apply fertilizers. Additional yield gains are likely to be achieved primarily through adoption of improved management practices and varieties that reduce losses from diseases and late planting (Byerlee et al., 1986).

Recent analysis of wheat enterprise data from rice-wheat farms in the Punjab indicates that, at current prices and average yields, farmers meet only variable operating costs (Byerlee et al., 1984). The budgets indicate that harvesting and threshing costs represent one of the largest single cost items in the wheat enterprise. Even with mechanized threshing, harvesting and threshing costs represent roughly one-third of variable costs for both farms with average and those with high yields. With limited opportunity to increase yields appreciably, farmers appear to have a strong cost-reducing incentive to mechanize harvest operations through rental of tractor-driven reapers or combine harvesters.

Combines are not a new technology in Pakistan, although until recently, they have been used by only a minority of very large farmers. A 1969 study by the University of Agriculture at Lyallpur estimated a total of 104 combines operating in Pakistan in that year. Most were tractor-drawn or small self-propelled combines imported from Massey-Ferguson, International Harvester, or Allis-Chalmers. Ninety percent of the machines had been imported during the two years preceding the study. They were used by large farmers with fully mechanized farm operations, for which the average size of holding was 1835 acres, with no holding smaller than 150 acres, and some extending over 7500 acres (Chaudhry et al., p. 22). These farm sizes were, and still are, on the outermost extreme of the farm size distribution in Pakistan.

In the early 1980's, the Agricultural Development Bank of Pakistan began to finance loans to Pakistani entrepreneurs, many of whom were themselves large farmers, for the development of custom combining businesses. Since 1982, the number of medium-sized (14 foot cutterbar) self-propelled machines has increased dramatically. In January of 1987, an estimated 250 of these combines were operating in Punjab. Twenty-nine loan projects had been financed, and an additional number were awaiting approval. All of the custom machines on record were imported from Klaas, Laverda, John Deere, and Sperry-New Holland in Europe.

Custom combining increases the access of farmers to harvesting technology by enabling them to rent the services of machines whose purchase costs would be otherwise prohibitive. The capacity of the machines described above is 20-25 hectares per day. For the custom operation, a contiguous area of relatively large fields reduces travel time between fields and minimizes wear on the machinery from turning in the field. Fields in Pakistan are typically fragmented. For these and other cash and credit-related reasons, farmers operating at least 10 hectares, or at most about 10 percent of farmers in irrigated Punjab, are the most likely initial clientele.

Recent comparative cost calculations for hand and combine harvesting have demonstrated cost savings associated with rental of combine technology, with savings largely diminished by loss of wheat straw sales (Byerlee et al.,1984; Greenham,1986). Companies are now experimenting with machinery and attachments to collect the straw discarded in the combining process. A cost factor that has not yet been documented is the cost of harvest delays resulting from difficulties in obtaining labor at wheat maturity. Costs of delay include yield losses due to aging of the crop and possible storm damage. In 1987, for example, unusually heavy wind and rain destroyed a substantial portion of the wheat crop in the rice-wheat zone. Delays in arrival of custom combines at the farm may also become important as the demand for combines increases, and especially during years of large aggregate output (Whan and Hammer).

Harvest Labor Displacement

Mechanization of wheat harvesting operations unambiguously displaces labor. Unlike some agricultural technologies, imported combines do not generate additional farm or non-farm employment opportunities for rural labor. Even if combine harvesting so increased the profitability of the wheat enterprise that farmers shifted to wheat production from production of other specialty rabi crops, the effect on area would not be great enough to stimulate a compensating demand for labor, and because other specialty crops tend to be more labor-intensive than wheat, the net effect of harvest mechanization on the demand for labor would probably remain negative.

Given the private cost incentives for harvest mechanization, the social cost of labor displacement emerges as an important research question (PARC/CIMMYT, 1986; Greenham, 1986). Labor displacement becomes a social cost when the labor released either remains unemployed or is obliged to accept inferior employment alternatives. Growing numbers of returnees from the Mid-East market may soon contribute to changes in the rural labor supply and rural wages. Irfan and Ahmed recently cautioned that "at a time when the economy is faced with the prospect of an accelerating flow of returnees," encouragement of more capital-intensive techniques of agricultural production "has potentially serious consequences for future employment growth"(1985,p. 433).

While studies have indicated that, in the aggregate, labor displaced by mechanization in South Asia has been largely absorbed by growth in related rural services and small industrial operations, aggregate studies do not reveal differential impacts on labor submarkets and subgroups. In reviewing the proceedings of a 1979 conference on labor markets in South Asia, Binswanger and Rosenzweig concluded that a major neglected theme in labor market studies is the heterogeneity of rural labor (1981). In other countries of the subcontinent, a relatively large proportion of harvest labor is female (Singh, 1982). In the Punjab, although harvest labor was traditionally supplied by village kammees (Eckert, 1972), recent labor shortages may have stimulated changes in the composition of labor that meets this seasonal demand. Seasonal labor may also be defined in part by ethnicity (M.H.Khan, 1986). Depending on the nature of the harvest labor force and alternative employment opportunities, harvest mechanization may have a dramatic impact on the welfare of some labor households.

Under these labor market conditions, the promotion of combine harvesting in the Punjab represents an important policy trade-off. The gains in efficiency that result from an increase in wheat yields may be offset by the loss in equity associated with the decreased welfare of labor households. Any distortion of real prices, such as the subsidization of mechanization costs through an overvalued exchange rate, also distorts the outcome of the efficiency-equity comparison.

Objective of the Survey of Wheat Harvest Technology

The purpose of this study is to contribute to existing knowledge on custom combining in Pakistan through a pilot survey in the irrigated rice-wheat production area of Punjab. The study was designed to focus on wheat harvesting, although the data include some information for both wheat and rice crops.

Based on the issues described above, the following information needs were identified: (1) an updated comparison of harvest wage and combine rental rates; (2) information on other cost factors and perceptions affecting farmers' choice of harvest technology, including the costs of harvest delay; (3) updated information on the employment characteristics of wheat harvest laborers; and (4) descriptive information on how wages and contracts are negotiated.

Sampling Method

Irrigated rice-wheat production in Pakistan is concentrated in Gujranwala, Sheikhupura, Gujrat, Lahore, Kasur, and Sialkot Districts of the Punjab. The team purposely selected Gujranwala district as representative of the zone. Secondary sources suggest that, among rural populations of the Punjab, the Gujranwala population has recently enjoyed a comparatively rapid increase in rural wages. Rising rural wages in the District have

accompanied the development of local industries and supporting services, and favorable agricultural growth rates.

Informal interviews with combine rental companies also indicated that they presently concentrate, and are likely to expand operations in this District. Several company representatives stated that although the farm size characteristics of the wheat-cotton area of Southern Punjab are better suited to combine-harvesting, the need for combine companies to reduce combine travel time and client transactions costs implies that, in the near future, a large number of companies will continue to combine wheat in areas where they can also combine rice. Company representatives indicated that the highest concentration of clients in Gujranwala District was found in Hafizabad QH, Gujranwala and Wazirabad Tehsils.*

Three population subgroups were identified as sources of data: (1) potential combine-users, (2) actual combine-users, and (3) wheat harvest laborers. Combine-users were defined as farmers of any size who had rented a combine at least once to harvest either rice or wheat before the 1987 wheat harvest. Potential combine-users were defined as farmers operating at least 10 hectares who had never used a combine to harvest either rice or wheat. With this definition, 'potential combine-users' are actually large-sized hand-harvesters or reaper-harvesters. Wheat harvest laborers were defined as laborers cutting wheat for the same hand-harvesters during the 1987 harvest.

The sample for the wheat harvest technology survey was drawn with a multi-stage cluster design using list frames. The first-stage sampling units were Potwari Circles in Hafizabad QH, Gujranwala and Wazirabad Tehsils. Second-stage sampling units were combine-users and potential combine-users farming in each Potwari Circle. Third-stage sampling units were laborers cutting wheat for potential combine-users during the 1987 harvest.

Each combine-user in the final sample of 37 represents 50 farmers in Gujranwala District with similar characteristics, each potential combine-user in the sample of 39 represents 160 similar farmers, and each laborer in the sample of 75 represents 360 wheat harvesters. In other words, the overall sampling percentage for combine-users is 2, and the overall sampling proportions for potential combine-users and laborers are 0.6 and 0.3 percent, respectively. Results are representative of Gujranwala District, and to the extent that harvesting patterns

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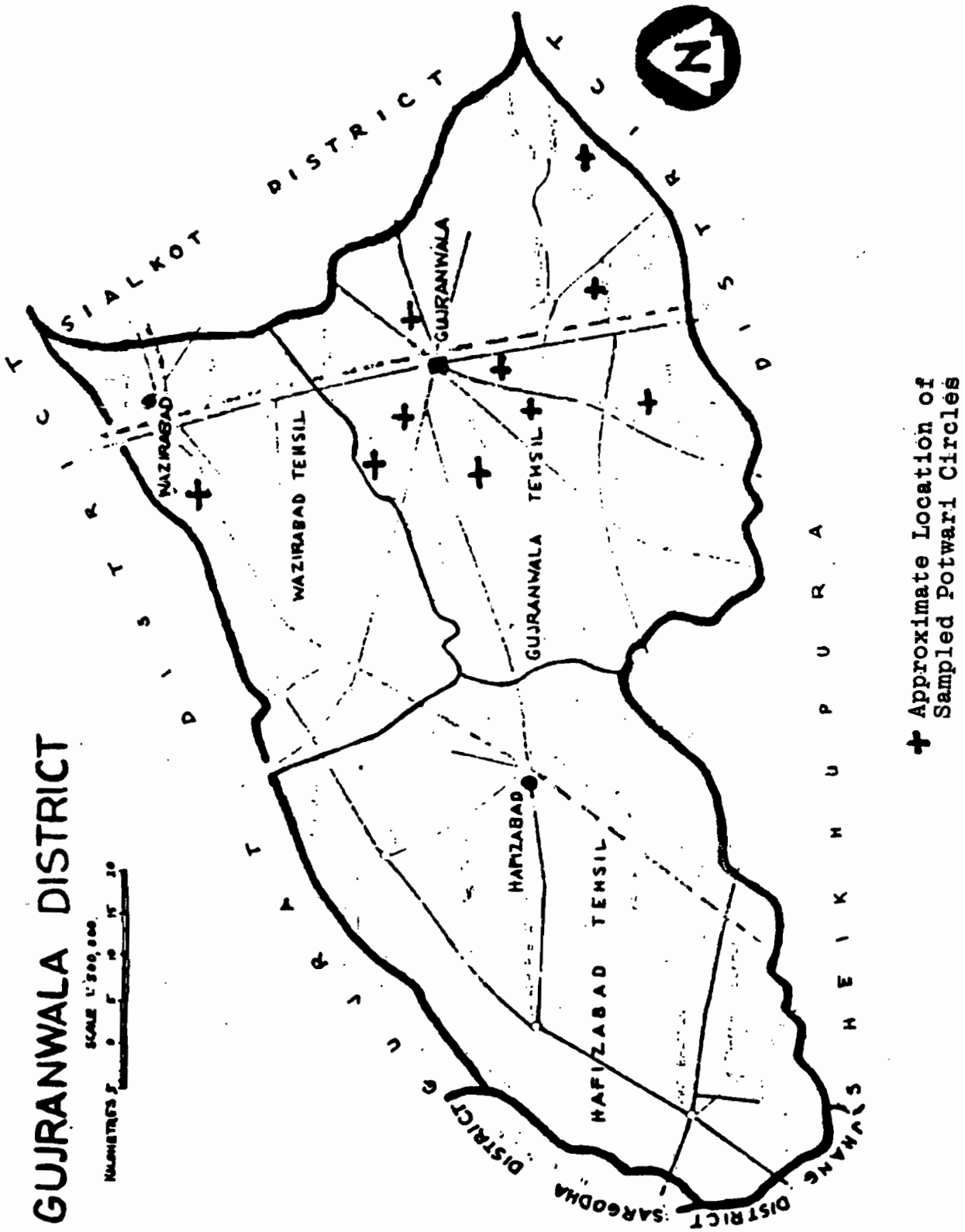
* In the 1981 District Census Report, a QH is the next smallest administrative unit after the Tehsil, and is composed of many Potwari Circles. Appendix 1 provides a summary of the sample survey design, and a more detailed discussion is found in M. Smale, "A Note on Multi-Stage Sampling with List Frames: The PARC/CIMMYT Survey of Wheat Harvest Technology," PARC/CIMMYT Economics Program, Paper No. 87-9, 1987.

Figure 1


GUJRANWALA DISTRICT
SIALKOT DISTRICT
KASUR DISTRICT
SHEIKHUPURA DISTRICT
SARGODHA DISTRICT
GUJRANWALA
WAZIRABAD
WAZIRABAD TEHSIL
GUJRANWALA TEHSIL
HAFIZABAD
HAFIZABAD TEHSIL
N
Approximate Location of Sampled Potwari Circles

and farm characteristics are similar between Gujranwala District and the remainder of the rice-wheat zone of Punjab, they can also be generally applied to Sheikhupura, Kasur, Lahore, and some portions of Gujrat and Sialkot Districts.

The following section reviews mechanization issues and secondary information on rural labor markets in Pakistan. Results from the three subgroup surveys are reported in the subsequent sections. Conclusions and issues raised by the survey results are presented in the final section.

Farm Mechanization, Demand for Labor, and Rural Labor Market Characteristics

Mechanization and Labor Demand

Singh has categorized mechanization as either land-intensifying or labor-displacing. The first category, consisting of motors, low lift pumps, tubewells and small power tillers, increases cropping intensity and displaces some task-specific labor, but increases the demand for labor in other tasks. The net effect of land-intensifying mechanization on the demand for labor is likely to be positive. The second category includes tractors and harvesting equipment. Citing the evidence of a number of studies in South Asia, Singh concluded that the second category does little but displace labor (Singh, 1982).

Based on his review of a number of studies in South Asia and the results of his work with a simulation model, Singh found that any labor-displacing effects of mechanization have been largely neutralized by the labor-increasing effects of higher yields, shifts to labor-intensive crops and large scale use of new inputs. Although his result does not necessarily hold where high rates of mechanization have accompanied the introduction of HYV's and fertilizers, as in the case of Indian Punjab, he argued that increases in nonfarm rural employment have undoubtedly absorbed the displaced farm labor (pp. 42-44).

In Pakistan, a number of researchers have investigated the effects of mechanization on employment, with conflicting conclusions. In summarizing the history of mechanization in Pakistan, Chaudhry stated that while the evidence is contradictory, the net direct effects of tubewell, HYV and tractor innovation on the demand for rural labor have been positive and significant. The indirect effects in stimulating non-farm employment in related small industries and services are likely to have been considerable (1986). Other authors have concluded that tractors have been associated with the resumption of land by some farmers and transfer of land from tenants to farmers (Lockwood et al. 1981), and that tractor adoption may have resulted in a relative increase in the demand for casual, seasonal labor, with a greater decrease in the demand for labor by full-time family, tenant, or permanently hired labor (McInerney and Donaldson, 1975).

Unlike other agricultural technologies associated with the seed-fertilizer revolution, harvesting technologies are clearly labor-displacing, although rates of labor displacement differ between threshers, reapers and combines. The Gardezi et al. study of mechanical wheat threshing in Multan indicated that mechanization reduced harvest labor requirements by 36 percent, and reduced harvest labor earnings by about 55 percent (1979, p. 27).

Nearly twenty years ago, hand harvesting with bullock threshing, hand harvesting with mechanical threshing, and combine harvesting were compared in a study conducted by the University of

Agriculture, Lyallpur (1969). For both hand harvesting with bullock threshing and hand harvesting with mechanical threshing, hired labor from landless households in the village provided most of the cutting labor. In hand cutting and and bullock threshing, casual labor was generally hired to cut, and family laborers threshed the wheat. In terms of man-days, the authors found that a combine displaced 98 percent of the labor hired with hand harvesting and mechanical threshing, and 95 percent of the labor hired with hand cutting and bullock threshing. The authors also found that grain losses were actually higher with combine technology because of delayed harvesting and lack of expertise in handling the combines. They recommended that, given the social cost of labor displacement, the introduction of combines should be discouraged, and if permitted, modelled as a phased program for large farmers.

More recently, Laxminaryan et al. conducted a study of combine-users and hand-harvesters in the rice-wheat production zone of Indian Punjab (1981). They concluded that there was no social gain from harvest combining in terms of increased cropping intensity or farm productivity. On the other hand, there was a net social loss resulting from labor displacement "which would seriously jeopardize the employment opportunities of the casual labour force and more particularly migratory labour coming from labour surplus areas"(p. 173).

In their farm budget analysis, the authors found that while the majority of farmers reported negligible grain losses when harvesting with combines, as compared to traditional harvesting methods, grain savings was "neutralized by complete loss of fodder"(p. 172-3). Combines did not necessarily save time for the farmer because machine availability was highly uncertain. In the survey area, as in the rice-wheat zone of Pakistan's Punjab, the problem of delayed harvesting and timely sowing of the next crop is less acute after the wheat harvest than after the rice harvest. Although combine-users finished their rice and wheat harvests earlier than hand-harvesters, the authors found no evidence to suggest that they began field preparation for the succeeding crop earlier (pp. 73-74).

Local and migratory casual labor represented the major components of harvest labor in the Laxminaryan study. The authors concluded that almost all casual labor was displaced by combine adoption, while family and permanent labor were freed to work on other farm or non-farm tasks (p. 132). They calculated that one combine displaced 2549 total person-days, of which 63 percent was migrant or casual labor from the village and 37 percent was permanent and family labor (p. 135). As a result of the research conducted on the effects of combine-harvesting and strong resistance of village laborer groups, additional imports of combines were subsequently banned in India.

The authors cited above tended to agree that the total net effects of the seed-fertilizer revolution, tubewell irrigation and tractor adoption on the demand for labor have been positive,

although the single effect of tractor adoption that has accompanied these technical changes may have been negative. Some of the authors suggest that certain labor subgroups have been adversely affected or that social costs have been associated with adjustments in labor markets. Singh estimated, for example, that while only two percent of Pakistan's rural labor force may be unemployed, unemployment is concentrated among casual labor (p. 17). He argued that in South Asia, in general, the rising wage rates that accompany increased demand for labor in land preparation, transplanting, and weeding can also lead to in-migration and displacement of the village work force. While wages may be higher for agricultural laborers, Singh concluded that the conditions of employment are riskier and seasonal security has deteriorated (p. 39-40).

Changes in Rural Labor Markets in Pakistan

Composition of Rural Labor

In Eckert's 40-village survey of labor force participants in the Punjab (1972), an estimated total of 2 million persons belonged to families of temporarily hired, landless laborers. Usually employed on a daily basis, and for an average of slightly over 11 out of 30 days per month, temporary laborers emerged from his study "as the occupational group most in need of employment attention" (p. 86). Eckert found the greatest proportion of temporary laborers in canal colonies, and the lowest in the villages settled before 1900, where the seyp system still predominated (p. 27). The seyp system is the traditional relationship by which a land-owner claims the services of several artisans throughout the year in return for in-kind payments at the end of each harvest, and occasionally, patronage in disputes or provision of credit.

In Eckert's study, hired labor was most often used in harvesting activities for wheat, rice, cotton, and sugarcane and in the making of gur. An average of 13.4 man-days of hired labor was employed per hectare (5.4 per acre) in wheat harvesting, primarily in cutting and winnowing, while family labor tended to be used in threshing (p. 37). Although payments for wheat cutting were traditionally a harvest share, the sample uncovered "a variety of responses including payment in cash and kind, per maund, and per day." Eckert concluded that "the variety of modes of payment and wage levels undoubtedly represents employers and employees experimenting with several alternatives in an effort to strike a new equilibrium" (p. 44).

As compared to permanent agricultural laborers, who tended to be employed fully (29 days per month) and fairly constantly throughout the year, temporarily hired laborers worked an average of only 11.3 days per month, with considerable seasonal variation. Eckert stated that "the respondents in this category were men whose primary source of livelihood came from day labor. They were not incompletely employed artisans who casually entered

the labor market in peak demand seasons"(p. 41). Employment for temporary labor peaked at three distinct points: during the wheat harvest and summer plowing, during the summer harvest (October-November) and land preparation for wheat, and during the sugarcane harvest and gur production period.

Akhtar surveyed Thekriwala Tehsil in 1977-78 to record labor utilization and income for cultivators and non-cultivator, or landless households. Landless households were classified as artisans, social laborers, permanently hired agricultural labor and off-farm workers. Social laborers included prayer leaders, barbers, cobblers, watchmen, washermen, mirasies, and waste disposal laborers. Off-farm workers were tailors, grain grinders, powerloom workers, tonga drivers, shepherds, oilmen, and chilam-makers. Non-cultivators represented 65 percent of the sample population.

Akhtar calculated that, in all their activities, four-fifths of non-cultivators earned annual income equivalent to less than or equal to Rs. 14 per day, cited as the current wage rate for casual hired labor. He also found significant differences in mean income per household between the four classes of non-cultivators--artisans, social laborers, off-farm workers and permanent laborers (p. 29). Those earning less than the casual wage rate were permanent hired laborers, watchmen, washermen, waste disposal laborers, mirasies, shepherds, oilmen, cobblers and chilam-makers. Aslam and Akhtar explained that "wages of casual and permanent labor were determined both by the market and non-market (family obligations of the labour, status, and social relations with the employer) and consequently, the wages were generally below the market equilibrium rate" (Aslam and Akhtar, 1979, p. 41).

In 1982, Elahi et al. conducted a survey of selected villages in Attock, Gujranwala, and Faisalabad Districts to investigate rural labor market conditions. Among them, Gujranwala represented the most commercialized and industrialized farming district. The greatest number of hired (permanent and casual) workers per farm was reported for the Gujranwala villages, and their numbers increased by farm size (p. 113).

The authors described landless households as consisting of a variety of artisans, or kammees, who provide professional services to the village community under the traditional seyp system and also supply hired labor for agricultural activities. Other suppliers of hired labor were members of groups that had converted to Christianity or Islam, and occasionally, small farmers (p. 22). Hired labor consisted of both permanent and casual laborers.

Permanent laborers generally worked under contracts of at least one year, receiving in-kind payments and meals, housing and clothing for tasks including plowing, planting, irrigation,

interculture, and livestock feeding (p. 17). Both adults and children were employed for these tasks, and women were also hired permanently for domestic work.

Casual laborers were employed seasonally in weeding, harvesting and threshing operations. Casual wages during these seasonal operations tended to be higher than average wages for the permanent rural employees. The authors found that permanent workers often preferred to become casual laborers during the peak seasons and "their permanent wage payments [were] discounted accordingly." Others continued to work for their employers, and were paid "the prevalent casual wage rates during the said periods"(p. 20). In Gujranwala villages, more than 80 percent of the farm households employed casual labor for rice transplanting and wheat and rice harvesting. Casual laborers were members of unskilled artisan groups, converted Christian and Muslim labor groups (p. 68-9).

For all types of workers, annual wage rates were highest in Gujranwala District, "supporting the proposition that wage rates in a commercially dominated region are comparatively higher than those in the remaining zones"(p. 115). Zonal averages of in-kind payments to permanent laborers revealed higher wheat, rice and other payments in Gujranwala (p. 75). Although income from seyp was also highest in Gujranwala District, the lowest proportion (5 percent) of landless households were engaged in seyp work. By comparison with other Districts studied, the proportion of landless households engaged in commercial and cash-yielding activities, including permanent and temporary farm labor, was highest in Gujranwala District (p. 46).

In Gujranwala District, as compared to other surveyed districts, Elahi et al. found higher income levels among landless households, but lower average literacy rates and lower average labor force participation (pp. 55-57,61). The authors explained that the relatively intensive, rice-wheat based farming region with its commercial activities offers a wide range of relatively high-paying farm and non-farm jobs to unskilled labor. As a result, laborers have less incentive to work under the seyp system, less incentive for educating themselves as a means of obtaining a job, and presumably, to generate the same level of income, they need fewer hours of labor force participation (p. 55).

Eckert, Aslam and Akhtar, Elahi et al., D. A. Khan, and Haider all found a trend in diversification of income for non-farm households from ancestral occupations to production of goods for sale, casual farm labour and non-traditional work. Elahi et al. found that the average income from seyp work was lower than that obtained through various farm-based and non-farm activities, which may explain "the declining share of seyp work in employment composition"(p. 60).

As indicated by the first three authors cited above, definition of the various labor subgroups is important when considering the

welfare effects of labor displacement. Wages, other contractual conditions, seasonality of income and the distribution of household income by source is likely to differ considerably between the permanent, casual, and seyp labor groups. For permanent workers and seypis, farm labor in the peak season represents an additional, though not necessarily principal, income source. For either migrant or local casual laborers, harvest labor may represent a major component of total income. Labor force participation rates and chances of alternative employment may also differ, depending on labor group. On the other hand, as suggested by several of the authors, the differences between these groups may have become less distinct over time as the structure of rural employment has changed and rural wages have increased.

Assumptions of increased labor mobility and alternative opportunities in non-agricultural employment may not be appropriate for many of the laborers described above. Some labor groups may face restrictions on employment that are associated with certain socio-economic characteristics. M. H. Khan has stated that "the practice of dependence on the caste or ethnic seasonal labour is found not only in India, but also in the Philippines, Bangladesh and Pakistan," and among these households, poverty is increasingly visible (1986, p. 26). According to M. Irfan, data from the Population and Labor Migration Survey shows that migration among regions and overseas is associated with younger age, and higher education. "Landless labor ranks lowest in out-migration [to the Mid-East]," and "in the case of illiterates, only 5 percent from rural areas moved, with a majority of them ending up in other rural areas"(1986,p.4). In Eckert's study, the most highly educated persons among permanent and temporary laborers averaged only 0.9 years of schooling, compared to 8.6 years among large farmer households. In the sample population, outmigration among occupational groups was related to education. Landless labor was the least likely to migrate (p. 87).

Changes in Rural Wages

Data assembled by Irfan and Ahmed (1985) indicate that over the 1960-70 period, all categories of Pakistani workers experienced a gain in real wages, followed by a slight contraction during the early 1970's. Real agricultural wages declined in 1974 and 1975, and did not recover previous levels until 1980. Real wage increases occurred in 1981, followed by stagnation. In 1984, real wages were about 10 percent higher than those reported a decade earlier. Irfan and Amjad (1984) also estimated that real wages of both permanent and casual workers recorded general increases over selected years through 1973. These major trends in real agricultural wages reflect significant changes in the Pakistani economy, which are described below.

In the 1960's, rapid agricultural growth was associated with the introduction of the HYV's, the expansion of farm irrigation, and relatively minor rates of adoption of mechanical techniques. In

the aggregate, technical changes appeared to increase the demand for farm labor and agricultural wages rose during the 1960's (Irfan and Amjad, 1984).

The technological changes of the 1960's were also associated with radical changes in the occupational distribution of rural households and the size distribution of farms. From population census data, Hussain estimated that 42.5 percent of the total agricultural labor supply in 1973 was composed of persons who became agricultural laborers between 1961 and 1972. (p. 69) Comparing the 1960 and 1972 Agricultural Censuses, Elahi et al. found a rapid increase of owner-operators and part-owners operating more than 7.5 acres, a decrease of those who operated less than 5.0 acres, a consistent decline of tenant farmers in all size categories except the 7.5-12.5 acres category, and an increase in non-farm and landless households (p. 22). Changes in the distribution of land ownership led to a growing rural labor supply, which exerted downward pressure on rural wages during the late 1960's.

According to Irfan and Amjad, the trend toward increasing proportions of non-farm households in rural areas continued during the 1970's. Rates of tractor and thresher adoption also increased more rapidly in the 1970's. Farmers who expanded their cultivated area and intensified their cropping systems "were compelled to mechanize" because of difficulties in hiring the required number of laborers during peak seasons(p. 40).

Hussain argued that, although the demand for hired harvest labor was initially stimulated by higher yields, other factors subsequently depressed the demand for labor and stimulated mechanization of various operations. First, with multiple cropping, the frequency of peak season demand increased while the time period available for operations decreased. To complete a given amount of work within the time period, a larger number of laborers was required. Second, with a larger number of laborers, farmers experienced difficulties in obtaining their services in a timely fashion and in supervising their work (pp. 70-75). Hussain reported that "the persistent explanation of larger farmers for mechanisation [was] not so much high wages of farm labour, but the difficulty of getting hold of them in time, and then ensuring that they [did] their job carefully"(p. 70).

Irfan and Amjad concluded that the mechanization of the 1970's had a net effect of contracting the demand for agricultural labor, at the same time that a growing number of landless households increased the total supply of agricultural labor. Although wages appeared to have declined briefly in the mid-70's, they rose again during the second half of the decade. The major source of relief came with the opening of the labor market in the Middle East, as surplus rural labor sought employment through overseas migration.

Migration affected wages through labor outflow, which contracted supply and exerted upward pressure on wages, and through changes

in the demand for labor stimulated by the flow of remittances into certain subsectors, such as construction and services (Tsakok, 1982; Irfan and Ahmed). According to these authors, migration began in the early 1970's and peaked in 1980-81, corresponding to a peak in rural wages. Displacement of labor by mechanization in the 1970's therefore coincided with a period of major exports of Pakistani manpower to the Mid-East. An estimated 3 million Pakistanis migated to the Mid-East. A major current concern is the extent to which the presumed "labor shortage" will continue, along with rises in agricultural wages. The last few years of data in the Irfan and Ahmed series indicate stagnating wages for unskilled agricultural laborers.

The evidence reported in this section suggests the following general conclusions. First, economists tend to agree that the net effects of the seed-fertilizer revolution and mechanization on rural employment in Pakistan may have been positive, although the single effect of tractor adoption is disputable, and harvest mechanization is undoubtedly labor-displacing. Although the combined effect of farm and non-farm employment generation may have increased the demand for labor in rural areas, some laborers may suffer from increased seasonality of employment and job insecurity. Second, over the past two decades, significant changes have occurred in the structure of rural labor. Traditional categories of seypi, social labor, permanent and temporary labor are increasingly obscured, as laborers work in jobs which no longer represent their ancestral occupation and the village economy becomes more monetized. Third, although it is unclear precisely which labor groups have benefitted from exports of Pakistani manpower to the Mid-East, outmigration has tended to sustain overall rural wages during a period when the increased rural labor supply that resulted from changes in the distribution of land ownership probably exerted downward pressure on wages. As the prospects for overseas migration decline, without a compensating increase in domestic employment opportunities, rural wage levels may decrease in the coming years.

Results of the Survey of Wheat Harvest Technology

Combine-Users

Size of Harvested Crop Area and Tenure

In the survey of wheat harvest technology, combine-users have been defined as farmers of any size who have rented a combine at least once before 1987 to harvest either rice or wheat. In 1986, they harvested an average of 26 hectares of rice and 21 hectares of wheat (Table 1). Of the total rice area harvested, roughly two-thirds was combined and one-third was hand cut and hand threshed. Of the total harvested wheat area, about three-fourths was combined, and the remainder was hand cut and mechanically threshed. As expected, in each crop, farmers combine-harvested a greater area than they hand-harvested. A negligible portion of total wheat area was hand cut and bullock threshed or reaper cut.

The distribution of combine-users by total harvested area suggests that they may be fairly well-distributed around the mean, with few farmers harvesting less than 10 hectares of rice, and few harvesting over 40 hectares of either rice or wheat (Table 2). In either crop, well over half of the sampled farmers harvested between 10 and 40 hectares. Given the farm size characteristics of Punjab's irrigated rice-wheat zone, the data indicate that combine-users tend to be large farmers.

A larger proportion of combine-users combined rice than combined wheat (Table 3). However, a larger proportional area of rice than wheat was hand cut. Several factors may explain these results. First, farmers and combine operators informally stated that although Basmati varieties can be and have been combined, combine operators prefer to combine only dwarf or semi-dwarf varieties because of the problems tall rice causes in machine operation. Second, waterlogged soils and field condition probably affect the proportion of rice fields combine-harvested. Third, all except one of the wheat combine-users owned cattle and buffaloes, and a majority chose to hand-harvest some crop area in order to meet their wheat straw needs. For wheat combine-users, the crop area hand cut may represent a physical relationship between herd size and bhusa needs. By comparison, the area hand cut by rice combine-users may reflect their varietal mix.

In either case, although the figures suggest different decision-making criteria for the two crops, they are not likely to accurately represent the farmers' decisions on optimal technology mix. Frequently, farmers noted that they would have combined a greater crop area if they had procured the combine services in time. Many farmers began to hand harvest while awaiting the arrival of the combine, or intended to hand harvest all crop area until they became aware of the presence of a combine in their village. This last factor reflects some aspects of the new custom combine market, such as imperfect information, which probably dominate the other factors described above.

Table 1. Average Crop Area Harvested, by Technology, Rice and Wheat Combine-Users, 1986

Combine User	Total Area Harvested	Area Hand Cut/ Hand Threshed	Area Hand Cut/ Machine Threshed	Area Combine-Harvested	Other[1]
	(ha)				
Rice					
mean	25.7	9.4		16.3 *	0.0
s.e.	(4.29)	(1.86)		(4.11)	
Wheat					
mean	20.8		3.5	16.1 *	1.2
s.e.	(2.46)		(1.17)	(2.33)	

[1]Residual category: for wheat, reaper cut/machine threshed, and hand cut/bullock threshed.

* Difference between crop area hand cut and combined significant at prob. = .05.

Table 2. Percentage Distribution of Combine-Users by Area Harvested, Combine-Harvested, and Hand-Harvested, Rice and Wheat, 1986

	Hectares						Total
	0	0-10	10-20	20-30	30-40	gt 40	
	Percent of farmers						
Total Harvested Area							
Rice		13.5	29.7	43.2	2.7	10.8	100
Wheat		27.0	29.7	27.0	2.7	13.5	100
Area Combine-Harvested							
Rice	16.2	37.8	18.9	18.9		8.1	100
Wheat	37.8	27.0	13.5	13.5		8.1	100
Area Hand-Harvested							
Rice	29.7	29.7	24.3	10.8		5.4	100
Wheat	29.7	45.9	13.5	10.8			100

Table 3. Percentage Distribution of Combine-Users by Proportion Total Area Combine-Harvested, Rice and Wheat, 1986

Crop	Proportion of Area Combine-Harvested					Total	Mean Percentage Combined[1]
	0.00	.1-.25	.26-50	.51-75	.76-1.0		
Rice	16.2	18.9	10.8	21.6	32.4	100	62
Wheat	37.8	2.7	2.7	24.3	32.4	100	75 *

[1] Means calculated only for those combining some crop area.
* Difference of means significant at prob. = .10.

Table 4. Years of Experience Renting Combines, Rice and Wheat Combine-Users

Combine User	Farmers Renting Combines in					Mean Years Renting[1]
	1986	1985	1984	1983	1982	
Rice						
pct.	83.8	24.3	13.5	5.4	0.0	1.5
Wheat						
pct.	62.2	24.3	18.9	10.8	2.7	1.9

[1] Mean of those farmers combining the crop in 1986.

A minority of farmers rented all their rice and wheat area. Over 90 percent owned more than half of their harvested area, and over 75 percent owned all of their harvested area. As can be expected, the mean proportions owned of wheat and rice area are not statistically different.

Contractual Characteristics

Market Information

Custom combining is an extremely young industry in Gujranwala District. On the average, both rice and wheat combine-users had rented combines for less than two years (Table 4). Less than one fourth of the users rented combines in 1985, and very small numbers rented combines in 1984 and 1983. Only one farmer interviewed rented a combine before 1983--and that combine was tractor-pulled. Only one farmer in the sample used a combine discontinuously. He combined rice in 1985, and hand-harvested all his rice in 1986, "due to shortage of machines."

The majority of combine-users had rented only self-propelled machines. A minority had rented tractor-pulled combines in earlier years and self-propelled in recent years. About half of the farmers used the combine on only one crop in 1986. Of those who used combines for both rice and wheat, two-thirds rented the combines from the same company.

Farmers knew relatively little about the companies from which they hired the combines. Informally, most farmers revealed that they knew the color, and sometimes the make of the combine, but not the name of the custom combine company. About 10 percent did not know the company location. Those who did know indicated a mean distance of 24 kilometers to the company from which they rented the rice combine, and 29 kilometers to the company from which they rented the wheat combine. The maximum quoted distance from the farm to the company office was 64 kilometers.

Most combine-users stated that their contracts were usually verbal, rather than written. Only one-third of all combine-users personally knew someone working for or owning the company from which they rented the machine. Approximately half of both rice and wheat combine-users were informed by a company representative or combine operator of combine availability (Table 5). About half were informed by other farmers, and a negligible number were informed by non-farmer friends or relatives.

As compared to wheat combine-users, a larger proportion of rice combine-users negotiated contract terms on the farm rather than at the company office (Table 5). This finding may reflect greater availability of machines in Gujranwala during rice harvest. Although custom companies work in a number of Districts during the wheat harvest, all companies are obliged to work in only

Table 5. How Farmers Learned of Combine Availability and Negotiated Custom Contracts, Rice and Wheat, 1986

Contract	How Learned of Availability			Total Contracts	How Negotiated Contract			
	Co. Rep.	Another Farmer	Non-Farmer		At Co. Office	On Own Farm	Through Another Farmer	Through Non-Farmer
Rice								
pct.	51.6	41.9	6.5	100	67.7 *	19.4 *	3.2	9.7
Wheat								
pct.	43.5	52.2	4.3	100	82.6	8.7	8.7	0.0

* Difference of proportions for rice and wheat significant at prob. = .05.

Table 6. Combine Rental Rates, Rice and Wheat, 1986

Combine-User	Total Payment (Rs/acre)	Cash Advance (Rs/acre)[1]	Advance as Percent of Total[2]
Rice			
All	345.2		
Paying Advances	342.7	174.2	51
Wheat			
All	328.3		
Paying Advances	336.5	113.4	34

[1]Lump sum advances contribute to high variability in per acre figures.
[2]Percentage ranges from 5-100 for rice; 6-100 for wheat.

three or four Districts during rice harvest, resulting in heavier competition over clients. A minority of both wheat and rice combine-users negotiated the contract indirectly through another farmer or non-farmer.

Rental Rates and Source of Cash

Mean total payments in 1986 were 853 Rs/ha (345 Rs/ac) for rice, and 811 Rs/ha (328 Rs/ac) for wheat (Table 6). The average total payment for wheat shows greater variability than for rice. Rice payments ranged from 300 to 375 Rs/ac, with a mode of 350. Wheat payments ranged from 200 to 350 Rs/ac. Flat rates quoted by combine companies indicated a higher rate charged for wheat than rice. The differences between quoted rates and survey results may be explained in part by yield and crop conditions, or by discounts some wheat farmers received for larger acreages. The extremely low rate of 200 per acre may have also been charged by a farmer renting an older, smaller combine to a neighboring farmer.

About half of both rice and wheat contracts required a cash advance. Cash advances tended to represent roughly half of the total payment in rice, and about one-third of the total payment in wheat. However, the high variability in means for advances, and advances as a proportion of the total payment, suggests little inference can be drawn from these figures. The variability in the means reflects, in part, non-standardized advance payment procedures. Some farmers reported per acre advances, but most farmers reported lump-sum payments which ranged from a small proportion of the total to a full advance payment.

Based on the mean crop area figures presented in Table 1, and mean payment figures shown in Table 6, a farmer paid Rs. 13-14,000 in cash to combine harvest either crop in 1986, and Rs. 26-28,000 to combine harvest both crops. These are significant cash outlays, especially considering that hand-harvesting is paid in kind.

Other than the farmers' savings, the only major source of cash was the grain merchant (Table 7). About one-third of combine-users obtained cash to pay the combine company through borrowing from the grain merchant. In informal interviews, company personnel mentioned that they often had difficulty obtaining immediate payment from farmers. A relationship may exist between the source of cash and timeliness of rental payment. For farmers who previously paid wheat cutters in kind, borrowing cash from the grain merchant in exchange for repayment in grain is one financial arrangement which allows them to shift technologies when they are short of cash. Other farmers may be unable to pay the combine operators until they have marketed the grain. Another notable detail is that the few combine-users who rented all their harvested area funded the custom work entirely from their own savings or another source, rather than borrowing from the landlord.

Table 7. Percentage Distribution of Combine-Users by Funding Source, Rice and Wheat, 1986

Combine User	Source of Cash for Rental Payment: Own Savings	Grain Merchant	Other[1]	Total
Rice	64.5	29.0	6.5	100
Wheat	56.5	34.8	8.7	100

[1]Credit institution or friend/relative. Those renting land were not provided funds by landowner.

Table 8. Pre-Harvest Delays Associated with Combine Contracts.[1] Rice and Wheat, 1986

Contract	When Negotiated: Days Before Maturity	When Negotiated: Days After Maturity[1]	When Combine Arrived: Days After Maturity[2]	Mean Harvest Duration	Total Days After Maturity Harvest Completed
Rice					
mean	13.5	0.6	3.3	3.2	6.5
Wheat					
mean	17.4	0.0	5.4	2.4	7.7

[1] All but one farmer in this category negotiated the contract "when the crop was ready", or 0 days after maturity.

[2] A large proportion of zeros, or no delays, especially among contracts negotiated after maturity.

Harvest Delays

About half of the rice contracts and more than half of the wheat contracts were negotiated before crop maturity, at an average of about 2.5 weeks before crop maturity. The remainder of the contracts were negotiated "when the crop was ready," with the exception of one rice contract that was negotiated 10 days later (Table 8).

Including all contracts, the combines arrived an average of 3.3 days after the rice crop was ready, and 5.4 days after the wheat crop was ready. Since the time at which "the crop is ready" is actually a period rather than a specific day, and farmers' methods for ascertaining crop maturity may differ from agronomists', the figures must be interpreted with caution. The estimates represent farmers' perceptions.

Farmers who negotiated contracts early did not appear to benefit by a shorter delay period--in fact, all except two of those who negotiated contracts at crop maturity reported no delays. This result may be another expression of those shown in Table 5. A number of the rice contracts, and some of the wheat contracts, were negotiated on the farm, or "on the spot," when the combine operator passed through the village.

Three-fourths of the farmers reported at least one labor contract delay during the last three years, all of which occurred before beginning to harvest. For all farmers, pre-harvest labor delays averaged 5.5 days (per year). Over half of the farmers had experienced rainfall delays. The rainfall delays occurred both before harvest commencement and during or after cutting, before beginning to thresh. Total rainfall delays averaged 4.9 days among all farmers. Farmers estimated an average yield loss of 0.35 t/ha (3.6 mds/ac) in the year of the longest delay. Longer rainfall delays usually also affected grain quality. Farmers' recall of the actual delay period and the associated harvesting stage was often fairly weak, and their estimates are rough. Occasionally, rainfall and labor delays and consequent yield losses were interrelated.

An interesting point raised by Tables 8 and 9 is that the initial combine delays and the initial labor delays average to about the same number of days for wheat. Despite a delay problem common to hand-harvesting and combining, the difference in estimated total harvest duration is dramatic for the farm size represented by this sample. Including initial contract delays, wheat harvesting by combine was completed an average of only 7.7 days after crop maturity. With labor contract delays, and excluding rainfall delays that may have been interrelated, the hand-harvested wheat was not completely cut and threshed until about 28 days after crop maturity.

Table 9. Delays Associated with Labor Contracts and Rainfall. Average for Three Years Preceding Shift to Combine

Wheat Harvest Delay Stage	Source of Delay: Labor Contract (Mean Days)	Source of Delay: Rainfall (Mean Days)	Mean Harvest Duration	Total Days After Crop Maturity Harvest Completed
Before Beginning to Cut	5.5	3.9		
During or After Cutting, Before Threshing	0.0	1.0		
During Threshing	0.0	0.0		
All Stages [1]	5.5	4.9	22.3	32.7

[1] Since labor and rainfall delays were occasionally interrelated, the two mean delays may not be additive.

Table 10. Farmers' Estimates of Differences in Supervision Time, Harvest Duration, and Yields with Hand-Harvesting and Combine-Harvesting, Rice and Wheat[1]

Item	Unit	Rice Harvesting: Hand	Rice Harvesting: Combine	Wheat Harvesting: Hand	Wheat Harvesting: Combine
Supervision					
mean	hrs/	10.4	2.6 *	10.4	2.7 *
s.e.	day	(0.40)	(0.49)	(0.60)	(0.74)
Harvest Duration					
mean	days	27.5	3.2 *	23.0	2.4 *
s.e.		(3.79)	(0.56)	(3.34)	(0.33)
Time to Prepare for Next Crop					
mean	days	10.0	28.4 *	9.1	29.4 *
s.e.		(1.64)	(1.96)	(1.05)	(1.83)
Mean Yields	mds/a				
mean		32.1	38.0 *	24.6	28.1 *
s.e.		(1.93)	(2.20)	(1.03)	(0.83)

[1]Holding input levels, variety, and acreage harvested constant.

* Difference between means for combine-harvesting and hand-harvesting significant at prob. = .01.

Farmer Comparisons of Hand Harvesting and Combining

The advantages usually attributed to combine harvesting include reduction in supervision time, increased time available to prepare the fields for subsequent crops (especially after rice harvest), and increased yields. Increased yields are likely to result from the reduction in shattering losses that accompanies more timely harvesting.[1] Farmers' estimates of several key parameters are summarized in Table 10.[2]

For both rice and wheat, combine-users estimated about 10 hours per day of supervision in hand-harvesting, and only about 2-3 hours per day supervising the combine operation. Farmers estimated only about 10 days available to prepare for the next crop when hand-harvesting either rice or wheat, with about a month available for preparation when combine-harvesting. Mean harvest duration for the sample farmers (harvesting an average of 26 hectares of rice and about 21 hectares of wheat) was about 20-24 days less with combining than with hand-harvesting. A mean harvest duration of over three weeks for wheat, excluding initial labor contract delays, suggests possible shattering losses for a large number of the farmers represented by the sample.

Farmers' estimates of mean yields with the two technologies support this assertion. The hypothesis that mean yield increases are equal to zero can be rejected with confidence.[3] The estimates suggest an average yield increase of 18 percent in rice and 14 percent in wheat due to combining. The estimated yield increase of 0.35 t/ha (3.5 mds/ac) from combining wheat also corresponds to the estimated losses in hand-harvesting, noted above, that farmers associated with labor and rainfall delays. These findings suggest that the farmer who combines his wheat tends to recuperate that proportion of the yield he lost when hand-harvesting as a result of aging, shattering, or rainfall damage.

Yield savings through combining were at least partially offset by two other factors. Rice-combiners recieved a lower price for combined rice than for hand-harvested rice. Wheat-combiners lost the extra revenue provided by sales of straw.

Almost all rice combine-users reported a lower grain quality and recieved a lower price when combining because of broken grain, wet grain, and rice chaff (Table 11). The average price differential was Rs 0.2/kg (Rs 7.4/md). Although the data do not include varietal information, we may assume from the reported yields that most combined rice was Irri. The price dockage represents about 12 percent of the 1986 Irri producer price. Based on these data and assumptions, rice combine-users nevertheless received a net increase in gross returns per hectare because the average increase in returns through higher yields was greater than the average loss resulting from the price dockage.

Table 11. Farmers' Comparison of Grain Price and Quality with Hand-Harvesting and Combine-Harvesting, Rice and Wheat

Crop	Quality: Better by Hand	Quality: Same	Quality: Better by Combine	Total Combine Users	Price: Better by Hand[1]	Price: Same	Price: Better by Combine
Rice	87.5	9.4	3.1	100	90.6	9.4	0.0
Wheat	4.3	78.3	17.4	100	8.7	87.0	4.3

[1] Average reported difference for rice was 7.4 Rs/md.

Table 12. Comparison of Wheat and Rice Harvesting Costs, Combine and Hand-Harvesting with Mechanical Threshing, 1986

Cost/Technology	Wheat Harvest: In-Kind Unit	Wheat Harvest: In-Kind Rate	Wheat Harvest: Rs/Acre	Rice Harvest: In-Kind Unit	Rice Harvest: In-Kind Rate[1]	Rice Harvest: Rs/Acre
Hand-Harvesting						
Cutting Labor						
Grain	mds/ac	2.98	238	kgs/md	4.55	226
Straw	mds/ac	1.66	8.3			
Threshing Labor	kgs/day	21.0	26			
Thresher	kgs/md	4.1	199			
Total Direct Harvest Costs			472			226
Costs of Delay	mds/ac	3.5	280	mds/ac	5.9	366
Total Costs			752			592
Combine-Harvesting						
Combine Rental[2]			350			350
Price Dockage						282
Foregone Straw Sales			246			
Total Costs			596			632

[1] Wage is for both hand cutting and hand threshing.
[2] Using modes, rather than means.

Data from the hand-harvester survey indicate an estimated 1986 rice cutting and threshing wage of one-eighth, or 4.6 kgs/md. Using this estimate, the gross revenue changes noted above, and valuing rice straw at zero, the total costs per hectare from combining appear to be slightly higher than those associated with hand-harvesting (Table 12).[4] This result may explain why farmers informally complained of relatively high rental rates. Yield increases in the succeeding crop, because of more timely planting, may offset this slight difference.

Wheat combine-users suffered no comparable price dockage from quality differentials. The majority stated that the quality of wheat was the same for both technologies, and consequently, they received the same price. However, all wheat combine-users in the sample sold wheat straw when they hand-harvested all their crop. Since combining, about two-thirds have met the dry fodder needs of their herd through hand-cutting some crop area, and about one-third purchase straw. Now, roughly 90 percent of the wheat combine-users burn the stubble remaining in the field after combining, and the remainder leave the stubble standing.[5]

Assuming a wheat price of 2 Rs/kg (80 Rs/md) a wheat straw price of 125 Rs/t (5 Rs/md), and a wheat straw yield of two maunds per maund of grain, wheat combine-users lost a value equivalent to 607 Rs/ha (246 Rs/ac) from straw sales, and gained 692 Rs/ha (280 Rs/ac) from grain yield increases. A very slight change in the assumptions would alter these conclusions--for example, a producer price net of marketing costs, or a higher bhusa price from a deferred sale. A reasonable conclusion is that, on the average, wheat straw loss offsets the increased gross revenue from yield savings.

Using data from the hand-harvester survey, total estimated wheat harvest costs (including grain and straw payments to cutters, payments to threshing labor, and machine rental) average Rs 1166/ha (Rs 472/ac). Considering the loss of straw sales, yield changes and comparative harvesting costs, sample farmers tend to gain Rs 385/ha (Rs 156/ac) in net revenues when they combine wheat (Table 12).

Despite broken rice and loss of wheat straw, the majority of farmers preferred combine-harvesting to hand-harvesting. Twenty-one percent of rice combine-users preferred hand-harvesting because of better grain quality. One rice combine-user noted that he had lost revenue because he previously sold rice straw. Wheat combine-users did not mention loss of wheat straw revenues. Only one wheat combine-user preferred hand-harvesting because of yield losses resulting from lengthy combine contract delay. The two major reasons most often cited for preferring the combine were time savings and freedom from problems associated with labor shortage. The category "time savings" included such responses as "more time to prepare for the next crop."

No rice or wheat combine-user reported that he planned to hand-harvest in the 1987 season. Over 80 percent of 1986 users stated they planned to combine the same crop in 1987, and the remaining 20 percent were uncertain because they were skeptical of combine availability. Slightly over two-thirds of both rice and wheat combine-users stated that they planned to combine the other crop.

Summary

In Gujranwala District during the 1986 crop year, a higher proportion of combine-users combined rice than wheat, although those who combined wheat tended to combine a larger proportion of their total harvested area. Correspondingly, the proportion of total area hand-harvested was lower for wheat than for rice. Proportional area hand-harvested may reflect a physical relationship between herd size and wheat straw needs for wheat combine-users. For rice combine-users, the proportion hand cut may represent their mix of Basmati and Irri varieties. Waterlogged fields may also affect the proportion of rice area combine-harvested. Presently, the characteristics of the new custom market, such as imperfect market information, probably dominate these criteria. On the average, farmers combined over 10 hectares in either crop, and most owned all their crop area.

Most farmers had only one or two years of experience combining their crops. About half were informed of combine availability by a company representative, and about half were informed by other farmers. The majority rented self-propelled machines, although some had rented tractor-pulled machines in previous years. Slightly under half combined both crops in 1986, and of these farmers, two-thirds rented the combines from the same company. Farmers appeared to know little about the companies from which they rented combines, most contracts were verbal, and a number of rice contracts were negotiated on the farm when combines arrived in the area. Rental rates in the 1986 crop year were higher for rice than for wheat, and other than own savings, the one major source of cash for either payment was the grain merchant.

According to farmers' estimates, combines tended to arrive 3 days after the rice crop was ready to harvest, and 5 days after the wheat crop was ready. Farmers' recall of delays associated with wheat hand-harvesting suggests a comparable initial delay period in contracting laborers. However, for farmers represented by the sample, the difference in total harvest duration with the two technologies is dramatic.

Farmers harvested an average of 26 hectares of rice and 21 hectares of wheat. With this farm size, the data suggest that lengthy harvest durations and labor and rainfall delays contributed to substantial yield losses with hand-harvesting in years of longer delays. Farmers' comparisons of yields with the two technologies indicate an average 18 percent increase through combining rice, and a 14 percent increase when combining wheat.

Rice combine-users received an average price dockage of about 12 percent because of inferior rice quality. A net revenue calculation suggests that, despite yield increases with combining and a relatively low wage for rice harvesting, price differentials lead to a slight loss in total net revenues from combining. The slight loss may be compensated by timely planting of the succeeding crop. Despite price differentials for broken rice, a majority of rice combine-users preferred combine-harvesting to hand-harvesting, citing time savings or timeliness of planting the next crop as the major reason for their preference.

Wheat combine-users received no price dockage, but lost wheat straw revenues. All of the farmers sold wheat straw before combining their crop area. Costs of hand-harvesting appear to be high for wheat relative to rice (because of mechanical threshing costs), so that with yield gains, and despite loss of wheat straw revenues, farmers obtain an increase in net revenues from combining wheat. These results also suggest that for farmers combining both crops, the slight loss in net rice revenues could be offset by the gain in net wheat revenues. Wheat combine-users also preferred combining to hand-harvesting primarily because of time savings, and the majority planned to continue combining their wheat crop.

Potential Combine-Users (Hand-Harvesters)

Size of Harvested Crop Area and Tenure

'Potential combine-users' are defined as farmers who operate over 10 hectares and have never rented a combine to harvest either wheat or rice.[6] In 1986, they harvested an average of about 15 hectares of rice and the same area of wheat (Table 13). All rice area was hand cut and hand threshed, and almost all of the wheat area was hand cut and mechanically threshed. On the average, a negligible proportion of total area was harvested by reaper.

Comparing the figures in Tables 1 and 13, total harvested area for potential combine-users appears significantly lower than that of actual combine-users, even though area operated was not used as a criterion in sampling combine-users. This result implies that, although 10 hectares may be a useful lower bound on the farm size of combine-users, most operate a much larger area. Another factor that contributes to the difference is that, while potential combine-users operated at least 10 hectares, their total harvested area in either crop ranged from 2 to 60 hectares. Some farmers kept fields in fallow or increased their fodder area during the 1986 crop year.

The figures in Table 14 indicate that 16 percent of farmers rented all their rice area, and 14 percent rented all their wheat area. Roughly two-thirds of the farmers were full-owners, and about 85 percent of the farmers owned over half of their total harvested area. The mean proportion owned was 78 percent for

Table 13. Average Crop Area Harvested, by Technology, Rice and Wheat Hand-Harvesters, 1986[1]

Crop	Total Area Harvested[2]	Area Hand Cut/ Hand Threshed	Area Hand Cut/ Machine Threshed	Area Reaper Cut/ Machine Threshed
	(ha)			
Rice				
mean	14.6	14.6	0.0	0.0
s.e.	(2.12)	(2.12)		
Wheat				
mean	14.6	0.0	13.7	0.9
s.e.	(2.10)		(2.17)	

[1] No bullock threshed rice or hand threshed wheat reported.
[2] All farmers owned or operated at least 10 hectares, but some grew more fodder or had land in fallow in 1986. One farmer sowed no rice in 1986.

Table 14. Percentage Distribution of Area Owned as a Proportion of Area Hand-Harvested, Rice and Wheat, 1986 [1]

Crop.	Proportion Owned of Hand-Harvested Area					Total	Mean Percentage Owned [2]
	0.00	.01-.50	.51-75	.76-.99	1.00		
Rice	15.8	2.6	5.3	13.2	63.2	100.0	78
Wheat	13.5		8.1	10.8	67.6	100.0	81

[1] Excludes one farmer who did not sow rice, and 2 who harvested all their wheat acreage by reaper.
[2] Difference of means not significant.

rice and 81 percent for wheat. Comparing these results to those found in Table 4, potential combine-users tended to own a slightly lower proportion of harvested area than combine-users.

Harvest Labor Use

Composition of Harvest Labor Teams

Farmers who hand-harvested tended to employ a minor number of permanent laborers or family members in rice and wheat cutting To cut their 1986 crops, each hand-harvester hired an average of about 8 laborers from the village, and 3 laborers from outside the village (Table 15). Almost all rice cutters were also hired to thresh for the same farmer, and rice cutting and threshing were generally accomplished simultaneously. In wheat threshing, farmers tended to employ more family and reciprocal (mangi) labor, although the average numbers of these types of labor remained small relative to casual hired labor. The average size of the threshing labor team for wheat is rather high, which suggests that some of the family or reciprocal labor may have been supervisory or part-time. Compared to rice, farmers hired less than half as many laborers to thresh the wheat crop, which reflects the mechanical threshing practices used in wheat. For the average hand-harvester, in either crop, the mean numbers of cutters and threshers hired from the village are significantly greater than the numbers hired from outside the village.

The figures for the total size of the labor team must be interpreted with some caution. Farmers were asked to report the average number of cutters and threshers working in their fields on any harvest day. Many employed rotating labor teams, and the number of laborers working in a field on a given day varied considerably during the harvest period. On some days, no labor was present in a farmer's fields, while on other days, a large number of laborers were working for the farmer. Sometimes labor teams began work in one farmers' fields and left to work for another farmer before harvest completion. In the interim, or while waiting for casual labor to become available to him, the farmer used family labor. The 1986 figures represent farmers' recollection of the average number of laborers in the field.[7]

A second cautionary note relates to the heterogeneity of the labor employed. Some of those "threshing", and particularly some family members and reciprocal laborers, were probably supervising or assisting part-time by tying and carrying bundles. The figures in Table 15 are best interpreted as simple measures of the composition of individuals working in a large farmer's harvest and the extent of his dependence on hired labor.

Table 16 provides evidence of the composition of hired casual labor by sex. On the average, about 88 percent of a farmer's labor team for cutting either crop was male. Some farmers hired additional women to glean rice. Almost 100 percent of the average wheat threshing team was male. Only one farmer hired

Table 15. Average Composition of Labor Teams Hired by Hand-Harvesters, by Labor Type, Rice and Wheat, 1986

Crop	Hired Casual: From Village	Hired Casual: Outside Village	Permanent[1]	Family	Reciprocal	Total Laborers
			------Cutting------			
Rice						
mean	8.2 *	3.3	0.5	0.7	0.0	12.7
s.e.	(1.38)	(1.04)				(1.13)
Wheat						
mean	7.9 *	2.5	0.5	0.5	0.0	11.4
s.e.	(1.06)	(0.85)				(1.06)
			------Threshing------			
Rice [2]						
mean	8.1 *	3.7	0.3	0.5	0.0	12.6
s.e.	(1.17)	(1.05)				(1.14)
Wheat[2]						
mean	4.7 *	0.8	0.8	1.6	1.6	9.6
s.e.	(1.03)	(0.54)				(1.09)

[1] Contract of at least one year.

[2] In wheat, an average of 3.4 laborers hired to cut also threshed for the same farmer; in rice, almost all those hired to cut for the same farmer.

* Difference between mean number of laborers hired from village and from outside village significant at prob.= .01.

Table 16. Average Number and Proportion of Male and Female Casual Laborers Hired by Hand-Harvesters, Rice and Wheat, 1986

Crop	Cutters			Threshers		
	Males	Females	Total	Males	Females[1]	Total
Rice						
mean	9.6	1.6	11.2	9.7	1.8	11.5
pct.	88.1	11.9	100.0	87.9	12.1	100.0
Wheat						
mean	8.9	1.5	10.4	5.4	0.2	5.6
pct.	87.7	12.3	100.0	98.2	1.8	100.0

[1] In wheat, only one farmer reported hiring female threshers, who assisted by carrying and lifting bundles to the thresher. In rice, hired female gleaners are included in threshing labor.

Table 17. Harvest Duration and Area Harvested Per Person, Per Day, Rice and Wheat Hand-Harvesters, 1986

Crop	Cutting			Threshing			Total Harvest Duration [2]	Acres Harvested/ Person/ Day
	Total Days	Total Persons	Acres Cut/ Person/Day	Total Days[3]	Total Persons	Acres Threshed/ Person/Day		
Rice[1]								
mean		12.7			12.6		29.4	0.10
s.e.		(1.13)			(1.14)		(3.25)	
Wheat								
mean	15.8	11.4	0.20	6.6	9.7	0.56	22.4	0.15
s.e.	(1.76)	(1.06)		(1.28)	(1.09)		(3.04)	

[1] For rice, cutting and threshing usually simultaneous.
[2] For both crops, lengthened harvest durations due to delays. Delays also reduce the estimated acres cut or threshed per person, per day.
[3] Ten-hour days used in conversion from hours.

female wheat threshers, who assisted by tying and carrying bundles. The mean number of males hired by farmers was significantly higher than the number of females, for both tasks and both crops.

Area Harvested Per Person, Per Day

In Table 17, total days cutting and threshing, total persons employed, and mean area harvested are used to estimate a physical coefficient for area cut per person, per day. Since rice cutting and threshing were simultaneous rather than sequential tasks, the physical relationships for the two tasks were not separable. Farmers estimated a total harvest duration of 29.4 days for rice cutting and threshing, including various harvest delays. With this harvest duration and a mean of 15 rice hectares, the average worker (including all labor types) produced the equivalent of 0.04 hectares (one-tenth acre) of cut and threshed grain in one day.

In wheat, the average worker cut 0.08 hectares (one-fifth acre) per day. Considering the average yields of 2.4 tons per hectare (24.3 mds/ac), and a harvest duration that includes some delays, this estimate compares favorably with the figure of 4-5 person-days per acre reported by earlier informal surveys of farmers. The estimated coefficient for threshing appears low. Overstatement of total laborers actually threshing may deflate the estimated physical coefficient compared to the true coefficient. Another factor affecting the magnitude of the coefficient is the use of a ten-hour day to convert hourly figures to days. Although hired laborers reported that they generally threshed under 10 hours per day, farmers reported that threshers (including family labor) will occasionally work night and day. For these reasons, the coefficient probably understates the physical relationship.

Area harvested per person, per day, is also computed for wheat, and is roughly twice as high as for rice, reflecting the use of mechanical threshing. Applying the physical coefficients, a wheat harvest laborer for farmers represented by this sample cut 200 kgs (5 mds) of grain per day and threshed 600 kgs (15 mds) per day.

Contractual Characteristics of Hand-Harvesting

Market Information

The majority of farmers surveyed hired at least some wheat harvest laborers from their village of residence. A minority of farmers hired laborers only from outside their village. Many of the laborers hired outside the farmer's village of residence lived in nearby villages. These findings imply that, despite increased labor mobility and commercialization of the wheat harvest labor market, the locus of the market remains the village, with a circumference of several villages. Migrant labor

is not a recognizable feature of this market, with the possible exception of village residents working in towns or cities who return home for the wheat harvest.

Market transactions also remain personal. Of farmers who hired laborers from their village, 93 percent personally knew all or most of the laborers. Even when farmers hired outside the village, about half of them knew most or all of the laborers.

When laborers were hired from the village, nearly all of the farmers visited the laborer household to discuss the verbal agreement. When farmers hired laborers from outside the village, several actually located labor teams through the grain merchant (Table 18).

In hiring both types of laborers, the farmer himself negotiated the contract with the laborer in most cases. The remaining farmers stated that they did not "negotiate" because wages were fixed by village custom or consensus. The farmers who located laborers through the grain merchant, negotiated the contract directly with the laborers. No "agent" or other farmer negotiated the contract on the side of the farmer or laborer. Only in one case did a hired farm manager (munshi) negotiate for the landowner.

Although farmers seemed to know the laborers they employed, their is no explicit evidence of "tied contracts", or laborers working in more than one task for the same farmer under binding conditions. Seventy-one percent of farmers reported that of all laborers hired, at least some had worked for the same farmer harvesting rice in 1986. Two-thirds of the farmers stated that at least some had worked for them in previous rice or wheat harvests. Only a minority stated that all the 1986 wheat harvest laborers had worked for them in rice or in previous harvests. These results suggest only that farmers may have hired a proportion of the 1986 laborers in preceding years, and that the labor team employed by each farmer does shift from crop to crop and year to year, although the total harvest labor pool available to him is limited.

Despite or perhaps because of the personal nature of the market, farmers often stated informally that they had difficulties ensuring that laborers would continue to work in their fields once they had begun cutting. In the formal survey, only two of the farmers reported that they were obliged to raise the wage during the wheat harvest. Informally, many farmers reported that one team harvested part of their area, and after an intervening delay, another team harvested the remainder.

Farmers' descriptions of the labor market situation and the team's own observations varied by Potwari Circle and even by village. The variations did not simply reflect proximity to larger towns with competing employment opportunities, although the contractual difficulties faced by the farmer generally seemed to have been greater in those cases. The relative bargaining

Table 18. How Farmers Negotiated Contracts with Hired Wheat Harvesters From the Village and From Outside the Village, 1986

Source of Labor	How Located Laborer: Farmer[1] Visited Laborer	Laborer Visited Farmer	Through Grain Merchant	Total Contracts	Who Negotiated Wage: Farmer and Laborer	Decided by Custom [2]
From Village	93.9	6.1		100	87.9	12.1
Outside Village	72.7	9.1	18.2	100	81.8	18.2
All Labor	88.6	6.8	4.5	100	86.4	13.6

[1] "Farmer" includes owner-operators, tenant operators, and in one case, a farm manager.

[2] Respondent said he did not "negotiate" and that wages were decided by village consensus.

Table 19. Wage and Rental Rates for Hand-Harvesting, 1986 and 1987

Payment Type	Wheat Harvest 1986: In-Kind Unit	In-Kind Rate[1]	Rs/Acre	Rs/Day	Wheat Harvest 1987: In-Kind Rate[1]	Rs/Acre	Rs/Day
Cutting Labor							
Grain	mds/ac	2.98	238	48	3.04	243	49
Straw	mds/ac	1.66	8.3	1.7	2.43	12	2.4
Threshing Labor	kgs/day	21.0	26	42	20.8	25	42
Thresher	kgs/md	4.1	199		4.1	199	
Harvest Costs			472			480	
Gross Returns	mds/ac	24.3	1946		25.5	2038	
Harvest Costs as % of Returns			24			24	

[1] Standard errors: grain wage 1986 (0.04), grain wage 1987 (0.16), threshing wage 1986 (0.83), threshing wage 1987 (0.77), thresher thresher rent 1986 (0.24), thresher rent 1987 (0.16).

strength of farmers and laborers also seemed to depend on the village and its customs, as well as the status of the farmer within the village.

Supervision of Harvest Labor

Most farmers also supervised their wheat harvest operations. In the remaining cases (a total of ten percent of cases), a relative, a permanent laborer or hired farm manager supervised the labor. This finding supplements the farm size and ownership picture provided by the sample. In this random sample of medium and large farms in the Punjab rice-wheat system, farmers tended to own most of the land and farmed as owner-operators, rather than as landlords with farm managers.

Wheat Harvest Wage and Rental Rates

Wheat harvest wages, rental rates, total harvesting costs and harvesting costs as a percentage of gross returns are shown in Table 19. For 1986, wages, rates and yields are based on farmers' recall. For 1987, cutting wages are actual and threshing costs and yields were those expected by farmers before harvest completion.[8]

Wage and rental rates showed relatively little variation. Most cutting wages were paid in threshed grain, at an average rate of 296.4 kgs/ha (3.0 mds/ac). With only a slight variation in cutting wages, the data do not reveal any systematic relationship between wages and wheat yields. This relationship may be more evident over time or with a larger sample. Cutting wages were generally supplemented by wheat straw payments, varying from a minor amount "that could be carried" to an amount equivalent to the grain wage (actually two maunds per maund of grain). Few farmers paid in bundles. For the mean payment rates in straw, those farmers paying no straw were included.

About 70 percent of the farmers hired threshing labor, and well over half rented threshers. Farmers renting threshers paid an average rental fee of one-tenth (4 kgs/md). Those hiring thresher labor paid an average of 21 kgs/day for laborers. Many of the farmers surveyed paid both machinery rental and thresher labor costs. To obtain a per acre cost for threshing labor, the mean rate was adjusted to include those who made no payment.[9] For machinery rental, the mean rental rate was also applied to owners, as a proxy for operating and capital costs.

The physical coefficients estimated in Table 17 were used to calculate the per unit figures. With a wheat price of 2 Rs/kg (80 Rs/md), the average farmer paid a monetary equivalent of 1166 Rs/ha (472 Rs/ac) to hand-harvest wheat in 1986 and an average of 1186 Rs/ha (480 Rs/ac) in 1987. In both years, harvesting costs (excluding marketing costs) absorbed about one-fourth of gross returns. With a harvested area of 15 hectares, farmers made a total payment equivalent to about Rs 17,000 to harvest their wheat in 1986.

Table 20 shows that some farmers also made in-kind payments in the form of green fodder, meals, drinks, temporary housing, and transport. Small quantities of green fodder were supplied to over a third of the 1986 and 1987 cutters. In both years, slightly under half of the farmers provided occasional meals, primarily to threshing labor. Slightly under half of the farmers provided some lassi or tea. A small percentage furnished temporary housing. In rare cases, farmers also paid cash advances to laborers or transported them by trolley from their village of residence to the farm.

Wage Differentials

None of the farmers reported paying different wages to men and women cutters or threshers. Women who threshed and also gleaned rice recieved an extra kg/md, but gleaning was an exclusively female task. Farmers reported that wages did not generally vary by age of the cutter or thresher. One explanation for a common wage, despite the heterogeneity of the workers, is that laborers are often family members, relatives, or friends who work as a team. In-kind payment also adjusts for any quality differentials. If one laborer harvests a higher proportion of a hectare per day, the laborer receives the same per hectare payment but earns more during the total harvest period by cutting a greater total area.

Harvest Delays

In 1986, although almost all farmers negotiated contracts before crop maturity, laborers tended to begin harvesting 4 days late in rice and 3.9 days late in wheat. During the 1987 wheat harvest, with the same farmers, the survey team observed an average pre-harvest delay of 4.7 days.

Seventy-two percent of the farmers surveyed had experienced wheat harvest delays caused by labor contracting difficulties at least once during the 1984-1986 period. Most of these delays occurred after crop maturity and before beginning to harvest. Some delays occurred during or after cutting, before beginning to thresh. Few labor delays occurred during threshing. Over the three-year period, total delays caused by inability to contract labor or to retain contracted laborers averaged about 4.8 days (Table 22).

Ninety percent of farmers reported harvest delays caused by untimely rainfall at least once during the 1984-1986 period. Most of these delays occurred during or after cutting, when the crop lay in bundles waiting to be threshed. Farmers reported that rainfall at this harvesting stage is more likely to cause yield or quality losses. The grain may sprout, or the grain and straw blacken. Rainfall delays were usually brief, and averaged about 5 days over the 1984-86 period for the farmers surveyed. Rainfall probabilities are slight for April and May, but long harvest duration increases the probability of rainfall delays.[10]

Table 20. Other Payments to Wheat Harvest Laborers, 1986 and 1987

Payment Form	Percent of Farmers Paying	
	1986 Wheat	1987 Wheat
Green Fodder (Cutters Only)	36.1	43.3
Meals[1]		
always	10.3	20.0
sometimes	38.5	23.3
Drinks[2]		
always	30.8	16.7
sometimes	20.5	20.0
Temp. Housing		
always	15.4	6.7
sometimes	2.6	6.7
Advance[3]	7.7	3.3
Transport[4]	10.3	

[1] Usually only threshing labor.
[2] Includes lassi and tea.
[3] In the few cases reported, advance consisted of grain payment.
[4] In the few cases reported for 1986, farmers provided transport by tractor trolley to laborers living outside the village. Not asked in 1987.

Table 21. Pre-Harvest Delays Associated with Labor Contracts, Rice and Wheat, 1986

Contract	When Negotiated: Days Before Maturity	When Negotiated: Days After Maturity[1]	When Labor Arrived: Days After Maturity[2]	Mean Harvest Duration	Total Days After Maturity Harvest Completed
Rice					
mean	10.1	0.5	4.0	29.4	33.4
s.e.	(2.04)			(3.25)	
Wheat					
mean	12.0	5.6	3.9	22.4	26.3
s.e.	(2.56)			(3.04)	

[1] Only 2 farmers negotiated after maturity in rice; 5 in wheat.
[2] Weighted average for farmers negotiating contract before and after maturity.

Table 22. Delays Associated with Labor Contracts and Rainfall, Average for 1984-1986, Wheat Hand-Harvesters

Wheat Harvest Delay Stage	Source of Delay[1]: Labor Contract	Rainfall
Before Beginning to Cut	2.8	0.4
During or After Cutting, Before Threshing	1.7	3.6
During Threshing	0.4	0.8
Total, All Stages	4.8	4.8

[1] Labor and rainfall delays may not be strictly additive as they can be interrelated.

In 1986, farmers estimated pre-harvest labor delays of 3.9 days. For the 1984-86 period, they estimated an average annual pre-harvest delay of 2.8 days. In 1987, the survey team observed an average pre-harvest delay of 4.7 days. Using the estimate for 1986 only, and the average 1986 harvest duration of 22.4 days, farmers tended to complete their harvest 26.3 days after crop maturity.[11] Tests of the farmers' wheat revealed that, in 1987, they tended to cut wheat at 10 percent moisture content.[12] When asked, farmers stated that the wheat was at the proper moisture content for harvesting. By agronomists' standards, the crop was relatively dry.

Shattering losses can be expected to result from the dryness of the wheat at "crop maturity" and the long harvest duration. For the years of the longest harvest delays, farmers estimated an average of 0.23 t/ha (2.3 mds/ac) lost because of labor delays, and 0.33 t/ha (3.3 mds/ac) lost because of rainfall. In some cases, delays reported in the same year were interrelated. The effects of labor and rainfall delays are difficult to separate either empirically or theoretically. The data can be roughly interpreted as indicating that, based on a three-year average and farmers' recall, large farmers in the Punjab rice-wheat zone can expect at most a 10 to 12 percent yield (and gross revenue) loss due to crop aging or untimely rainfall delays. In terms of percentage loss, the estimate provided by the combine-users for the years when they hand-harvested was very close (14 percent), considering they harvested a larger crop area.

Farmers' Harvest Plans and Preferences

In March of 1987, farmers appeared to be fairly evenly divided between those who planned to hand-harvest and those who planned to combine-harvest wheat (Table 23). Eighty percent had considered another technology, and of these, the majority had considered combining. A small percentage had considered using a reaper. When the team visited the same farmers during the harvest one month later, 15 percent of the hand-harvesters had in fact combined at least a portion of their area.

Over half the farmers planned to hand-harvest rice in 1987. The same percentage had considered another technology, and since no intermediate harvesting technology is available for rice, all had considered combining. No farmer mentioned tractor-pulled combines, perhaps because they did not distinguish between the two types.

When asked why they had not tried the alternatives to hand-harvesting, the majority of farmers stated that the other technology was "not available" or was "too costly." Ten percent said they were concerned about straw loss, and the remaining farmers said they were "not prepared to make the decision." One farmer had tried a reaper, but was not particularly pleased with the result.

Table 23. Hand-Harvesters' Plans and Preferences, 1986

Crop	Plan to Hand-Harvest in 1987			Have Considered Another Tech		Technology Considered[1]		
	yes	no	maybe	yes	no	Reaper	Combine	Both
	--------Percent of Farmers---------							
Wheat	46.2	43.6	10.3	79.5	20.5	16.1	80.6	3.2
Rice	59.5	27.0	13.5	57.9	42.1		100.0	

[1] Only self-propelled combines mentioned; perhaps farmers did not distinguish between tractor-pulled and self-propelled.

Summary

In 1986, potential combine-users harvested an average of 15 hectares of rice and wheat, or less than the average area harvested by combine-users. As compared to combine-users, hand-harvesters tended to own a slightly lower proportion of harvested area than combine-users.

Farmers estimated that on a given day during the 1986 wheat harvest, they hired an average of about 10 laborers, most of whom were contracted from the village. The number of family and reciprocal (mangi) laborers used to thresh wheat was higher than the number employed to cut wheat, although the average number was, in both cases, very small. In the 1987 harvest, the average number of hired cutters actually working on a given day for the same farmers was about 8, or slightly less than the farmers' estimates for the preceding year.

Based on farmers' recall of the 1986 wheat harvest, 88 percent of hired cutters were men, and almost 100 percent of the hired threshing team were men. They also unanimously stated that the wages received by men and women did not differ, explaining that laborers often work as a team, and negotiate one "team" wage. One possible explanation for this result is that in-kind wages adjust for any quality differentials associated with age, sex, or experience. If a worker cuts a smaller proportion of an acre each day, the worker receives the same payment per acre but earns less during the harvest period by cutting a smaller total area. An alternative hypothesis is simply that labor quality differentials are minor or unobservable.

The majority of farmers supervised the harvest themselves. Market transactions were fairly personal and the village appears to remain the locus of the labor market. Most farmers hired at least some labor from their own village, and personally knew the laborers, many of whom had worked for them in previous harvests. Many of the laborers hired outside the village lived in nearby villages. In most cases, farmers themselves negotiated the contract whether they hired labor from the village or from outside the village.

Despite these general characteristics, several farmers faced such difficulties locating labor that they consulted the local grain merchant for assistance. Many farmers recalled problems in ensuring that once a team had begun to cut their crop area, the team would remain to complete the harvest. Farmers descriptions of the labor market and the team's own observations varied by Potwari Circle. Variations reflected not only the proximity of the village to larger towns and competing employment opportunities, but the customs of the village and the status of the farmer within the village.

Costs of wheat harvesting were high for the sample farmers, and wage and rental rates varied little. Including grain and straw payments, thresher labor and rental costs, farmers paid an average of 1166 Rs/ha (472 Rs/ac) to harvest their wheat crop in 1986. Estimates for 1987 totalled 1186 Rs/ha (480 Rs/ac). In addition to these outlays, a certain proportion of farmers also provided small amounts of green fodder, occasional meals, and drinks to harvest laborers. Only a small number furnished temporary housing, paid advances, or paid transport costs for laborers.

Another substantial harvest cost was yield loss associated with labor contract delays and rainfall. Farmers completed their harvest an average of 26.3 days after crop maturity. Based on measurements taken in 1987, "crop maturity" meant a wheat moisture content of only 10.5 percent. Farmers estimated that, in the years of longest delays during the 1984-1986 period, they lost an average of 10-12 percent of their yield due to contract and rainfall delays. Given their harvest duration, and the dryness of their wheat, the magnitude of the losses is not surprising. The percentage loss estimated by hand-harvesters is also very close to that estimated by combine-users when they compared yields with the two technologies.

Wheat Harvest Laborers

Wheat Harvest Labor Participation

In the 1987 wheat harvest, 85 percent of cutters were men, and women represented only 15 percent of cutters. Among age groups, the largest proportion of cutters were from 19 to 34 years of age (45 percent). About one fourth of cutters were between the ages of 35 and 49 years. Fifteen percent were under 18 years of age, and 16 percent were 50 years or over. Among all cutters, slightly under two-thirds were hired by the same farmer to thresh. Only 3 of these were women. The proportions of male and female cutters found on farms in 1987 compared closely with those estimated by farmers' recall for 1986.

Laborers stated that they expected to cut or thresh for an average of about 9 hours per day. Average hours worked were not significantly different between age or sex categories, ranging from about 8 to 10 hours in either task (Table 24). Although farmers often suggested that wheat was threshed "day and night", hired laborers reported an average figure which was similar to a standard workday. Laborers were asked to state actual work hours.

In the 1987 season, laborers expected to harvest for about 21 days and work for a total of 2.9 farmers, with little variation among categories. Last year, they worked an average of about 18 days. Several cutters did not harvest wheat last year.

Table 24. Hours Per Day, Days Harvesting, and Area Cut Per Day, Wheat Harvest Laborers, 1987

Labor Category	Work Hours Per Day		Total Days Harvesting 1987[2]	Total Days Harvesting 1986	Acres Cut/ Person/Day [3]
	Cutting	Threshing[1]			
1-18 yrs mean	10.3	9.4	17.6	16.3	0.22
19-34 yrs mean	8.6	7.9	21.8	18.8	0.18
35-49 yrs mean	8.9	9.2	19.4	18.2	0.22
50 + yrs mean	9.6	9.0	22.1	19.2	0.19
All Male mean	9.0	8.5	20.5	18.4	0.20
All Female mean	9.7		21.1	17.6	0.15
All Labor mean	9.1	8.7	20.6	18.3	0.19
s.e.	(0.25)	(0.31)	(1.29)	(1.54)	

[1] Sixty-four percent of cutters also hired by same farmer to thresh. Calculation of threshing hours per day includes only these laborers.

[2] For 1987, expected; for 1986, recall.

[3] Estimate represents a lower bound. Calculated by dividing total expected earnings by mean wage and total expected harvest days less days threshing for sample farmer. Excludes days threshing for other farmers, which would reduce total days cutting and raise the estimate of acres cut per day.

Based on calculations from the laborer sample, the average area cut per person is 0.08 hectares (one-fifth of an acre) per day. In Table 24, the coefficient is calculated on the basis on expected earnings, wages, and expected total days harvesting rather than actual days cutting. For these and other reasons, the figures may slightly understate actual physical coefficients. The coefficient estimated from the laborer sample is nevertheless equivalent to that estimated from the farmer sample by a different method.

The physical coefficient for all male laborers is exactly 0.08 hectares (one-fifth of an acre). The only marked difference in estimated coefficients among labor categories is between male and female groups. The coefficient for female laborers is slightly under 0.06 hectares (one-sixth of an acre) per day. The female group is too small to estimate a standard error, and the difference between the coefficients may not be statistically significant. The female group is also slightly younger than the male group, with an average age of 26 years as compared to 33 years. Age is related to harvesting experience, and may be associated with area cut per day.

Table 25 shows expected earnings of harvest laborers, and annual caloric equivalents. As in the farmer survey, no differences in wheat harvest payments by age or sex were apparent. Total expected earnings are lowest among women cutters, but the difference may not be statistically significant. Among age group categories, total expected earnings varied little. On the average, laborers expected to earn 380 kgs (9.5 mds) from cutting, and 52 kgs (1.3 mds) from threshing, for a total of 432 kgs (10.8 mds).

The average laborer therefore expected to earn 0.43 tons of wheat in the 1987 harvest season. This amount provides one person with about 4200 calories per day for one year. In Punjab's rural areas, wheat provides an estimated 67 percent of total per capita calories. [13] Assuming a minimum requirement of 2200 calories per day, the average harvest laborer can meet the subsistence wheat needs of 2.8 persons for one year. In this sample, the average labor household size was 8 persons, of which 2.9 participated in the wheat harvest. Consequently, the annual wheat requirements of the average labor household were met through in-kind payments. This finding underscores the critical importance of wheat harvest income to laborers and their household members.

Contractual Characteristics

On the average, laborers had harvested for the same farmer for 4.2 years, and had harvested on any farm for a total of 12.3 years. With a mean age of 32 years, they had harvested since the age of 20 (Table 26). Women laborers in this sample were probably less experienced than men, with an average of 8.5 as compared to 13 total years of harvesting. As can be expected, years harvesting for the same farmer and total years harvesting increase with age group categories. Although little can be

Table 25. Expected 1987 Harvest Earnings, and Annual Equivalent in Calories Per Day, Wheat Harvest Laborers, 1987[1]

Labor Category	Cutting Mds	Threshing Mds	Total Mds	Total Kgs/Day at Harvest	Annual Equivalent [1] Kgs/Day	Annual Equivalent [1] Calories/Day
1-18 yrs						
mean	8.8	1.1	10.0	19.9	1.1	3862
19-34 yrs						
mean	9.7	1.0	10.7	21.4	1.2	4147
35-49 yrs						
mean	9.6	1.6	11.2	22.3	1.2	4333
50 + yrs						
mean	9.4	1.8	11.1	22.2	1.2	4310
All Male						
mean	9.7	1.4	11.1	22.1	1.2	4295
All Female						
mean	8.1	0.8	8.9	17.8	1.0	3457
All Labor						
mean	9.5	1.3	10.8	21.5	1.2	4170
s.e.	(0.44)	(0.34)	(0.51)			

[1] Assumes 40 kgs/md, 365 days per year, and 3540 calories per kg of wheat.

Table 26. Years of Harvesting Experience, and Years Harvesting for Sample Farmer, Wheat Harvest Laborers, 1987[1]

Labor Category	Years Harvesting on Sample Farm	Years Harvesting on Any Farm
1-18 yrs		
mean	2.3	3.7
19-34 yrs		
mean	3.4	7.4
35-49 yrs		
mean	4.3	16.6
50 + yrs		
mean	8.9	21.3
All Male		
mean	4.1	13.0
All Female		
mean	4.8	8.5
All Labor		
mean	4.2	12.3
s.e.	(1.18)	(1.56)

[1] The sample farmer was the hand-harvester selected in the second stage of the sampling procedure. Each sample farmer represents a cluster of wheat harvest laborers, but only one of the farmers for which each laborer expected to harvest.

inferred from the data, the number of years with the same farmer appears to decrease as a proportion of total years harvesting, or laborers seem to 'diversify' their clients (farmers) as they gain harvesting experience.

Between age groups, few differences were observable in how laborers located and negotiated contracts with the sample farmer. Some differences do appear between men and women laborers (Table 27). Fewer women visited the farmer to obtain the job, and none of the women actually negotiated the contract. Among men, the majority were visited by farmers who sought harvest laborers, and most negotiated the contract personally. For all laborers, slightly over half negotiated the contract personally, and most of the others negotiated through a friend or relative who was also a laborer. Often, the laborers worked as a team, and were probably associated by kinship. In most cases the farmer sought the laborer, and the farmer therefore bore the transactions costs of the arrangement.

Consistent with the results from the farmer survey, laborers provided no clear evidence of tied contracts (Table 28). Laborers were fairly evenly divided among those who had worked for the same farmer in crop or livestock tasks and those who had not. The data do suggest that men, but not women, may have worked for the same farmer in tasks unrelated to crop or livestock production. If women had worked for the same farmer at any time, they had worked in crop or livestock production tasks.

Other Employment and Sources of Income

Table 29 shows the three income sources that laborers considered most important in rabi and kharif seasons this past year. Among agricultural sources of income, the most important were wheat harvesting and hoeing vegetables. Ninety-five percent of laborers reported that wheat harvesting was the most important agricultural income source in rabi, and about one-third stated that vegetable hoeing was the second major agricultural income source in that season. Laborers also reported income from vegetable picking, sowing and seedbed preparation, crop irrigation and on-farm crop transport, livestock rearing and own farming.

In kharif, rice harvesting was the major source of agricultural income for 76 percent of the laborers. Rice transplanting was the secondary source of agricultural income most frequently reported for that season.

The laborers can be generally described as "landless," although for the few of them who had access to land, farming was one of the major sources of income. Only 20 percent owned or rented any land, and several of these had rented land for one or two seasons only. On the average, laborers owned 0.04 hectares of land, shared or rented 0.45 hectares, and operated a total of 0.49 hectares.

Table 27. How Laborers Learned of Wheat Harvest Jobs and Negotiated Contracts, 1987

Labor Category	How Located Job: Farmer Visited Laborer	How Located Job: Laborer Visited Farmer	Total Contracts	Who Negotiated Wage[1]: Laborer	Who Negotiated Wage[1]: Laborer Relative or Friend	Who Negotiated Wage[1]: Non-Laborer Relative or Friend	Who Negotiated Wage[1]: By Village Custom
Male	85.9	14.1	100	60.9	32.8	1.6	4.7
Female	90.9	9.1	100		90.9	9.1	
All Laborers	86.7	13.3	100	52.0	41.3	2.7	4.0

[1] "Laborer relative or friend" is a relative or friend who is also a laborer. The category "non-laborer relative or friend" includes a farm manager, whom the respondents did not consider as a laborer. "By village custom" means that, according to the respondent, wages were decided by consensus.

Table 28. Experience Working with Sample Farmer in Other Farm and Non-Farm Tasks, Wheat Harvest Laborers, 1987[1]

Labor Category	Worked for Farmer in Crop or Livestock Tasks: This Year	Worked for Farmer in Crop or Livestock Tasks: Other Years	Worked for Farmer in Non-Crop or Livestock Tasks: This Year	Worked for Farmer in Non-Crop or Livestock Tasks: Other Years
	------Percent of Laborers-------			
Male	43.8	35.9	25.6	18.8
Female	45.5	54.6		9.1
All Laborers	44.0	38.7	25.3	17.3

[1] The sample farmer was the hand-harvester selected in the second stage of the sampling procedure. Each sample farmer represents a cluster of wheat harvest laborers, but only one of the farmers for which each laborer expected to harvest.

Table 29. Percentage Distribution of Laborers by Three Most Important Agricultural and Non-Agricultural Income Sources, Rabi and Kharif, 1986-87

Income Source	Percent of Laborers Ranking Income Source as					
	Rabi[2]			Kharif[3]		
	First	Second	Third	First	Second	Third
Agricultural Income[1]						
Wheat Harvesting	94.7	5.3				
Rice Harvesting				76.0	4.0	
Rice Transplanting				2.7	48.0	5.5
Hoeing Veg. or Sugarcane		30.7	5.4	1.3	5.3	8.2
Vegetable Picking		6.7	4.1		4.0	5.5
Sowing/Seedbed Prep.		4.0	2.7			
Crop Irrigation			2.7		1.3	1.4
On-farm Crop Transport		1.3				
Farming	2.7	4.0	2.7	8.0	4.0	4.1
Rearing of livestock	2.7	6.7		4.0	5.3	1.4
No agricultural income		41.3	82.4	8.0	28.0	74.0
All Laborers	100	100	100	100	100	100
Non-Agricultural Income[4]						
Production						
Construction/Transport/ Material Handling	36.0	12.0	1.3	32.0	8.0	1.3
Weaving/Sewing/Dying/ Food Processing	13.3	1.3		14.7	1.3	1.3
Service	5.3	1.3		4.0	1.3	
Clerical		1.3		1.3		
Sales	4.0		1.3	4.0		1.3
No non-agricultural income	41.3	84.0	97.3	44.0	89.3	96.0
All Laborers	100	100	100	100	100	100

[1] Agricultural income is defined as a job or task related to crop or livestock production. The job or task occurs on the farm.

[2] Rabi is defined as the period from wheat sowing to wheat harvesting.

[3] Kharif is defined as the period after wheat harvesting through rice harvesting.

[4] Non-agricultural income sources are defined by Pakistan Standard Occupational Codes.

In either season, over half of the laborers also had at least one source of income that was not related to crop or livestock production. In Table 29, these are classified according to the Pakistan Standard Occupational Codes (see Appendix 2). The major category that includes production work is subdivided into the two most frequently reported types of occupations found among the laborers. Most non-agricultural jobs were related to construction, material handling, loading, driving or equipment operation, and canal digging. The only other major category of jobs consisted primarily of weaving, sewing, tailoring, and dying or printing of cloth. Women laborers, when they reported any non-agricultural work, were engaged in these occupations. A minority of laborers were engaged as watchmen, peons, or as shop assistants. Only 2 or 3 laborers described themselves as seypis, and these were barbers.

Table 30 shows the income sources, among both agricultural and non-agricultural sources, that the laborers considered most important. In rabi, 82 percent of laborers stated that wheat harvesting was the single most important income source. In kharif, about two-thirds reported that rice harvesting was most important. Overall, agricultural-related income was most important for 87 percent of laborers in rabi, and 76 percent in kharif. The non-agricultural jobs were most important in less than a quarter of the cases in either season, and among these, heavy manual work was most frequently cited.

Estimates for selected agricultural and non-agricultural wages are shown in Table 31. The average wheat harvesting wage, including threshed grain only, was 296.4 kgs/ha (3.0 mds/ac). The average rice harvesting wage was about one-eighth (4.7 kgs/md), for both cutting and threshing. For rice transplanting, laborers were paid an average of 189.9 Rs/ha (76.9 Rs/ac), and for hoeing, 21.4 Rs/day. Using rough estimates for physical conversions, the wheat harvesting wage appears to be considerably higher in daily cash equivalent than the wage in some other tasks. For example, assuming that one laborer transplants a quarter of an acre per day, the rice transplanting wage represents less than 20 Rs/day. The hoeing daily wage is about 21 Rs/day or less than half the wheat harvesting wage. Using the conversions for rice harvesting estimated in Table 17, an average yield (from the sample) of 2.3 t/ha (22.4 mds/ac), the rice harvesting wage appears to be well under the wheat harvesting wage, or around 32 Rs/day. In hoeing, and in vegetable picking (not shown in Table 31), some wage differentials between men and women were observed, although the number of cases for women was small. Informally, women reported that they were paid less in vegetable picking. For the other wages cited in Table 31, no differentials were observable.

Table 30. Percentage Distribution of Laborers by Most Important Income Source, Rabi and Kharif, 1986-87

Most Important Income Source	Percent of Laborers	
	Rabi[2]	Kharif[3]
Agricultural Income[1]		
Wheat Harvesting	82.7	
Rice Harvesting		62.7
Rice Transplanting		2.7
Farming	1.3	6.7
Rearing of livestock	2.7	4.0
All Agricultural	86.7	76.0
Non-Agricultural Income[4]		
Production		
Construction/Transport/ Material Handling	9.3	10.7
Weaving/Sewing/Dying/ Food Processing	1.3	5.3
Service	1.3	1.3
Clerical		
Sales	1.3	1.3
No non-agricultural income		5.3
All Non-Agricultural	13.3	24.0
All Laborers	100	100

[1] Agricultural income is defined as a job or task related to crop or livestock production, occurring on the farm.
[2] Rabi is defined as the period from wheat sowing to wheat harvesting.
[3] Kharif is defined as the period after wheat harvesting through rice harvesting.
[4] Non-agricultural income source are defined by Pakistan Standard Occupational Codes.

Table 31. Selected Agricultural and Non-Agricultural Wages of Wheat Harvest Laborers, 1986-87

Task/Job	Unit	Mean Wage
Agricultural		
Wheat Harvesting		
mean	mds/ac	3.0
s.e.		(0.16)
Rice Harvesting		
mean	kgs/md	4.7
s.e.		(0.23)
Rice Transplanting		
mean	Rs/ac	76.9
s.e.		(2.79)
Hoeing Veg. or Sugarcane		
mean	Rs/day	21.4
s.e.		(2.23)
Non-Agricultural[1]		
Rabi		
mean	Rs/day	34.1
s.e.		(6.40)
Kharif		
mean	Rs/day	33.7
s.e.		(6.89)

[1] For first non-agricultural income source only. For definitions and jobs, see Table 29.

Non-agricultural wages were averaged for all occupations, and ranged from 3 Rs/day for a very elderly vegetable peddler to 100 Rs/day for a wagon driver. The average daily wage was 34.1 Rs in rabi and 33.7 Rs in kharif, or about 34 Rs/day in either season. Wages for construction and loading, or heavy manual labor, show a mode of about 30 Rs/day.

Assuming a wheat price of 2 Rs/kg (80 Rs/md), and using the estimated coefficient of 0.08 hectares harvested per day, a laborer earns a daily wage of 48.6 Rs in wheat harvesting. For these laborers, the wheat harvest wage compares favorably with non-agricultural wages in daily cash equivalent.

Laborers do not appear to relocate in pursuing most of their agricultural and non-agricultural activities (Table 32). Only a few laborers travelled to other districts or regions for either agricultural or non-agricultural jobs. Four-fifths of the agricultural jobs were located in the village where the laborer cut wheat in 1987. About half of the non-agricultural jobs were located in the same village, and about half in the same district. Limited geographical dispersion may reflect the fact that Gujranwala District offers employment in both wheat and rice crops as well as in rural industry and supporting services.

Despite the relatively high daily wages obtained by laborers, the data suggest that their employment levels vary tremendously during the year. Only 13 percent of the laborers considered themselves fully employed in 4 to 6 of the rabi months, as compared to 20 percent for the same period in kharif. In rabi, 25 percent reported that their period of least employment spanned 4 to 6 months. For the remaining 75 percent, the months of least employment fell between December and March, and the period of peak activity was March 15 through May 15. In kharif, 78 percent worked least in the period from mid-July through September. For 55 percent of laborers, the months of peak activity were October and November, and another 25 percent were most employed from mid-May to mid-July.

In the least active months of rabi, laborers worked only 11 days, while they sought work for an additional 6 (Table 33).[14] In those months, they worked 70 percent of the total days in which they sought work , and only 40 percent of the total available days. In the most active rabi months, laborers worked an average of 26 days, or almost all of the days in which they sought work and almost all of available workdays. In the least active months of kharif, laborers worked only 9 days per month, and during the most active months, they worked 26 days per month. The measures reported in Table 33 are rough, but they suggest large seasonal swings in labor force participation. Wide variation in labor force participation implies that daily wage levels should not be used to estimate annual income.

Table 32. Location of Laborers' Agricultural and Non-Agricultural Jobs, Rabi and Kharif, 1986-87

Location/Job Type[1]	Percent of Jobs	
	Rabi	Kharif
Agricultural		
Same Village	80.5	82.6
Another Village/Same District	18.8	16.0
Another District/Same Region		1.4
Another Region	0.8	
All Agricultural Jobs	100	100
Non-Agricultural		
Same Village	45.6	45.3
Another Village/Same District	51.5	50.9
Another District/Same Region	1.5	1.9
Another Region	1.5	1.9
All Non-Agric. Jobs	100	100

[1] Includes first, second, and third most important job. "Same village" is village where laborer was interviewed.

Table 33. Measures of Labor Force Participation for Wheat Harvest Laborers, Rabi and Kharif, 1986-87

Measure of Labor Force Participation	Rabi[1]		Kharif[2]	
	Least Active Months	Most Active Months	Least Active Months	Most Active Months
Days Working Per Month				
mean	11.0	26.3	9.4	26.3
s.e.	(2.01)	(1.20)	(1.75)	(1.81)
Days Not Working But Seeking Work Per Month				
mean	5.9	0.6	5.6	0.3
s.e.	(1.28)	(0.27)	(0.75)	(0.16)
Ratio of Days Working to Days Seeking Work	0.7	1.0	0.6	1.0
Ratio of Days Working to Days Available [3]	0.4	0.9	0.3	0.9

[1] Rabi defined as period from wheat sowing to wheat harvesting.
[2] Kharif defined as period after wheat harvesting to rice harvesting.
[3] In one month, 30 days are assumed available, which is an upper limit.

General Labor Household Characteristics

Most wheat harvest laborers had never attended school. No women laborers had attended school, and the mean years of education among men, which varied littled among age groups, was 1.5. No women laborers stated that they were primary earners in their households. About two-thirds of respondents were themselves considered as primary earners, and among the remaining one-third, male relatives of the respondent were the primary earners. The mean educational level for all primary earners who were not respondents was 1.4 years.

Most of the harvest laborers were cutting wheat in the village that they considered their home and residence (Table 34). Less than one-fifth lived in other villages, and many of these villages were at fairly close proximity to the village where the team found them cutting. Only one laborer stated that his home was in another region, but he actually resided nearby. The data suggest that harvest laborers were not migrants, but considered the locality as both their residence and their original home.

About half of the laborers reported that their fathers shared the same occupation (Table 35).[15] Among those who reported that their fathers had different occupations, the only occupation frequently reported was farming. Over one-fourth of all laborers stated that their fathers had been farmers (owners or tenants). These results suggest that a sizeable share of laborers are from families who recently lost their access to land. The evidence is limited, but striking.

The average labor household consisted of 8 persons, of whom half were male and half female (Table 36). Over a third of household members were under 12 years of age and a very small proportion were 60 years of age or older. Among those of working age (16 to 59 years), one out of four women and almost all men worked for payment. The ratio of non-workers to workers indicates that, on the average, one person supports 1.4 other persons.

Summary

Most wheat harvest laborers had never attended school, and no women cutters had attended school. Their average age was 32, and they regularly ate and resided with a total of 8 persons. Each worker in their households supported an average of 1.4 non-workers. About half of the laborers reported that they shared the same occupation as their fathers, and twenty-five percent reported that, although they were laborers, their fathers had been farmers (owners, sharecroppers or tenants).

During the 1987 wheat harvest, 85 percent of the cutters were men and 15 percent were women. These proportions compare closely with the estimates provided by farmers for the 1986 harvest. The largest single group of cutters were between the ages of 19 and 34. The only major contractual differences between groups were

Table 34. Residence and Home of Wheat Harvest Laborers, 1987

	Location[1]				All Laborers
	Same Village [2]	Another Village, Same District	Another District, Same Region	Another Region	
Home					
pct.	82.7	16.0		1.3	100
Residence					
pct.	86.7	13.4			100

[1] Only three laborers had homes and residences in different locations.
[2] "Same village" is village where laborer was cutting wheat when interviewed.

Table 35. Percentage Distribution of Wheat Harvest Laborers by Occupation of Father[1]

Occupation of Father	Different from Laborer's						All Laborers
	Same as Laborer's	Farmer [2]	Sales	Clerical	Service	Production/ Transport	
Pct. of Laborers	56.0	26.7	2.7	1.5	5.3	8.0	100

[1] Does not vary by age group or sex. Occupational categories as defined in Pakistan Standard Occupation Codes.
[2] Includes both owner-operators and tenants.

Table 36. Size and Composition of Household[1], and Number of Workers and Non-Workers, Wheat Harvest Laborers, 1987

Age/Sex Category	No. Working For Payment	No. Not Working For Payment	Total Per Category	Category As Percent of Household	Ratio of Non-Workers to Workers
lt 12 yrs					
male	0.15	1.4	1.5		
female	0.12	1.5	1.6		
subtotal	0.27	2.8	3.1	38.7	10.5
12 to 15 yrs					
male	0.25	0.11	0.36		
female	0.12	0.31	0.43		
subtotal	0.37	0.42	0.79	9.8	1.1
16 to 59 yrs					
male	2.1	0.2	2.3		
female	0.4	1.2	1.6		
subtotal	2.5	1.4	3.9	48.6	0.6
ge 60 yrs					
male	0.08	0.07	0.15		
female	0.03	0.05	0.08		
subtotal	0.11	0.12	0.23	2.9	1.1
All Male	2.6	1.7	4.3	53.5	
All Female	0.71	3.0	3.7	46.5	
Household Total [2]	3.3	4.7	8.0	100	1.4

[1] Household defined as number of people with whom laborer regularly resides and shares meals.
[2] Standard error of mean 8.0 is 0.65.

found for men and women. Most men negotiated their own wages, and no women personally negotiated their wages. While some men worked for the sample farmers in tasks unrelated to crop or livestock production in previous years, women had worked for them only in crop or livestock production. Wheat harvest laborers were not migrants, nor did they migrate far in search of their other agricultural and non-agricultural jobs. Most of them resided in the village where they were found cutting wheat, and all their major jobs last year were located in the same District. In 1987, laborers expected to cut or thresh about 9 hours per day, harvest for a total of 21 days and work for a total of 2.9 farmers. Based on calculations from the data, the average worker cut one-fifth of an acre (0.08 h) each day. This estimate agrees with that calculated with a different method from the farmer survey data.

The average laborer expected to earn a total of 10.8 mds (432 kgs) in one wheat harvest season. Assuming a minimum requirement of 2200 calories per day, of which 67 percent is provided by wheat, each laborer can meet the subsistence wheat needs of 2.8 persons for one year with the proceeds of one harvest season. The average labor household size was 8 persons, of which 2.9 participated in the harvest. Based on these figures, the annual wheat needs of the entire household can be met through in-kind harvest payments.

This finding underscores the critical importance of wheat harvesting in the annual income of the laborers and their households. A majority of laborers stated that wheat harvesting was the most important single source of income in rabi season.

In kharif season, the major sources of agricultural income were rice harvesting and rice transplanting. In either season, other major sources of agricultural income were vegetable and sugarcane hoeing and picking. Only 20 percent of the laborers had access to land. The laborers generally can be described as "landless," although for the few who had access to land, farming was one of the major sources of income.

In either season, over half of the laborers had at least one source of income that was not related to crop and livestock production. The types of jobs most often cited include heavy manual labor (construction, canal digging, material handling, driving and equipment operation) and weaving, sewing, or tailoring. Women laborers, when they reported any non-agricultural work, were engaged in this second category of occupations. Two of the laborers were permanent laborers hired on a casual basis during the wheat harvest, and only two described themselves as seypi. In terms of total annual income, non-agricultural jobs were most important in less than 25 percent of the cases, and among these, heavy manual work was most often cited.

Estimates of selected agricultural and non-agricultural wages indicate that, in monetary equivalent, the wheat harvest wage compares favorably with non-agricultural daily wages for these laborers. The cash equivalent for wheat harvesting is well over 40 Rs/day, as compared to about 34 Rs/day for all non-agricultural occupations and estimates of about half that equivalent for other reported agricultural tasks. Wage differentials for men and women were observable in hoeing and vegetable picking, although the number of cases was too small to state the difference with confidence.

Although wages may appear relatively high, laborers reported that their employment varied seasonally from a low of 9 to 11 days in the least active months of rabi and kharif, to a high of 26 days in the most active months. The least active months included any of the months except April and May in rabi, and in kharif, they were usually during July and August, or the monsoon period. The most active months most often fell during the wheat harvest, rice transplanting, and rice harvesting. Only 13 percent of the laborers considered themselves fully employed during 4 to 6 of the rabi months, and 20 percent reported that they were fully employed during the same period in kharif. Measures calculated from the data suggest that, in the least active months, laborers worked about 60-70 percent of the days in which they sought work, and only 30-40 percent of available days. In the most active months, they worked almost all of the total available days.

Implications

The data from the Gujranwala survey underscore the policy trade-off associated with the decision to promote combine-harvesting. The findings confirm that substantial yield losses result from delays associated with hand-harvesting. Combines increase efficiency in wheat harvesting through reducing yield losses associated with delays and lengthened harvest duration, and contribute to greater total wheat supply, but at the cost of decreased welfare of laborer households. Any gains in efficiency are therefore met by a loss in equity. The wheat yield loss per hectare in years of long delays is roughly equivalent to the per hectare harvest wage. In other words, in the Gujranwala data, almost a one-to-one correspondence exists between the efficiency gain and the equity loss. Harvest conditions in Gujranwala are fairly representative of those found in other districts in the rice-wheat production zone, although they may differ from those found in other production zones.

The potential social cost of combine-harvesting can be depicted using the survey data. With a wheat yield of 25 mds/a (2.5 t/h), an average of 6.5 person-days are needed to both cut and thresh an acre. Given the capacity of the combines now rented, about 6500 person-days would be displaced per combine in wheat alone. If each hired laborer works 20 days during the wheat harvest, one combine displaces 325 persons. Based on the survey estimates, each laborer supports 2.4 household members. Per combine, the wheat consumption of 780 persons would be directly affected by the loss of the wheat harvest job.

Viewed from another perspective, if all farmers operating more than 10 hectares in the rice-wheat zone became wheat combine-users, about 300,000 wheat hectares would be combined. If each laborer cuts 1.3 h (3.2 acres), 231,000 laborers would lose in-kind harvest payments. If each laborer provides subsistence wheat needs for 2.8 household members, the wheat consumption of about 633 thousand persons, or about 7 percent of the zone's rural population, would be jeopardized (based on 1980 Agricultural Census data). For many of these laborers, the rice harvest is the other major annual source of income, and their rice consumption might also be affected by loss of in-kind earnings.

Seasonal unemployment among the laborers surveyed suggests that the capacity of laborer households to purchase the same amount of grain with cash may be limited. The wheat harvest wage is high relative to both other agricultural wages and those of casual labor in non-agricultural employment, and laborers choose to harvest wheat because it provides their households with a certain grain supply. Although Gujranwala District has enjoyed both relatively high rates of agricultural growth and an expansion of rural industry and services, off-farm employment opportunities may not continue to expand at present rates. As labor returns from the Mid-East market, and as opportunities for migration decline, the overall supply of labor in the region may increase.

The data also indicate that the market for wheat harvest labor remains predominantly a local, village market in this production zone. Adverse effects on the welfare of laborers will therefore have an immediate impact on the village socio-economy.

Alternatives to the current program, such as development and promotion of improved, smaller combines that can be locally-manufactured, or improvement of reaper design, might provide other solutions to the policy problem. Local manufacture would stimulate rural industry and employment. Smaller combines are also more easily maneuvered on fragmented plots. The whole crop harvester produces chopped straw while it cuts and threshes, has a 5-to 6-foot cutting width, and is transported directly behind the tractor. With these characteristics, the harvester may be easier to use on small fields than either the self-propelled or the tractor-pulled, offset-cutting models (Seager). Currently, the cost of reaper harvesting, including the reaper and thresher rental and labor costs, is roughly 300 Rs/acre, or slightly below the combine rental rate. Reapers can be used by a broader range of farmers, and when locally manufactured, generate employment opportunities.

Rental rates for combines probably understate the actual operating costs of the machines because companies receive discounts on the purchase price from manufacturers. With current inflation rates, the real interest rate on the machines may be zero or negative. Any understatement of the true cost of the combines distorts market conditions for the alternative, locally-manufactured technologies that are more likely to stimulate non-farm employment and reach a broader range of farmers. Under more competitive conditions that reflect real prices, farmers would have a greater choice of technologies ranging from rental of large combines for extensive contiguous areas, to rental of reapers or small combines for fragmented areas, and contracting of laborers for less extensive farm areas, where costs of delay are minor.

Agricultural research and extension can also contribute to reducing losses associated with harvest delays through the development and promotion of varieties more resistant to shattering. Work by the Wheat Research Institute at Faisalabad has shown the differential effect of varieties on shattering losses after crop maturity (M. H. Chaudhry et al). Continued work with varietal characteristics is critical to reducing the yield losses associated with harvest delays, independent of the choice to promote or to limit the promotion of combines. In the near future, since combine technology is an option for few farmers, the welfare of a greater number of farmers in the region could be improved through varietal changes.

Notes

[1] Evidence from both the hand-harvester survey and farmers' estimates from the combine-user survey support the hypothesis that for many medium and large farmers, labor contracting delays and occasional rainfall delays increase the total harvest duration to a point where wheat yield losses from aging may be considerable. Aging contributes to shattering and lodging losses, particularly among older wheat varieties. (see M.H. Chaudhry et al., Genotypic Differences in Shattering Losses in Bread Wheat, Wheat Research Institute, Faisalabad, 1985) On the average, hand-harvesters in the Gujranwala survey cut their wheat at 10.5% moisture content. At this low moisture content, and with the lengthy harvest durations found in this survey, shattering losses can be expected to occur in the process of hand-cutting, bundling, and transporting the bundles to the threshing floor.

[2] Combine-users were asked to compare the parameters while imagining the two technologies applied to the same field--e.g., while "controlling" for variable input levels, varietal composition, and total area harvested.

[3] The simple correlation coefficients between yield differences and yields are 0.53 and 0.65 for rice and wheat, respectively. Simple regression of yield differences on yields, when controlling for the effect of total harvested area, reveals regression coefficients significantly different from zero for both crops. Total area harvested affects total harvest duration, and consequently, aging losses associated with hand-harvesting (or the magnitude of yield savings associated with combining).

[4] Valuing rice straw at zero is probably a poor assumption. In informal interviews, the survey team discovered that rice straw, although an inferior fodder, is sold as both a fodder and perhaps more significantly, as a raw material for the District's paper mills.

[5] No significant differences in herd size are evident between rice combine-users, wheat combine-users, and wheat hand-harvesters. For all combine-users, the average number of cattle owned was 6, and the average number of buffaloes owned was 8, for a total herd size of 14. The distribution of herd size is skewed towards lower intervals, with 40 percent under 10, about one-third between 10 and 20, 10 percent between 20 and 30, and the remainder from 20 to 50 total cattle and buffaloes. In this sample, herd size was not correlated with wheat area hand-harvested, wheat area combine-harvested, or proportions of total wheat area hand- or combine-harvested.

[6] The sample therefore includes several farmers who rented reapers to harvest some or all of their wheat area. On the average, a negligible proportion of wheat area was harvested by reaper. For simplicity, the potential combine-users are termed hand-harvesters in the remaining presentation of results, and the two farmers who harvested all their area by reaper are excluded from relevant analyses.

[7] In 1987, the survey team conducted a census of labor teams as part of the sampling procedure for wheat harvest laborers. The average actual labor group size on a given day was 8.2 hired cutters, as compared to farmers' 1986 estimate of 10.4. The team was not able to observe actual numbers of threshers hired in 1987. The two estimates for numbers of hired cutters, each based on a different measurement method, are close. Any differences are probably explained by year-to-year variation in the labor market or sampling error.

[8] Eight to ten days after harvesting began among the farmers surveyed, unusually heavy wind and rain destroyed much of the 1987 crop in Gujranwala District. The figures in Table 19 are representative of costs and yields in the absence of these subsequent, abnormal weather conditions.

[9] As explained above, the cost of threshing labor may be overstated because of prolonged threshing duration and an underestimated physical coefficient. Cases with extreme threshing durations were excluded from the rate calculation in Table 19.

[10] See Salimi, Mohammad Ashraf, et al. Weather Risk Assessment for Punjab, Department of Agricultural Meteorology, University of Faisalabad, 1986. Probabilities were calculated from 1950-1984 rainfall data using a Markov chain. For Lahore District, which is adjacent to Gujranwala District, the probability of more than 5 mm. of rain is 29 percent for April 20-30, 38 percent for May 1-10, and 29 percent for May 11-20. The probability of more than 5 mm. of rain for April 20-May 20 is 57 percent; the probability of more than 10 mm. of rain during the same period is 21 percent; and the probability of more than 15 mm. of rain during the period is 13 percent (p. 39).

[11] Using the 1984-1987 average based on both farmers' recall and direct observation would reduce the pre-harvest labor delay to 3.3 days, for a 25.7-day harvest duration.

[12] Mean 10.51 (s.e. 0.65). All moisture readings taken before the wind and rainstorms in Gujranwala District.

[13] See Household Income and Expenditures Survey of Pakistan, 1979-80, and calculations reported in "Equity Aspects of Wheat Research in Pakistan," Muhammad Asim Maqbool and Melinda Smale, report prepared for CIMMYT, July 1987.

[14] Some laborers explained: "I don't look for work because I know I won't find it (during the winter months)."

[15] "Ancestral occupation" proved to be a sensitive term during the pre-test, and enumerators suggested that the term be simply worded as "the occupation of your father." The concepts measured by the two terms are different and should not be used interchangeably.

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Appendix 1. Sample Survey Design

Budget and Time Constraints

Survey objectives were met with a modest budget, and within a time period of two-three months total for data collection and two months total for analysis and report preparation. The survey team was composed of 4-6 enumerators (economists and rural sociologists), two driver/field assistants, and one survey designer (economist).

Another minor logistical consideration was the desirability of completing the interviews before the commencement of Ramazan, the Islamic month of fasting. Wheat harvesting is one of the peak labor seasons of the crop year, and in 1987, harvesting work began only one week before Ramazan. Respondent burden and workload considerations affected the questionnaire design more than the sample design, although the overall laborer sample size was reduced in order to complete work before Ramazan.

Selection of Survey Area

Irrigated rice-wheat production in Pakistan is concentrated in Gujranwala, Sheikhupura, Gujrat, Lahore, Kasur, and Sialkot Districts of the Punjab. The team purposely selected Gujranwala district as representative of the zone. Secondary sources suggest that, among rural populations of the Punjab, the Gujranwala population has recently enjoyed a comparatively rapid increase in rural wages. Rising rural wages in the District have accompanied the development of local industries and supporting services, and favorable agricultural growth rates.

Informal interviews with combine rental companies also indicated that they presently concentrate and are likely to expand operations in this District. Several company representatives stated that although the farm size characteristics of the wheat-cotton area of Southern Punjab are best suited to wheat combining, the need for combine companies to reduce combine travel time and client transactions costs implies that, in the near future, a large number of companies will continue to combine wheat in areas where they can also combine rice. Company representatives indicated that the highest concentration of clients in Gujranwala District were found Hafizabad QH, Gujranwala and Wazirabad Tehsils.

Definition of Population Subgroups

Combine-users were defined as farmers who had rented a combine at least once to harvest either rice or wheat before the 1987 wheat harvest. Potential combine-users were defined as farmers operating at least 10 hectares who had never used a combine to harvest either rice or wheat. With this definition, 'potential combine-users' are actually large-sized hand-harvesters or reaper-harvesters. Wheat harvest laborers were defined as laborers cutting wheat for the same hand-harvesters during the

1987 harvest. The definitions are explained in the following paragraphs.

Given the brief time frame of the study, the survey was originally designed to collect data only on wheat harvesting. In the informal survey and pre-test, the team discovered some potential relationships between the demand for rice combining and the demand for wheat combining. Rice is the primary commercial crop in the District. Consequently, the team decided to define a combine-user as a farmer who had rented a combine to harvest either crop. The team designed the questionnaire for more detailed data collection from wheat combine-users, with the idea that more comprehensive data could be collected from rice combine-users in a subsequent study. No farm size limitation was imposed on combine-users, and combine-owners were not included in the population.

Through informal surveys with custom combine companies, the team attempted to formulate a profile of potential combine-users. In the early years of custom combining, many companies were unable to impose lower limits on the crop area of their clients because of the need to promote the new technology and meet short-term operating costs. Each combine rented by the companies has a capacity of approximately 20-25 hectares per day, but because of land fragmentation, small field sizes, and variation in road quality, many combine companies stated that they averaged only about 10 hectares per day. This minimum requirement can be most easily satisfied by harvesting one 10-hectare block per day. Over the long-term, companies will be obliged to meet at least this quota in order to cover their costs. One square of land, or 10 hectares, also represents one of the bounds on farm size classes used in the Pakistan Agricultural Census.

The survey designer decided that 10 hectares represented a rough approximation of the minimum farm size of potential clients in the coming years. The team did not attempt to impose a lower limit on fragment size, harvested acreage in either crop, or distance of fields from finished or metalled roads. Although these additional criteria would have improved the definition of the potential-user population, they would have dramatically increased the cost of list frame construction.

Accurate identification of labor households and labor market participants often requires a costly preliminary village census. To save time and reduce costs, the survey designer decided to use the potential-user as a cluster of actual wheat harvest labor participants. From a census of the hired harvest laborers cutting wheat on each potential-user's farm, a sample of participants were drawn during the harvest. Using this definition, the laborer sample represents the population subgroup that will be displaced if each potential-user shifts from hand-harvesting to wheat combining.

Sample Size and Cluster Size

Overall sample size was limited by cost and logistical considerations, or a modest operating budget and staff. A total sample size of 280 farmers and laborers, or 40 farmers per subgroup and 200 total laborers was considered sufficient to conduct simple statistical tests on subgroup means and proportions.[1] In the case of the laborer subgroup, the planned sample size was reduced by a combination of logistical considerations and by unusual harvesting conditions in 1987.

Despite associated difficulties in estimating sampling errors, a cluster design was selected because of its low cost where little is known about the population of interest and list frame construction is necessary. Within a brief time period, and with two vehicles and 4-6 enumerators, a maximum of only 10 primary sampling units was feasible. With 10 primary sampling units, each unit provided an average of 4 secondary units per cluster (per subgroup), and yield 40 total laborer clusters with an estimated average of 5 laborers per cluster.

First-Stage Sampling Frame and Procedure

The 1981 District Census Report for Gujranwala District, which provides the most recent listing of administrative subunits, was used to construct the first-stage sampling frame. The team chose the Potwari Circle as the appropriate sampling unit because of the characteristics of the custom combine market.[2] From the full 1981 list of 209 Potwari Circles located in Hafizabad QH, and Wazirabad and Gujranwala Tehsils, 10 were selected using a random number table. The first-stage sample consisted of the clusters of combine-users and potential-users registered within the 10 Potwari Circles.

Second-Stage Frame Construction and Sampling Procedure

In the second stage, all potential-users and combine-users registered in the Potwari Circle were listed by consulting Numberdars, Village Union Council Chairmen and larger farmers. Several representatives from these groups were usually available to furnish the information for each Potwari Circle. The fact that large farmers are well known in the Potwari circles greatly facilitated the listing process.

The frame constructed from 10 Potwari Circles revealed 235 potential-users and 99 combine-users. To select the sampling procedure for the second-stage, the survey designer consulted sampling statisticians working for the U.S. Department of Agriculture Statistical Reporting Service (SRS) and stationed in Islamabad. The lists, or census of the two population subgroups within the Potwari Circles, indicated wide variation in cluster size. The number of potential users in a cluster ranged from 1 to 49, with an average of 23.5. The number of combine-users in a cluster ranged from 0 to 38, with an average of 9.6.

The sampling statisticians recommended setting a lower limit on the number of units drawn from each cluster, with a constant sampling proportion from remaining clusters. The total sample of 42 potential-users and 41 actual-users was distributed according to this recommendation among the clusters. Where the population in a subgroup cluster was 2 or less, a census was taken. Where the population of potential users was greater than 2, the cluster was sampled at the rate of 1 in 6 (.17). Where the population of combine-users was greater than 2, the cluster was sampled at a rate of 2 in 5 (.4).

Out of 42 potential users, 2 did not meet the definition. One farmer operated only 8 acres, and the other farmer had used a combine on some of his rice acreage in 1986.[3] One farmer was unwilling to participate in the interview. The final sample of potential users contained 39 out of 42 originally sampled, which the SRS statisticians considered as acceptable. Out of the original sample of 41 combine-users, 4 had never used combines.

Third Stage Sampling Frame and Procedure

The total laborer sample size of 200 was reduced by 50 percent because of the desirability of completing the survey before Ramazan with only 4 enumerators. The frame for sampling wheat harvest laborers was provided by the potential-user subgroup survey. Of the 39 potential-users, 3 farmers used reapers to cut all their acreage or employed family labor in 1986. The number of cutters hired by the remaining 36 farmers in 1986 was used as an estimate of the total number of laborers in the farmer clusters in 1987. Based on the 1986 figures, a sampling proportion of 1 in 3 yielded a laborer sample size of 100.

At the commencement of the wheat harvest, the team returned to the potential-users to interview their cutters. When the team arrived at the farm, they contacted the farmer and requested the number of cutters employed in his fields on that day. The team drew a sample of 1 in 3 from a random number table, and identified the laborers corresponding to those numbers as they counted from left to right in the field. If hired laborers numbered fewer than 3, the team took a census within that cluster.

While some team members interviewed laborers, other team members requested updated harvest wage information from the farmer and measured the moisture content of the wheat cut on that day. Average interview time was 15-20 minutes for laborers, and only 5 minutes for farmers.

With the sampling technique used in the third-stage, actual sample size was unknown until the team reached the fields. Of the 36 farmers who hired casual laborers to cut their wheat in 1986, 6 decided to combine wheat in 1987. This reduced the total number of laborer clusters to only 30, and further decreased the actual sample size to 75.

In most years, wheat harvesting begins during the last ten days of April. When the team began the laborer survey, many farmers had not yet begun to harvest, few interviews could be completed, and the team was obliged to return to the farms at a later date. As the temperature increased, the wheat dried rapidly, and more farmers began to harvest. However, many of the farmers had difficulty locating laborers, and the team was again obliged to circulate among farmers as they waited for the commencement of delayed harvesting. In some cases, farmers reported that a labor group had begun to harvest their fields, but left to work for other farmers. These logistical difficulties for the team were an expression of the labor contracting problems experienced by the farmers, and provided more evidence of existing incentives for adoption of combines in Gujranwala District.

Labor contract delays resulted in the need to continue work during Ramazan fasting. Two days after the commencement of Ramazan, unusual windstorms and abnormally high rainfall struck the wheat crop in the District. The team was unable to reach the last two farmers by dirt road. The harvesting delays that resulted from the storms were lengthy, and the team could not complete the two clusters.

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[1] One rough guideline in small sample surveys is a minimum of 20 to 30 observations per characteristic, with some additional observations to allow for substandard questionnaires or problem cases. Although statistical research has shown that sampling errors decrease rapidly as sample size for one characteristic rises to 200 (with modest reductions thereafter), the team did not have the resources to collect data from 200 elements per subgroup. With fixed resources, increasing sample size can also contribute to greater non-sampling error by reducing resources devoted to data quality.

[2] The informal survey that preceded the sample survey suggested that, while combine use is fairly widespread within the Tehsils, custom combine companies prefer clients in some proximity to metalled or finished roads and tend to seek clients with large acreages or villages where farmers with contiguous fields can organize large acreage blocks. The survey team concluded that the village represented too small a cluster of farmers to use as a primary sampling unit, because some villages may contain only one or two farmers with suitable acreage requirements or fields that are accessible by combine.

[3] Some farmers owned or operated a square, but their rice and wheat acreage in 1986 was considerably under a square because they kept land in fallow, planted a higher proportion in fodder and other crops, and in one case, shifted from crop enterprises to cattle production. These farmers were considered as potential-users. A more complete definition in terms of acreage harvested in wheat or rice would have resulted in a more accurate representation of a potential-user, but a more detailed definition would have required considerably more time during the listing procedure,and may not have been feasible.

Appendix 2

PAKISTAN STANDARD CLASSIFICATION OF OCCUPATIONS

Major Group O/1 : Professional, Technical and Related Workers

Minor group	*Title*
0–1	Physical scientists and related technicians
0–2/0–3	Architects, engineers and related technicians
0–4	Aircraft and ships' officers
0–5	Life scientists and related technicians
0–6/0–7	Medical, dental, veterinary and related workers
0–8	Statisticians, mathematicians, system analysts and related technicians
0–9	Economists
1–1	Accountants
1–2	Jurists
1–3	Teachers
1–4	Workers in religion
1–5	Authors, journalists and related writers
1–6	Sculptors, painters, photographers and related creative artists
1–7	Composers and performing artists
1–8	Athletes, sportsmen and related workers
1–9	Professional, technical and related workers not elsewhere classified

Major Group 2: Administrative and Managerial Workers

2–0	Legislative officials and government administrators
2–1	Managers (including directors, working proprietors)

Major Group 3: Clerical and Related Workers

3–0	Clerical supervisors
3–1	Government executive officials (non-gazetted)
3–2	Stenographers, Typists, and card & tape punching machine operators
3–3	Book-keeper cashier and related workers
3–4	Computing machine operators
3–5	Transport and communications supervisors
3–6	Transport conductors
3–7	Mail distribution clerks and workers
3–8	Tele-communication operators
3–9	Clerical and related workers not elsewhere classified

Major Group 4 : Sales Workers

4–0	Managers (whole-sale and retail trade)
4–1	Working proprietors (whole-sale and retail trade)

4–2 Sales supervisors and buyers
4–3 Technical salesmen, commercial travellers and manufacturer's agents
4–4 Insurance, real estate, securities and business service salesmen and auctioners
4–5 Salesmen, shop assistants and related workers
4–9 Sales workers not elsewhere classified (including money-lenders)

Major Group 5 : Service Workers

~~5–0~~ Managers (catering and lodging services)
5–1 Working proprietors (catering and lodging services)
5–2 House-keeping and related service supervisors
5–3 Cooks, waiters, bartenders and related workers
5–4 Maids and related house-keeping service workers not elsewhere classified
5–5 Building caretakers, char-workers, cleaners and related workers
5–6 Launderers, dry cleaners and pressers
5–7 Hairdressers, barbers, beauticians and related workers
5–8 Protective service workers
5–9 Service workers not elsewhere classified

Major Group 6 : Agricultural, Animal Husbandry and Forestry Workers, Fishermen and Hunters

~~6–0~~ Farm managers and supervisors
6–1 Farmers, agricultural and animal husbandry workers
6–3 Forestry workers
6–4 Fishermen, hunters and related workers

Major Group 7/8/9 : Production and Related Workers, Transport Equipment Operators and Labourers

~~7–0~~ Production supervisors and general foremen
7–1 Miners, quarrymen, well drillers and related workers
7–2 Metal processers
7–3 Wood preparation workers and paper makers
7–4 Chemical processers and related workers
7–5 Spiners, weavers, knitters, dyers and related workers
7–6 Tanners, fell-mongers and pelt dressers
7–7 Food and beverage processers
7–8 Tobacco preparers and tobacco product makers
7–9 Tailors, dress makers, sewers, upholsterers and related workers
8–0 Shoemakers and Leather goods makers
8–1 Cabinet makers and related wood workers
8–2 Stone cutters and carvers
8–3 Blacksmiths, tool makers and machine tool operators
8–4 Machinery fitters, machine assemblers and precision instrument makers (except electrical)
8–5 Electrical fitters and related electrical and electronics workers

8–6	Broadcasting station and sound equipment operators and cinema projectionists
8–7	Plumbers, welders, sheet metal and structural metal preparers and erectors
8–8	Jewellery and precious metal workers
8–9	Glass formers, potters and related workers
9–0	Rubber and plastics product makers
9–1	Paper and paper board products makers
9–2	Printers and related workers
9–3	Printers
9–4	Production and related workers not elsewhere classified
9–5	Bricklayers, carpenters and other construction workers
9–6	Stationary engines and related equipment operators
9–7	Material-handling and related equipment operators, dockers and freight handlers
9–8	Transport equipment operators
9–9	Labourers not elsewhere classified

Major Group X : Workers not Classifiable by Occupation

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