STRENGTHENING ON FARM RESEARCH WITH FARMING SYSTEMS RESEARCH PERSPECTIVE FOR SUSTAINABLE GROWTH OF PUNJAB

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Punjab agriculture has witnessed spectacular progress since the evolution and adoption of High Yielding Varieties of Mexican Wheats in mid sixties and Phillipine varieties of rice in the seventies. The area under wheat increased from 1.5 million hectares in 1965-66 to 3.3 million hectares in 1990-91 and area under rice increased from 0.3 million hectares to 1.9 million hectares over this period. The production of wheat increased from 1.9 million tonnes in 1965-66 to 12.2 million tonnes in 1990-91 and the production of rice increased from 0.3 million tonnes to 6.7 million tonnes over this period. However, this growth rates have tended to decelerate over time. Production of wheat and rice which recorded the growth rates 10.62 and 18.25 per cent over the period 1965-66 to 1979-80 have declined to 4.69 and 8.40 per cent over the recent decate 1980-81 to 1990-91. The growth rates of productivity of wheat and rice which were estimated at 6.48 per cent and 7.08 per cent over the period 1965-66 to 1979-80 have decelerated to 2.54 per cent and 3.03 per cent respectively over the recent decade.

The predominance of rice-wheat rotation has put into sharp focus the considerable strain on underground water resources and has also lead to the emergence of new weeds and flora besides causing micro nutrient deficiencies and has involved heavy reliance on non renewable commercial sources of energy.

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The present study therefore, seeks to examine the sustainability of agriculture in the central belt of the Indian Punjab where rice-wheat rotation has come up as the most predominent rotation occupying more than 80 per cent of the cropped area.

The sustainability issues are proposed to be discussed from the stand point of On Farm Research (OFR) with a Farming System Research Perspective (FSR). On Farm Research with a Farming System Research perspective is a research conducted in farmers fields with participation of the farmers. The various stages of On Farm Research include, diagnosis, planning, experimentation, assessment and recommendation. Diagnosis include identification of farmers circumstances and constraints. Experimentation involves conduct of agronomic experiments in farmers fileds. Assessment refers to agronomic and economic evaluation of technologies. Recommendation implies certification of technology as fit to be adopted in farmers field. Assessing farmers reaction to recommended technologies is an important feed back mechanism to the research process. If the farmers are accepting the recommendations the researchers can turn to other problems. If the farmers are rejecting or substantially modifying their recommendations then an understanding of why the farmers do this might lead to modification of recommendations.

The discussion is proposed to be conducted as under:

a) Changes over time in farmers external circumstances,
b) Changes over time in resource quality,
c) Changes over time in enterprise productivity and
d) Changes over time in system resilience.

a) Changes over time in farmers external circumstances -- National goals--foodself-sufficiency, agricultural output and input price policy.

The main reason for tilting the cropping pattern in favour or rice-wheat rotation has been the support price policy of assured and rising procurement prices for rice and wheat, and heavily subsidised inputs of canal water, electricity, fertilisers, and other inputs. Incentive prices and input subsidisation have been the key factors responsible for preponderance of rice-wheat rotation. The recent shift in government policy of withdrawal of subsidy on phosphetic of pottassic fertilisers is likely to act as a discentive to fertiliser consumption and is likely to have a marginally adverse affect on production. However, the proposed hike in power tarrif for agriculture and canal rates is likely to rationalise the use of power and irrigation.

b) Changing in Resource Quality

i) Changes in Soil Quality: The Punjab soils are inherently low in native fertility and water retentivity. However, these have been subjected to intensive cultivation to boost agricultural production. Rice Wheat rotation which has become predominant particularly in the central region especially causes severe depletion of soil fertility and degrades soil physical environment. Hence these soils require a constant and intensive care to maintain their health and crop productivity on a sustained basis. Some soil surveys have indicated that these soils are coarse in texture and have very low nutrient and water holding capacity and thus have inherently low production potential of 1 to 2 tonnes/hectare. Almost 50 per cent of Punjab soils are deficient in nitrogen and 25 per cent have low phosphorus but are well supplied with potash. However, in recent years due to continuous paddy-wheat sequence, some micro and macro nutrient deficiencies

have been appearing. For example some paddy fields provide evidence of zinc deficiency and wheat fields of sulphur and manganese deficiency. Besides the uptake of the macro nutrients is in excess of their recoupment.

ii) Changes in Water Quality: The drastic shift in the cropping pattern in favour of rice-wheat sequence has led to intensive exploitation of underground water resources in the state. In several areas of the state, the tubewells have been sunk close to each other resulting in over-drawal of water. As a result of indiscriminate withdrawal of underground water, water table in the central districts where paddy-wheat rotation is dominant has been receeding at the rate of 30-50cm per year. The climax was reached in 1987-88 the drought year when 4 lakh tubewells had to be deepened at an estimated cost of more than Rs. 200 crores. There are now about 60 development blocks out of 118 in the state which have been declared as dark blocks by the Central Ground Water Board from which no further withdrawal of water should be allowed. In south-western districts of the state the underground water which is brackish and of marginal quality for irrigation has been excessively used for raising paddy. The problem of soil alkalnity and salinity has started emerging in several pockets in this region.

The dwindling ground water table in several region of the state is mainly due to extravagant irrigation practices followed by the farmers involving huge wastage of precious water resources. This is particularly so where the source of irrigation is an electric motor for which the farmers are charged on a flat rate basis. In many situations where irrigation capacity exceeds irrigation requirements the farmers tend to over irrigate their crops as the marginal cost of additional irrigation is zero. It would be seen from Table1that the number of irrigations applied to paddy varied from 25 to 52 on different farm sizes with an average of 32. More than 60 per cent of the farmers applied more than the optimum number of 25 irrigations

and 36 per cent of the rice area was over irrigated. The horse power available for irrigation on per acre basis showed a negative relationship with farm size. This was true when electric motors alone were taken into account. Although the over use of irrigation on paddy is glaring, over irrigation is commonly followed in other crops also. The main reason for over use of water are the flat rate charges for electricmotors and the belief among farmers that paddy requires standing water.

The over use of irrigation water has far-reaching implications not only from the user's point of view but also from the ecological standpoint. Over irrigation leads to leaching of plant nutrients, loss in yields because of loss of nutrients, lodging and higher incidence of pests and disease.

iii) Changes over time in Energy Quality--Increasing Dependence on Commercial and Non-renewable sources of Energy

Sustainability is the ability of a system to maintain productivity in the absence of additional inputs of energy. Studies at the Ludhiana Centre of the All India Co-ordinated Project on Energy Requirements in Agriculture reveal that the energy requirement has been increasing by more than twice the ourput in agriculture. Theenergy expenditure in two predominant rotations of rice-wheat and cotton wheat in Punjab which occupy around 80 per cent of the gross cropped area is 51773 and 28733 MJ Ha^{-1} respectively. Among the various components of energy the share of non-renewable and commercial sources was around 86 per cent and 91 per cent respectively. The contribution of fertilisers for these crops ranged from 32 to 44 per cent. The contribution of agricultural chemicals is more than 52 per cent and irrigation comes next with 20 per cent. With continuous fall in water table on account of over exploitation time is not far off when itsuse will be economically unviable.

c) Changes over Time in Enterprise Productivity

It would be seen from Table 1 that both paddy and wheat recorded sustained increases in production over the green revolution period 1965-66 to 1975-76 and also the post green revolution period 1976-77 to 1988-89. However, growth in productivity was continuing from pre to post green revolution in case of wheat but has stagnated in case of paddy.

Thesustainability of any cropping system ultimately depends on the changing pattern of costs and returns. Tables 3 and 4 show the costs of production, procurement prices, profit margins at current and constant prices for wheat and paddy. It would be seen that although the profits have been increasing at current prices these have been contracting at constant prices for both wheat and paddy. The main reason for continuance of rice-wheat rotation has been lack of any technological breakthrough in alternate crops.

Indiscriminate use of agro-chemicals has also endangered sustainability . The rapid increase in the use of nitrogenic fertilizers has increased nitrate content of water much above the tolerance limits. The excessive use of pesticides has resulted in the disturbance of the natural balance between insect, pests and their natural enemies. The alternate method of controlling pests through use of what are called benign insects to destroy harmful ones needs to be given serious trial. Besides, pollution is also being caused due to improper disposal of agricultural and industrial wastes. Ther is therefore an urgent need to monitor the impact of disposal of industrial effluents and recycling of agricultural wastes.

d) Change over time in System Resilience

A system is "an assemblage of elements contained within a boundary such that the elements within the boundary are strongly interconnected but have limited weak or non existent connections with the elements in other assemblages; the combined outcome of the strong relationships within the boundary is to produce a distinctive behaviour of the assemblage in that it responds to many outside forces as a whole, even if they are applied to any part."

The productivity of plants can be measured as the amount of biomass produced per unit of time. Productivity is more appropriately measured either a yield or income or in terms of other benefits that derive from the harvest commonly, yield is measured per hectare. Stability is measured by the coefficient of variation in productivity. Stability measures the behaviour of agro-eco-system in response to normal fluctuations in the surrounding environment. Productivity goes up and down but is not seriously threatened. However agro-eco-systems are also subject to major disturbing forces which can cause productivity to fall well below its previous level. If productivity falls, it may recover either to its original level or to a new lower level. Sustainability is the ability of an agro-eco-system to withstand such disturbing forces. We can distinguish two kinds of disturbing forces. First, these are forces that are relatively small and predictable, act on a regular and continuous basis and produce a large cumulative effect. Salinity, toxicity, erosion, pest or disease attack may be quoted as examples. Such a force constitutes stress. The other kind of force is one that is very large, in-frequent and relatively unpredictable and produce a large disturbance or perturbation. This can be called a shock. Examples are rare floods or drought or an outbreak of a new pest or a sudden rise in input price. There is a continuum between stability and sustainability but they are usually distinguishable by qualitatively

different patterns of behaviour. Stability is easily measured from a time series of productivity but the measurement of sustainability is more complex because of the range of forces and responses that may be encountered. The strength and nature of shock and stress has to be assessed. The pattern of response to disturbance has to be described and the degree of resistance or resilience quantified. How far is the productivity depressed low quickly and to what level does it return and in what manner? Sometimes the productivity may not recover; it may remain at a new lower level.

Our analysis of productivity of rice and wheat shows that although we have achieved remarkable increases in productivity of these two crops, yet these increases have been achieved at the cost of disturbance of the hydrological imbalance, and have aggravated hazards of monoculture and involved over dependence on non-renewable commercial inputs pushing up cost of production. Thus sustainability of rice- wheat cropping system is under stress. There is, therefore, an urgent need to strengthen on farm research so as to avoid inefficient and uneconomic use of the scarce inputs of water and chemicals. The results of micro-level analysis for paddy and wheat indicate that water, fertilizers, and pesticides are being used in excess of recommendations. There is, therefore, vast scope for improving economic efficiency at the farm level, through adoption of improved production practices. Even changes in data of sowing/planting and scheduling of irrigation can help improve productivity. On farm research with farm systems perspective needs to be strengthened so as to avoid inefficient and uneconomic

use of resources. Power tarrif policy for agriculture needs to be revised so as to avoid wastage of precious water resources. Likewise excessive use of chemical inputs beyond their eco nomic optima needs to be discouraged. This is possible only if the framework for on Farm Research which can help diagnose the inefficiencies and constraints in agriculture is upgraded and strengthened.

Table 1

Number of Irrigations for Paddy on Different Sized Farms in Punjab

Farm size category	No. of farmers	Average farm size (acres)	Average area under paddy (acres)	Average number of irrigations per acre of paddy	Total HP available for irrigation through electric & diesel engine		HP for irrigation through electric motor per acre	Farmers covered %	Area covered %
					Per farm	per acre			
Very small	9	3.78	2.59	52	5.44	1.44	0.62	22.5	5.83
Small	10	8.05	5.97	34	10.50	1.30	0.48	25.0	15.16
Semi-medium	6	12.21	10.93	26	11.67	0.96	0.41	15.0	16.65
Medium	9	18.13	13.72	24	12.44	0.69	0.22	22.5	31.37
Large	6	26.44	20.34	26	17.16	0.64	0.21	15.0	30.99
Total:	40	12.74	9.84	32	10.97	0.86	0.31	100	100

Source Compiled from "A Study into the economics of farming in Punjab", Deptt. of Economics & Sociology, PAU, Ludhiana

Table 2: Sustainability of Average Yields of Rice and Wheat in Punjab, 1966-67 to 1990-91

Year	Rice	Wheat
1966-67	1185	1524
1967-68	1322	1863
1968-69	1364	2177
1969-70	1490	2245
1970-71	1765	2238
1971-72	2045	2406
1972-73	2007	2233
1973-74	2287	2216
1974-75	2071	2395
1975-76	2553	2373
1976-77	2611	2430
1977-78	2910	2538
1978-79	2937	2716
1979-80	2604	2797
1980-81	2733	2730
1981-82	2955	2932
1982-83	3144	3004
1983-84	3063	3015
1984-85	3073	3289
1985-86	3531	3200
1986-87	2966	3331
1987-88	3540	3164
1988-89	3667	2770
1989-90	3593	3510
1990-91	3715	3229
Compound Growth Rates		
1965-66 to 1979-80	7.08	6.48
1980-81 to 1990-91	3.03	2.54

Cost of production and profit margin for paddy, Punjab state (Rs/qtl)

Year	Cost of production	Procurement price	Profit Margin	Cost at 1967-68 prices	Procurement price at 1967-68 prices	Margin at constant prices
1981-82	102.31	123	20.69	35.22	47.86	12.64
1982-83	103.87	130	26.13	31.67	49.09	17.42
1983-84	122.32	140	17.68	35.85	49.05	13.20
1984-85	137.00	148	11.00	37.71	49.88	12.17
1985-86	125.74	150	24.26	32.47	48.77	16.30
1986-87	129.23	154	24.77	32.17	48.43	16.26
1987-88	149.19	175	25.81	32.61	48.42	15.81

Cost of production and profit margin in wheat crop, Punjab state

(Rs/qtl)

Year	Cost of prodn.	Procure-ment price	Profit margin	Cost at 1967-68 prces	Procure-ment price at 1967-68 prices	Margin of constant prices
1975-76	99.5	113	13.5	48.27	69.56	21.29
1976-77	101.4	110	8.6	47.71	71.67	23.96
1977-78	108.6	113	3.4	50.81	63.79	12.98
1978-79	101.5	115	13.5	44.97	68.76	23.89
1979-80	102.8	117	14.2	38.03	64.88	26.85
1980-81	124.7	130	5.3	42.05	56.25	14.20
1981-82	118.5	142	23.5	38.56	61.44	23.28
1982-83	125.22	151	25.8	36.67	58.75	23.08
1983-84	137.5	152	14.5	37.67	60.92	23.25
1984-85	136.3	157	20.7	35.06	60.57	25.51
1985-86	129.3	162	32.7	31.20	56.63	25.43
1986-87	150.4	165	14.6	34.99	53.82	18.93
1987-88	139.95	173	33.05	29.62	49.60	19.88
1988-89	150.01	183	32.99	30.64	44.81	14.17

Factors affecting paddy yields in Punjab

Sr. No.	Const	ST	FS	DP	HL	DHP	EM	DE	Nit	Pest	Fert.	R^2
1.	64.56 (9.22)	-5.11** (2.14)	-1.16** (4.52)	0.093 (0.97)	0.004 (0.09)	-0.018 (0.37)	-0.010* (2.44)	0.019* (2.04)	0.040** (1.91)	-0.0055 (0.518)	-	0.36
2.	68.74 (10.75)	-6.03** (2.61)	-1.24** (4.93)	0.087 (0.90)	0.0052 (0.119)	-0.021 (0.429)	-0.009* (2.21)	0.018* (1.91)	-	-0.0079 (0.720)	0.004+ (1.31)	0.34
3.	66.49 (10.43)	-6.24** (2.66)	-1.16** (4.61)	0.071 (0.73)	-0.0002 (0.035)	-0.031 (0.628)	-0.004 (1.25)	-	-	-0.0089 (0.80801)	0.004+ (1.30)	0.31
4.	66.42 (10.44)	-6.95** (3.21)	-1.15** (4.57)	0.072 (0.75)	-0.0001 (0.032)	-0.034 (0.707)	-0.0035 (1.131)	-	-	-	0.344+ (1.144)	0.31
5.	65.67 (5.52)	-7.03** (3.26)	-1.12** (4.74)	-	-	-0.041 (0.874)	-	-	-	-	0.0031 (1.051)	0.30

**Significant at 1 per cent level. *Significant at 5 per cent level. +Significant at 20 per cent level.

ST Soil type = 1 for clay loam
= otherwise

FS Farm size (ha) DP Date of planting HL Human labour DHP Date of harvesting EM Electric Motors hour ha

DE Diesel engine hours Nit Nitrogen kgs per ha

Pest Expenditure on pesticides (Rs) Fert. Expenditure on fertilizers (Rs)

Factors Affecting Wheat Yields in Punjab

Intercept	ST	DS	Tenure IT	DHW	DVW	DS-DHP	EM	DE	Nit	Ph	Pot	For.	Pest	R^2
597.96 (1.98)	106.34 (1.41)	-	75.84 (0.66)	-	+176.58* (1.59)	-	-0.21 (0.23)	-0.64 (0.33)	-2.15 (1.66)	-1.09 (0.60)	1.17 (0.38)	-	-0.52 (0.69)	33
435.55 (1.23)	133.70 (1.36)	-5.64 (1.96)	-	4.62 (0.66)	+179.94* (1.45)	3.43 (0.64)	-0.12 (0.14)	-0.79 (0.40)	-	-	-	-0.33* (1.74)	-0.62 (0.83)	32
415.48 (1.22)	128.54 (1.53)	-8.93* (1.98)	91.52 (0.83)	4.94 (0.72)	+186.49* (1.56)	3.75 (4.71)	-	-	-	-	-	-0.32* (1.71)	-0.66 (0.89)	31
575.57 (2.04)	-	-3.77* (1.98)	-	-	+170.23* (1.68)	-	-	-	-	-	-	-0.34* (1.86)	-0.49 (0.61)	28

ST Soil Type clayloam=1 otherwise =0
DS Date of Sowing
IT Tenure Dummy Tenanted=0 owned =1
DHW Date of harvesting
DVW Dummy for Varieties old=0 New =1
DS-DHP Turnaround period between harvesting paddy and sowing wheat
EM Electric motor hrs
DE Diesel hrs
Nit nitrogen
Ph Phosphorus
Pot Potash
Fert Fertilisers (Rs)
Pest Pesticides (Rs)