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The Green Revolution and the Rural World of Two Punjabs

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Introduction

The introduction of green revolution technologies in the Indian and Pakistan Punjabs in the mid-1960s produced impressive results in reversing the food crisis and stimulating agricultural and economic growth. Numerous studies have attributed agricultural growth experience in the two Punjabs to rapid technology diffusion in the region (Day and Singh, 1977; Hamid, 1981; Feder *et al.*, 1985; Sims, 1988).

However, questions are now being asked about the sustainability of the 'green revolution' in the light of high use of external inputs and growing evidence of a slowdown in productivity growth and degradation of the resource base (Byerlee, 1992; Pagiola, 1995; Pingali and Heisey, 1996). Stagnating yields in farmers' field have also been observed despite growing input use, especially where intensive cereal mono-cropping has been continuously practised (Byerlee and Siddiq, 1994). These problems have been considered especially important in the wheat-rice belt, the breadbasket of northern Indian and Pakistan which covers over 12 million ha and provides food security for some 500 million people (Hobbs and Morris, 1996).

In an attempt to construct an answer to these questions, the present paper seeks to explain the pattern of innovation and adoption of 'improved technology' in the agrarian sectors of the two Punjabs. The paper commences with a debate on the importance and role of infrastructure, information and incentives in the adoption of innovation and level of investment in an agrarian setting. The following section delineates an overview of the agrarian change in the two Punjabs and presents basic statistics as evidence in support of the claim that levels of adoption of innovations in the Indian Punjab have been relatively higher than in the Pakistan Punjab. The level of innovation and investment in the agriculture sectors of respective Punjabs is understood in terms of three categories of variables i.e. infrastructure, information and incentives (referred to as "three I's"). The following paragraphs discusses the issue of sustainability of the intensification strategy and presents evidence in support of the claims that higher use of farm inputs in the two Punjabs has slowed down the productivity and resulted in the degradation of resource base. And finally, the last section summarises the main conclusions and outlines policy implications.

The Conceptual Framework

Many agricultural economists argue that instead of an individual factor determining technology diffusion, the combined effect of several factors is responsible for a higher level of adoption of technology. The level of innovation and investment in agriculture would thus largely depend upon three categories of variables: infrastructure, information and incentives (Chadha, 1986; Sims, 1988; McGuirk and Mundlak, 1992).

Infrastructure, being an important factor can reduce cost in ways that make innovations more profitable. The growth of small towns, for instance, can be aided by the development of infrastructure, which in turn paves the way for relatively rapid adoption of innovations. These small towns become growth poles with supporting light industries such as repair, services and manufacture of agricultural implements. Many economists argue that out of the "three I's" infrastructure is one of the most critical factors in explaining the process of development and transformation of agriculture (Rogers, 1983; McGuirk and Mundlak, 1992).

Secondly, it has been argued that farmers with holdings of all sizes, regardless of the title and legal form would use greater amount of technology inputs. This suggests that these variables (farm size and land ownership) are not important by themselves in motivating farmers to adopt technological innovations. Small farmers will attempt to follow the pace of large farmers in their willingness to adopt new technology. Such adoption incidences, it is hypothesised; indicate that the general thrust to promote the adoption of new technology will add emergence of imitative behaviour among farmers. The first few farmers will be stimulated to adopt the technology promotion schemes and other favourable conditions while the rest of the farmers will base their adoption decisions on favourable information imparted to them by the action of the first few which out-weighs their own information that the technology might not be profitable. As such, information, the second of the "three I's" is also crucial in explaining the level of adoption of new technology (Parthasarthy and Parsad, 1978).

The final "I" i.e. incentives, one should take for granted. The usual focus of analysis of economic decision-making is generally on private profit. While direct incentives in terms of input subsidies and so on are important, the provision of 'infrastructure' and 'information' may have a positive effect on 'incentives' as well. For instance, the availability of roads and electricity can make investment and innovation more profitable in expected terms and even despite disincentives (e.g. below-market government procurement prices, taxes etc.); incentives (e.g. inputs and infrastructure subsidies) can imply a net positive gain to farmers. It is thus possible to argue that farmers will generally adopt the new technology quickly in spite of disincentives. This emphasises the role played by the first two "I's".

In short, to understand the nature of technological change the three-fold classification of (1) infrastructure (2) information and (3) incentives seems to be a useful conceptual framework. The performance of 'green revolution' technology and its impact on the agrarian settings in the two Punjabs is viewed in the context of these various considerations.

Comparative Performance of Agriculture in Two Punjabs: An Overview

The Indian and Pakistan's Punjabs provide an interesting case study in comparative agrarian performance and development. Both regions have historically been the most developed and continue to be so today. In Pakistan, the Punjab has been the most developed and continues to be so today. Comprising around 26 per cent of the total area and a population of 47.3 million representing 56 per cent of the total population, the province appears to 'dominate' the political and economic scene. In contrast, the Indian Punjab, comprising only 1.57 per cent of area and a population of 20.28 million, representing a mere 2.5 per cent of the total population, contributes a significant share from its agricultural output to the central pool. It was reported that the percentage share of the Indian Punjab to the central pool in wheat and rice was 69 per cent and 57 per cent respectively during the 1996-97 period (Aulakh *et al.*, 1998; Singh, 1999).

The two Punjabs have pretty much the same climate, both started off with similar agro-economical and land tenure systems and both share a common culture, language, historical traditions and institutional arrangements. Furthermore, both regions have, since the mid-1960s, experienced rapid technological change associated with the so-called 'green revolution' technology (see Table 37.1).

Table 37.1: Selected Statistics on the Comparative Performance of Agriculture in the Two Punjabs

	Pakistan Punjab	Indian Punjab
	I. Basic land use statistics (1995-96)	
Divisions	8	4
District	34	17
Tehsils	116	71
Villages	25892	12428
Geographical Area	20630 ('000 ha)	5036 ('000 ha)
Total cropped area	15645 "	7818
Net sown area	11136 "	4234
Current Fallow	997 "	92
Culturable waste	1736 "	20
Area under forests	471 "	290
Cropping intensity	128 per cent	183 per cent
	II. Irrigated Area (1996-97)	
Canal	3920 ('000 ha)	1620 '(000 ha)
Tube wells	2411 "	2408 "
Total irrigated	12954 "	4035 "
	III. Farm Machinery & Implements (No) (1995-96)	
Tractor	210628	387007
Tillers	N.A	235000
Combines	N.A	4700
Tube wells	435228	895000
Electric	79557	725000
Diesel	355671	170000

Table 37.1 Cont'd

	IV. Production and Yield of Major Crops (1995-96)			
	Production ('000 tons)	Yield (Kg/ha)	Production ('000 tons)	Yield Kg/ha
Wheat	12710	2150	13542	4090 Rice
1680	1260	7703	3383	Cotton 8780
666	1779	449		
	V. Marketing and Storage (1995-96)			
No. of regulated markets		N.A		144
No. of sub-yards		N.A		519
State owned storage capacity		2.9 Million Tones		15.03 Million Tones
No. of villages reserved/regulated market		N.A		86

Source: (1) Govt. of Punjab, India (1995) (2) Govt. of Punjab, Pakistan (1999).

Yet, in terms of agricultural development, the Indian Punjab has shown relatively better performance (Ahmed and Chaudhri, 1996).

A brief note on the comparative performance of agriculture in the two Punjabs may be in order. As noted earlier, the Indian Punjab has been one of the most developed states in India in terms of agrarian performance and development and continues to be so even today.

Not only has it achieved an irrigation coverage of 95 per cent of the net sown area, cropping intensity of 185, and 98 per cent HYV coverage which are all the highest among the Indian states, but even the yields of major crops – wheat and paddy – are of a very high order, i.e., 3941 kgs and 3393 kgs per hectare respectively (CACP, 1997). Almost all (99 per cent) villages of the Indian Punjab were connected with all-weather roads by the late 1980s and about 77 per cent of the rural households were electrified by the early 1990s. Indian Punjab contributed 21 per cent of India's wheat production, 9 per cent paddy and 21 per cent cotton. With 0.744 million energised tube wells, 0.387 million tractors and 66000 combine harvesters, the state's agricultural production sector is highly capital – intensive and mechanised (Singh, 1999). It also has the highest consumption of electricity, fertilisers and the highest number of tractors (28) per unit of land (1000 acres) in the country. In fact, every third farming household in the Indian Punjab owns a tractor, and Punjab's farmers own one third of the tractors in India. In some villages, the proportion of tractor owners was found even higher (Sharma, 1998). On the other hand, the Punjab in Pakistan, like its counterpart in the Indian Punjab made spectacular progress in its farm sector over the period, 1960's through 1990's. The yield of all crops in Pakistan Punjab increased at an average rate of 1.8 per cent per annum led by wheat and cotton. The highest yield gain occurred during 1966-74. The introduction of short-duration varieties of major crops, supported by increased water availability triggered double-crop cultivation on the same land. Overall, the cropping intensity rose about 30 per cent during 1966-94. At the same time, the production of all crops in Pakistan Punjab increased at the rate of 3.3 per cent per annum during 1966-94, slightly higher than the rate of population growth. The rate of growth was highest during the green

revolution period (1966-74) at 3.8 per cent per annum, and then declined to about 3 per cent as yield growth in wheat slowed sharply. Production growth rates were maintained in the post-green revolution period (1974-84) due to rapid increases in cotton yields and release of new early maturing mungbean varieties. Significant differences in the performance of wheat-cotton and wheat-mungbean systems found was double that of the wheat-rice system (Ali and Flinn, 1989; Khan, 1994).

It is argued that the relatively superior agricultural performance of Indian Punjab, as demonstrated by almost twice the rate of productivity, owes its origins to the well-established facilities in social infrastructure, higher irrigation intensity of private tube wells, a greater use of fertilisers and insecticides and a more stable price policy in agriculture in India than in Pakistan. These policies may also be traced back to the nature of the political regimes and the consequent role of political leadership in the two countries (Day and Singh, 1977; Sims, 1988).

In addition, the agrarian structure of the Indian Punjab, it is argued, proved to be more conducive to the development of agriculture than was the case for Pakistan Punjab. Whereas in Pakistan Punjab, big landlords dominate the rural scene, the case in the Indian Punjab is that the majority of the area is under owner-cultivation, predominantly in the hands of the middle and rich peasantry (see Table 37.2). Owner-cultivation and smaller size of holdings, helped by effective land consolidation and land reform policies, have proved to be a vital factor in the Indian Punjab's success in agricultural development (Randhawa, 1954, 1974).

Table 37.2: Distribution of Land Holdings in the Two Punjabs (1990-91)

	Indian Punjab	Pakistan Punjab	
	No. of operational holding	Distribution of land ownership	
Size of holdings	Number (%)	Owners (%)	Area (%)
Up to 2 ha	44.74	53.48	14.07
2-5 ha.	34.46	29.87	27.87
5-10 ha.	14.78	10.79	21.17
10-20 ha.	5.00	4.06	15.40
20 & above	1.01	1.78	21.46

Calculated from data obtained from the following sources:
1. Govt. of Punjab, India (1995).
2. Govt. of Punjab, Pakistan (1999).

The major effect of the differences in agrarian structure (as also reflected in the differences in political power structures) has important implications for the manner and intensity of the utilisation of new technology as and when it became available. In Pakistan Punjab, a small minority of large landowners controlling a majority of the land and monopolising the agricultural inputs market are believed to have largely appropriated the benefits, channelled through rural institutions whereas in the Indian Punjab, it was both the middle and the rich

peasants, managing most of the land, who seized the opportunities for capitalist agriculture. Thus, in the former case, benefits remained restricted to a small minority whereas in the latter, benefits were diffused throughout the peasantry, albeit disproportionately (Hussain, 1982; Sims, 1988).

The Role of Rural Institutions in the Spread of Improved Farm Technology

The role of rural institutions (cooperatives, credit banks and commercial banks) in the two Punjabs may be judged by analysing their performance in the spread of improved farm technology (e.g. improved seed, chemical fertilisers and pesticides etc.). The new farm technology evolved in the 1960s was generally technically appropriate to the farming conditions in the two Punjabs. Nevertheless, it is difficult to conclude that rural institutions made any significant contribution to its initial spread.

According to some observers, the key constraint on the spread of improved technology did not appear to be institutional. Firstly, it has been argued that the spread of new seeds and the concomitant increase in chemical fertiliser use were associated primarily with the availability of good irrigation systems in the two Punjabs. Secondly, as could be anticipated, profitability appeared to be an important factor in the adoption of new technology in the two Punjabs (see Table 37.3). However, profitability may not have been seriously influenced by rural institutions such as credit banks and cooperatives in the green revolution wheat areas in both the Punjabs. Higher market price levels, fertiliser imports and distribution policies, rural electrification and regulated markets were some of the other major factors influencing profitability, not the specific local institutions (Bhalla and Chada, 1983; Chada, 1986; Johl, 1988).

The spread of hybrid wheat and/or chemical fertiliser use depended much more on the new technology of irrigation. The widespread access to irrigation water in Pakistan Punjab was the result of an enhanced supply of water from an effective canal network system and improved 'On-Farm Water Management Programme' undertaken by the Department of Agriculture and the Water and Power Development Authority (WAPDA) throughout the country. In addition, heavy public investment in the installation of tube wells and subsidy granted to farmers for the installation of private tube wells were some of the other factors for enhancing supplies of irrigation water. In the Indian Punjab, on the other hand, widespread access to irrigation water was attributed to the lending activities of rural institutions, particularly the land development banks (Chaudhry and Dasgubta, 1985; Aulakh, 1998; Ahmad and Chaudhri, 1996). Thus during the key years i.e., 1965-69, when new varieties were becoming established, public lending for tube wells represented the major share of the cost of installed wells in the Indian Punjab, and private credit for tube wells expanded only in the mid 1960s and subsequent period when lending was competitive and credit was in ample supply. This situation helped to establish new varieties by improving water control on the farm and it also helped the smaller farmers who benefited from an improved supply of credit at lower rates.

Table 37.3: Net Returns of Wheat and Paddy in the Two Punjabs (Rs/hectare)

Item	Wheat		Rice	
	Pakistan Punjab	Indian Punjab	Pakistan Punjab	Indian Punjab
Fixed Cost Net	4172.46	6221	7212.12	5925
Operational Cost	9456.13	7677	7882.21	9998
Total Cost	13628.77	13898	15094.33	15923
Yield (Kg/ha)	2150.00	3834	1260.00	5255
Gross Return	8600.00	15758	6615.00	19117
Net Return	-5023.77	1860	-8479.33	3194

Source: Ahmed and Chaudhri (1996).

Relevance of "Three I's" in the Transformation of Agriculture in the Two Punjabs

As noted in the preceding section, the combined effect of several factors has been responsible for higher levels of adoption of technology in the two Punjabs. However, adaptation of the green revolution technology to suit local conditions in the Indian Punjab reinforces the explanation that there was a general thrust to promote the adoption of technological inputs in the state. By removing financial constraints and by making the technological innovations and their complementary inputs more easily and cheaply available, the farmers in the Indian Punjab were provided with an environment conducive to extensive adoption of new technology. These factors, along with a literacy rate greater than that of Pakistan Punjab may have enabled farmers in the Indian Punjab to adopt higher levels of technological inputs (Hamid, 1981; Leaf, 1984; Sims, 1988).

The role of infrastructure was regarded as an important factor in explaining improvements in the transportation and communication during the period, of 1965 through 1970s. Improvements in the infrastructure (power, communication, transportation, marketing and water availability) reduced costs in ways that made innovations more profitable in the Indian Punjab, compared with Pakistan Punjab. In addition, the growth of small towns, aided by the development of infrastructure paved the way for relatively rapid adoption of innovations in the Indian Punjab. These towns essentially became growth poles, with supporting light industries such as repair services and manufacture of some agricultural implements (Chadha, 1986; Sims, 1988; McGuirk and Mundlak, 1992). Thus, in our view, the first of the "three I's", i.e. infrastructure, was one of the critical factors in explaining relatively better performance of agriculture in the Indian Punjab.

The fact that farmers in the Indian Punjab with holdings of all sizes, regardless of title and legal form, used greater amounts of technological inputs suggests that these variables (farm size and land ownership) were not important by themselves in motivating farmers to adopt technological innovations. Small farmers were almost in pace with larger farmers in their willingness to adopt new technology (Frankel, 1971). It was reported that provision of easy credit tempted small farmers to purchase machines despite the fact that these farmers paid little attention to their ability to repay their loans. The demand for tractors and other machinery

may have been unjustified on short-term economic grounds, but such adoption incidences indicate that the general thrust to promote the adoption of new technology aided the emergence of imitative behaviour among the farmers. The first few farmers were stimulated to adopt by the technology promotion schemes and other favourable conditions, while the rest of the farmers based their adoption decision on favourable information imparted by the actions of the first few, which outweighed their own information that the technology might not be profitable. As such, the informational cascades or bandwagon effects may have driven the technology diffusion process in the Indian Punjab, compared with Pakistan Punjab (Feder and Slade, 1984; Kohli, 1996).

Let us now turn to see the role of the final "I", i.e. incentives. As noted earlier, the usual focus of analysis of economic decision-making rests on private profit. While direct incentives in terms of input subsidies and other incentives provided by the respective governments in the two Punjabs were not markedly different, those were certainly not adverse. Furthermore, the provision of infrastructure and information had a positive effect on incentives as well: the availability of roads and electricity made it possible to make investments and innovation more profitable in expected terms. Although disincentives were also present (in the form of below-market government procurement prices and other state taxes on land and produce), yet two points should be recognised. First, positive input and infrastructure subsidies likely implied relatively a net positive incentive in the Indian Punjab, compared with that in Pakistan Punjab. Second, farmers in the Indian Punjab were able to get market prices for some of their farm outputs (more so than their counterparts in Pakistan Punjab, for example). It thus became possible for the farmers in the Indian Punjab to adopt new technology quickly in spite of disincentives.

In conclusion, the threefold classification of (l) infra-structure, (2) information, and (3) incentives offers a useful conceptual framework to understand the nature of technological change in the agriculture of the two Punjabs. It was the congruence of favourable conditions with respect to the first two of the "three I's" (infrastructure and information) and probably the third as well, that made Indian Punjab special. Some of the groundwork in Indian Punjab was laid before independence, and some was the result of slow and fortuitous historical developments. However, the successful role played by contemporary state government policies in the Indian Punjab should not be under-valued. It is also useful to realise the political economy of favourable policies. Decentralisation with respect to agriculture and responsiveness of government to its constituents in the Indian Punjab (less so for its counterpart Punjab in Pakistan) were important political preconditions for the success of these policies (Hamid, 1981; Leaf, 1984).

The Post Green Revolution Scenario in the Two Punjabs

The momentum of the green revolution in the two Punjabs has not been sustained. Stagnation in yields is now accompanied by increasing costs of cultivation. For instance by the mid-1980s, a wheat grower in the Indian Punjab was obtaining lower net returns per hectare, even after incurring higher costs per hectare on modern inputs (Nadkarni, 1988). The cost increase came largely from over mechanisation, labour and irrigation costs, and not from

modern (green revolution) inputs like fertilisers, seeds or pesticides, so far as wheat and paddy crops are concerned (Gandhi, 1997). Almost similar findings have been reported in various studies undertaken in Pakistan Punjab (Ali and Flinn, 1989; Byerlee and Siddiq, 1994).

There has also been evidence of declining viability of smallholdings in the Indian Punjab. The number of operational holdings in 1980-81 declined compared to those in 1970-71 due to a phenomenon of 'reverse tenancy' under which small and marginal farmers started leasing out land on cash terms to the medium and large farmers who had sufficient capital and family labour and had made investments in machinery and irrigation structures. Due to this phenomenon largely, and the non-farm work to some extent, by 1987-88, 34 per cent of the holdings in the Indian Punjab had leased in land as compared with only 26 per cent in 1971-72. This trend made agriculture in the Indian Punjab capital intensive, rather capitalist in nature. It was reported that about 20 per cent of the total farming population, 24 per cent of the small farmers, and 31 per cent of the marginal farmers in the Indian Punjab had income below poverty line (Shiva, 1991; Chand, 1999). On the other hand, farm size in Pakistan Punjab had continuously declined over the past three decades, with a decreasing share of that land farmed by the tenant. This trend, like that in the Indian Punjab, has caused disparity in the farm income between various categories of farm holdings and also shifted the poverty profile upward, particularly so in case of tenants and marginal farmers. Nonetheless, human resource investments and infrastructure in Pakistan Punjab steadily improved during the period 1960s through 1990s period, while rural literacy remained very low (Byerlee and Siddiq, 1994).

Due to the intensification brought about by the green revolution, the farming sector in the Indian Punjab has ended up growing only two crops - wheat and rice - which accounted for as much as 71 per cent of the gross cropped area (Johl, 1996). The intensive production has led not only to monocultures in general in the state due to rice and wheat rotation and, within these two crops in particular, but also higher incidence of pests and diseases. This has led to ecological problems: decline in water table, water logging, soil salinity, toxicity and micronutrient deficiency (Shiva, 1991). On the other hand, soil and water quality in Pakistan Punjab also deteriorated during 1966-94. For example, average soil organic matter, which was already lower than 1 per cent during the early 1970s, further deteriorated at an average annual rate of 2.3 per cent, or a decline of over 33 per cent during the 1980s and early 1990s. Similarly, there has also been an increase in the deterioration in tube well water quality, reflected in a significant increase in residual carbonate and electro-conductivity of tube well water. Residual carbonates have almost doubled over the years, reflecting the common observation that farmers in Pakistan Punjab are increasingly tapping poorer quality groundwater (Byerlee and Siddiq, 1994; Faruqee, 1995).

Lessons and Options

Indian and Pakistan Punjabs were at the forefront of the green revolution in the late 1960s and early 1970s, during which farm machinery, pesticides and fertilisers, irrigation and the replacement of traditional crops with high-yielding varieties dramatically increased

productivity. But the land in the Indian and Pakistan Punjabs is increasingly unable to support the burden of intensive agriculture. Crop yields – and water resources are declining alarmingly, and some parts are close to becoming barren. Many farmers are heavily in debt from their investments in new equipment and reliance on chemicals, and rural unemployment is increasing. Other intensive farming practices in both the Indian and Pakistan Punjabs, particularly with wheat and rice, have virtually mined nutrients from the soil. For instance, heavy use of fertilisers has had disastrous effects: excess nitrates have leached into groundwater and contamination of groundwater with nitrates has increased dramatically. As such, the cultivable lands have become sick through over-application of chemicals.

There have been growing concerns about degradation in most valuable asset-irrigated land base in the two Punjabs in recent years. Resource degradation in itself is not a reason for policy intervention if it is internalised into producer decision-making. However, in this case, there are several reasons to believe that this is not the case. First, some of the problems have arisen from distorted policies that have lead to divergence in private and social costs. In particular, several modern inputs were subsidised for much of the period, i.e 1966-96. Even now, electricity for tube well operation is priced at a fixed annual rate leading to overuse of poor quality tube well water which is a major contributor to soil salinity. Second, the information base on which farmers make decisions is inadequate with respect to internalising rapid changes in soil and water quality variables by moving to more sustainable practices such as integrated nutrient and pest management, more diversified crop rotations, and incorporation of legumes into the system. Third, public sector research has undoubtedly been biased towards development of technologies based on packages of modern inputs, and has neglected research on public goods such as integrated crop management and crops that enhance diversification and sustainability of production systems. Indeed, until recently, very little research addressed efficient use of inputs, and the balancing of external inputs use and internal sources of nutrients. Thus from a policy perspective, there is a case for public and private initiative on several fronts-increased investment in resource management, research and extension, research to develop diversified and more sustainable cropping patterns and rotations, removal of price distortions on key inputs, especially water, and special incentives to invest in inputs such as gypsum that can counteract the problem of poor quality tube well water. Such policy interventions may be rewarding if they can reverse the trend in resource degradation. However, costs of such interventions have to be considered against potential benefits, before making definite policy prescriptions.

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