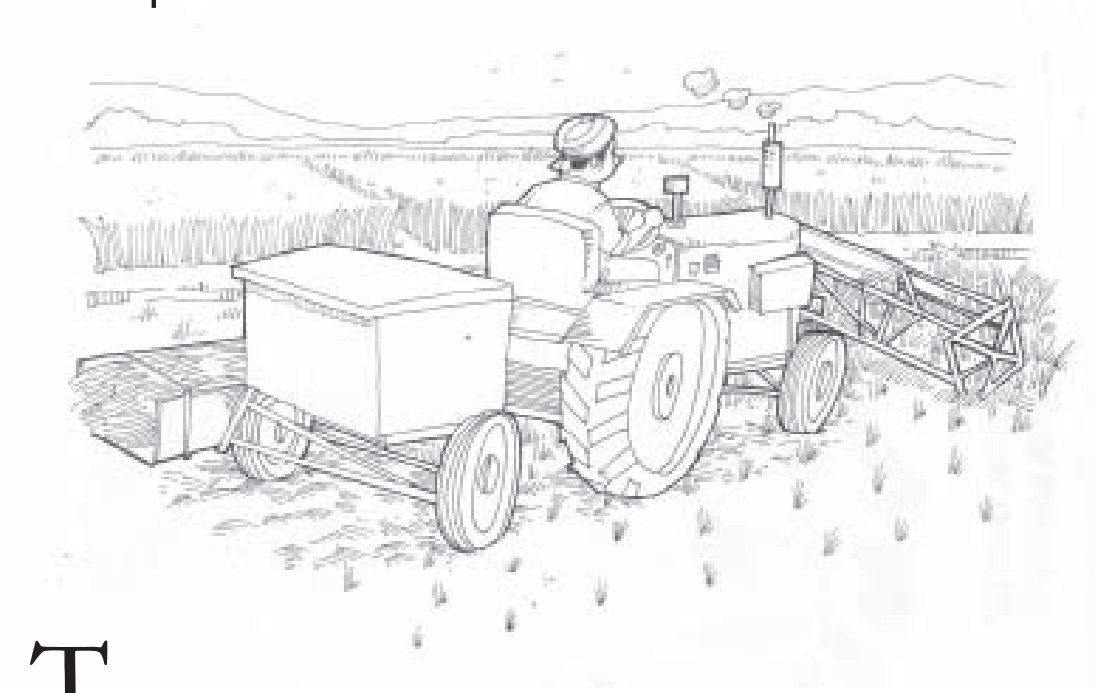
Farm-level Sustainability of Intensive Rice-Wheat System: Socioeconomic and Policy Perspectives



The rice-wheat system (RWS) is one of the widely practiced cropping systems in India and covers about 9.5 million ha. About 90% of this area is concentrated in the Indo-Gangetic Plains (IGP) comprising the states of Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, Bihar and parts of Rajasthan, Madhya Pradesh and West Bengal. Almost 90% to 95% of rice area in Punjab, Haryana and western Uttar Pradesh is under intensive RWS.

The favorable resource-base, availability of suitable modern technologies, and expansion of irrigation infrastructure complemented by the attractive macro- and micro-policy environments facilitated increase in rice and wheat outputs and yields tremendously in the intensive RWS over the past three decades. But recently, several causes have been reported for the decline in productivity of RWS. Some of these causes are declining soil fertility due to continuous and intensive monocropping, increasing soil salinity and alkalinity, declining partial factor productivity to fertilizer use, increasing pest and disease incidences, and deteriorating quality of water. The magnitude of yield decline is higher for rice than for wheat; rather there is an increasing trend for wheat yields under intensive RWS.

Most of the currently-available knowledge on these issues is based on data from long-term experiments (LTE) on research station or on-farm adaptive trials. But there is limited information on how farmers perceive these issues in terms of the yield losses. Therefore, the changes that occur in RWS under controlled environment at research sites (also in adaptive trials) may not be the same under real farm environment in farmers' fields.

The Transformation of the System

The agricultural production system has been transformed under RWS over the past three decades in several states in India in relation to micro- and macro-policy changes.

Is the sustainability of intensive RWS under threat in farmers' fields in India as it was reported from research sites? Farmers adjust their farm operations over the period to cope with the changing production and micro-policy environments.

Shift in Cropping Pattern

Total food grain production in India increased from 142 million tons in the triennium ending (TE) 1985/86 to 203 million tons in TE 2000/01. This was possible because of area expansion and productivity improvements in rice and wheat crops during this period. The area of coarse cereals and pulses has reduced due to crop diversification in favor of rice and wheat crops in RWS-dominant states. Cultivation of pulses in Punjab has almost disappeared over the period.

Shifts in Cropping Pattern and Composition of Food Grain Production in Punjab, India

Year (TE*)	Total area of food grain crops (million ha)	Share (%) in total cropping pattern				Total food grain production (million tons)	Share (%) in total food grain production			
		Rice	Wheat	Coarse cereals	Pulses		Rice	Wheat	Coarse cereals	Pulses
1971/72	3.9	10.5	58.0	20.4	11.2	6.8	10.7	76.1	8.1	5.1
1984/85	5.2	28.5	59.5	8.1	3.9	15.0	30.5	63.9	4.7	0.9
1995/96	5.9	37.8	57.9	3.6	0.8	21.1	34.9	62.5	2.5	0.2
2000/01	6.2	41.8	54.7	3.2	0.3	25.0	34.8	62.8	2.4	0.1

*TE = Triennium ending

Trends in Input Use Levels

Adoption of Modern Varieties

Farmers especially in irrigated environment found the modern or high-yielding varieties (HYVs) of rice and wheat more profitable and suitable for their production system, when these new varieties emerged in the 1960s and 1970s. Therefore, adoption of modern rice and wheat varieties eventually took place rapidly in Punjab, Haryana, and Uttar Pradesh. Nearly 95% to 98% rice and wheat area was planted to modern varieties by 1981/86. By 1992/97, nearly 100% wheat area was planted to HYVs while interestingly, rice area under HYV dropped in Punjab and Haryana between 1981/86 and 1992/97. Farmers in these states are substituting HYVs of rice with exportable and traditional rice varieties whose yields are quite low but higher priced.

Expansion of Irrigation Infrastructure

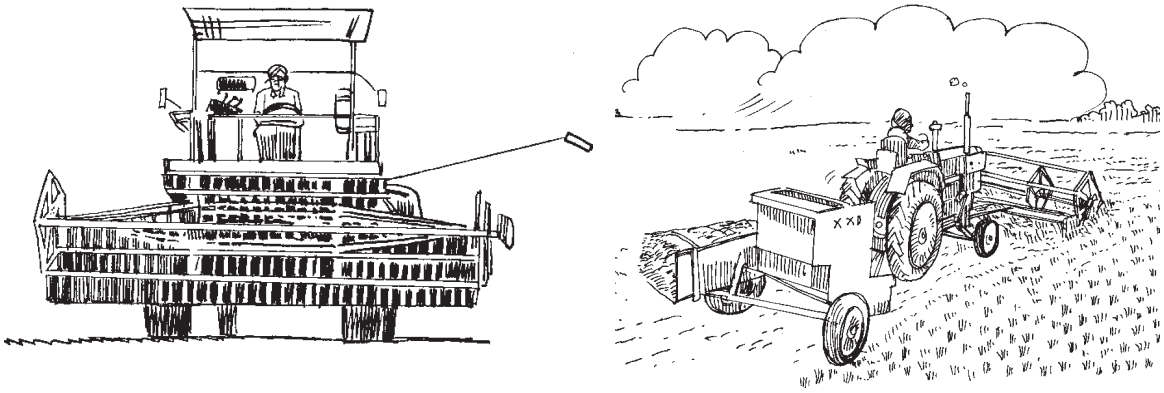
About 95% to 98% of the RWS had assured irrigation sources by the 1980s in Punjab and Haryana. Irrigated area under rice and wheat in other states also increased in the 1990s. Irrigation infrastructure is essentially required to adopt modern rice/wheat varieties. Thus, lack of assured irrigation is the major cause for non-adoption of modern rice and wheat varieties in eastern India. However, 68% and 78% of wheat area in Bihar and West Bengal respectively were covered by irrigation sources.

Increase in Use of Chemical Fertilizer

Modern rice and wheat varieties are highly responsive to chemical fertilizers. Therefore, use of fertilizers has increased tremendously for rice and wheat in the intensive rice-wheat belts. Use of chemical fertilizers is still low in Bihar as adoption of HYVs is low with less proportion of area under irrigation. In West Bengal, fertilizer use increased after the 1980s as modern varieties started spreading.

Labor Use

Intensification of RWS in Punjab and Haryana has increased demand for labor. Agricultural commercialization in this region has led to diversion of labor force from farm sector to non-farm sector leading to mechanization of RWS in this region. Thus, labor use in rice-wheat crops has significantly dropped between 1971/76 and 1992/97 in the intensive rice-wheat states of Punjab, Haryana and Uttar Pradesh. To cope with the increasing labor demand, labor-saving machinery such as combine harvester, power tiller, sprayers, dusters, threshers, balers, etc. have been widely adopted in these states.



Availability of labor in time is a major constraint in Punjab and Haryana. Farmers in these states bring contract labor from eastern states especially Bihar during March/April for wheat harvesting. To cope with the labor demand mainly for paddy transplantation, farmers in these states have changed sowing time from May/June to March/April so that paddy transplantation could be done with the same labor brought from Bihar after wheat harvesting season.

Use of Organic Manure

Intensification and mechanization of RWS in Punjab, Haryana, and some parts of Uttar Pradesh had reduced cattle population. This is due to lack of demand for animal power and conversion of pastures and other areas under fodder crops into agricultural lands. As a result, use of organic manure for rice and wheat crops has drastically reduced over the period in these states as well as in eastern India. Further, availability of chemical fertilizers at subsidized cost is also a principal factor for the negligence of conventional organic manures under intensive RWS.

On-farm Assessment of Long-term Productivity Trends

Are Rice and Wheat Yields Declining Under Farmers' Fields Over the Period?

The productivity growth of rice in farmers' fields declined but there was no negative growth during 1982/83 to 1995/96 under RWS in Punjab, Haryana and Uttar Pradesh. Thus, there was no yield decline in absolute terms in farmers' fields during this period. On the other hand, wheat yields in these states increased significantly at 1.8% to 2.6% per annum in the late Green Revolution Period. This increase has sustained the system productivity.

Changes in Productivity Levels of Rice and Wheat in India

State/Crop	Yield (tons/ha)				% change in yield		
	1971/72 (TE)	1984/85 (TE)	1995/96 (TE)	2000/01 (TE)	1984/85 over 1971/72	1995/96 over 1984/85	2000/01 over 1995/96
Punjab							
Rice	1.8	3.1	3.3	3.4	75.3	8.1	0.3
Wheat	2.3	3.1	4.0	4.6	35.7	28.5	15.8
Haryana							
Rice	1.7	2.5	2.6	2.4	43.4	2.7	-8.5
Wheat	2.1	2.5	3.7	4.1	22.9	44.4	12.6
Uttar Pradesh							
Rice	0.8	1.2	1.9	2.1	54.5	52.5	10.0
Wheat	1.2	1.9	2.4	2.7	50.5	29.9	17.2
Bihar							
Rice	0.8	0.9	1.3	1.5	9.6	45.1	18.6
Wheat	1.3	1.5	2.1	2.2	20.6	35.3	6.8
West Bengal							
Rice	1.3	1.6	2.1	2.3	22.3	32.7	12.6
Wheat	2.1	2.4	2.3	2.4	16.6	-4.6	2.6

*TE = Triennium ending

Has Instability of Yields Increased Under Farmers' Fields?

Instability indices for system productivity have declined between the early and late Green Revolution Periods and the productivity levels of RWS have stabilized by reducing yield variations over the period. However, instability of rice productivity in West Bengal has substantially increased during 1982/83 to 1995/96. This may be due to rapid coverage of HYVs.

The total factor productivity (TFP) for rice and wheat crops has increased significantly between 1971/72 and 1981/82 in intensive RWS of North India. During this period, TFP growth was higher for rice than for wheat and later it was vice-versa.

Yield Trend in the IGP

In eastern India and Bangladesh, where rice is the predominant crop and wheat has unfavorable production environments (shorter duration of winter, heavy soils and scanty rains during the winter season), rice-wheat systems expanded during the 1970s in response to the food grain shortage and the availability of higher-yielding wheat varieties. By 1980, the expansion of wheat stagnated at 5% of the area in Bangladesh and West Bengal in India. Since the mid-1980s, wheat yield has stagnated at around 2.0-2.5t/ha in Bangladesh and West Bengal, whereas rice yield continues to increase. In northwestern India, however, rice yield has stagnated and wheat yield increased. In northwestern India and Pakistan, rice yield is already the highest in the region. In other regions, the yields of both rice and wheat are steadily increasing.

Insights from Farmers' Experiences

Sample Farmers

Survey data was collected during 1999-2000 for a collaborative study of the Directorate of Rice Research (DRR) of the Indian Council of Agricultural Research (ICAR) and the International Rice Research Institute (IRRI), Philippines. Ten high productive rice-growing villages in each state of Andhra Pradesh, Karnataka, Punjab and Uttar Pradesh were selected. Ten progressive farmers were randomly selected from each village. These farmers had more than 10 years experience in rice cultivation.

Does Yield Gap Still Exist Under Intensive Rice System?

Only 30% of the sample farmers reported a decline in yield by 0.6 to 0.8 tons per ha while 60% stated yield stagnation between 1990 and 1999 under intensive RWS. Decline in yield of 0.8 tons per ha in rice-rice system was reported by only 40% of sample farmers during wet season while about 0.8 to 1.0 ton per ha of yield increase was mentioned by 60% farmers during dry season. Thus, the magnitude of 'yield decline' in RWS over the past 10 years was not as serious as earlier perceived by the researchers.

Are There Significant Losses Caused by Biotic and Abiotic Stresses that Could be Recovered Through Further Development of Technologies?

Based on farmers' perceptions over the past 10 years (1990-99), the annual yield loss is estimated at 536 kg/ha. This is equivalent to the total annual loss of about 5 million tons of paddy under the intensive rice system of which nearly 60% is due to biotic stresses (insect pests and diseases). The remaining 40% is due to resource (soil and water) degradation. The total yield loss accounts for only 8.5% of average yields obtained by farmers.

Insect pests have caused more yield loss than diseases in rice system. The total yield loss due to all major insect pests, after all possible plant protection measures was only 2% (125 kg/ha) and 3% (116/ha) of average yields obtained by farmers in Punjab and western Uttar Pradesh respectively. Stem borer, brown plant hopper, green leaf hopper, and leaf folder were the major yield-reducing insect pests while bacterial leaf blight and blast were major disease-causing yield losses.

As intensive RWS is concentrated under assured irrigation sources in Punjab and western Uttar Pradesh, the annual yield losses due to water-related stresses was minimum, i.e., less than 1% of average levels. However, soil-related problems have caused yield loss of about 2% (about 100 to 120 kg/ha) of average rice yields obtained by farmers under intensive RWS. Zinc deficiency, alkalinity, and iron deficiency are major yield limiting soil-related stresses under intensive RWS.

Estimated Annual Yield loss of Paddy Due to Biotic and Abiotic Stresses Under Intensive Rice Systems in India

System/State	Annual yield loss (kg/ha)				
	Insect pests	Diseases	Water-related stress	Soil-related stress	Total
Rice-rice system					
Andhra Pradesh	180	140	120	124	564
Karnataka	160	170	40	80	450
Rice-wheat system					
Punjab	125	65	40	102	332
Western Uttar Pradesh	166	91	48	119	424
Average*	**181**	**140**	**84**	**131**	**536**

*Proportion of rice area in each state was taken as weight for computing 'average' figures.
Data source: Survey data collected for an IRRI-ICAR (DRR) collaborative study "Constraints to increasing rice production in the irrigated rice systems in India", 1999-2000.

Implications

The introduction of modern varieties or HYVs of rice and wheat in the 1960s and 1970s complemented with supportive macro-policy environment made these two crops more attractive to farmers. The expansion of irrigation infrastructure, almost free electricity, subsidized input supply, minimum support pricing, procurement, etc. are major macro- and micro-policies that induced farmers to expand the area under rice and wheat at the cost of pulses and coarse cereals in the rice-wheat region.

Changes in Macro-Policies to Ensure Farm-Level Sustainability

- There is a need to withdraw gradually all protective policy support for rice and wheat crops.
- Subsidized input supply policy should be reviewed and public investments should be allocated for resource conservation activities instead of direct production subsidies.

The incidence of poverty was low in Punjab, Haryana and western Uttar Pradesh where there was high adoption rate of HYVs and irrigation coverage. Thus, increase in rice and wheat supplies through the Green Revolution era significantly brought down real prices of rice and wheat to reducing poverty in India from about 56% in 1973 to 26% during 1999-2000.

Although the rate of decline in real prices per ton was higher than the rate of decline in real cost of production per ton for both rice and wheat, overall real profitability for production of these crops has increased at farmers' level due to tremendous yield improvements over the period. Therefore, under current policy environment with available technologies, production of rice and wheat crops is more profitable than other alternative crops in the intensive RWS dominant states. Although these micro-policies have played a greater role in boosting food supplies during chronic deficit era, continuation of the same policies even in the 1990s has brought in market distortions for other crops that prevented the farmers to diversify agricultural production systems under RWS leading to several of today's environmental concerns.

Price Trend in the IGP

In northwestern India and Pakistan, where wheat has a favorable growing environment and rice can be grown only with full irrigation, the rice-wheat system expanded after the early 1970s in response to market opportunities and the availability of high-yielding rice varieties. Rice gradually emerged as a commercial crop while wheat remained the principal staple food. Bangladesh receives a large quantity of wheat (1.0-1.5 million t/yr) as food aid from wheat-surplus donor countries such as the United States, Australia, and Canada. This should have depressed the prices of wheat in the local market and provided disincentives to the growth of wheat production. But there has been a faster decline in the real price (adjusted for inflation) of rice compared with that of wheat. The price of both rice and wheat generally remained above the world market price. The data indicate that the price trend was not a dominant factor in the unfavorable system where the productivity growth of wheat was slow.

Information generated on costs and returns shows that boro rice has higher financial and economic returns than wheat. Where the production environment is favorable for both crops (availability of assured irrigation), wheat cannot compete with dry-season rice. Wheat, however, has a comparative advantage in areas with a longer duration of winter and light soils. The year-to-year variation in area under wheat was related to the price of wheat relative to that of the competing crop. But the long-run variation in area under both wheat and rice was price-inelastic. For Nepal, the price response for wheat was higher in areas with assured irrigation and access to developed infrastructure.

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