Sustainable Agriculture, Poverty and Food Security

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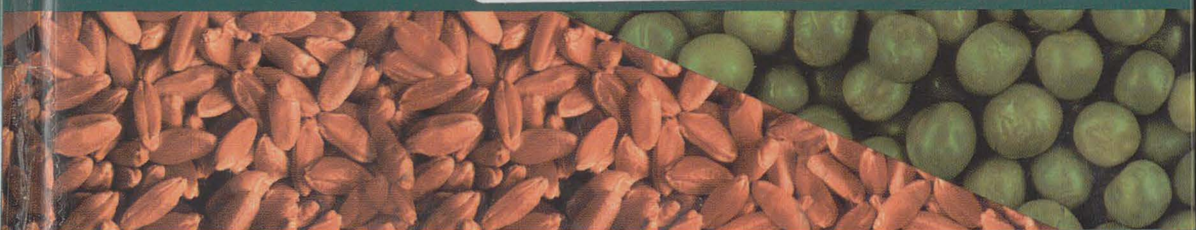

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Sustainable Development of Agriculture in Haryana (India)

K.N.Rai and D.B.Yadav

With the increase in crop yields from modern farming techniques, reaching a plateau and the mounting environmental problems, the need for sustainable and ecological agriculture is increasingly being felt in the country. The bio-chemical technology introduced in the mid-sixties has been the major exogenous technological change witnessed by Indian agriculture. No doubt, India has emerged from a food-deficit to self-sufficient country. However, the benefits of the Green Revolution have not come without environmental costs. Agricultural resources in several areas have been severely degraded, and signs of agro-ecosystem stress and even of its breakdown are visible here and there. Despite the adverse effects the modern technology/inputs have generated or resulted by their use (miss/under/over), neither it is possible nor advisable to ignore the positive gains in the short run, especially in case of developing countries on account of burgeoning population vis-à-vis lack of instant readymade package to switch over to the sustainable ways and means. Therefore, the option open is to iterate in between the losses and gains of the present technology and the input use in vogue and make gradual shift towards the sustainable pattern keeping in view the present and future needs.

Haryana, being one of the states which experienced Green Revolution in the first instance of its introduction, has witnessed impressive increase in foodgrain production from about 26 lakh tonnes in 1966-76 to 114.48 lakh tonnes in 1996-97. Moreover, it improved its relative position in terms of per capita income from fifth in 1966-67 to third in 1996-97. Haryana is the second state after Punjab contributing to the national foodgrain pool. In addition, it produces a large quantity of cotton, oilseeds, sugar, vegetables and animal products such as milk, eggs and broilers.

Evidence is accumulating, however, to suggest those gains from the Green Revolution are being eroded. The expansion of paddy and wheat area has nearly halted, growth in paddy and wheat productivity is thought by many to have slowed and historical sources of productivity growth appear to be exhausting their potential. Declining soil fertility, organic matter loss, water-induced land degradation, declining/rising water table, increasing nitrate content in ground water, hazardous residual contents in food and fodder chain, and threat to beneficial flora and fauna – all appear to be important factors. Therefore, the need is for a new approach, equally revolutionary but different in its ideas and strategies on three fronts, viz., ecological, economic and equity. It is not necessary that every planned/visualised development will bring the positive impact in isolation but may yield negative diversions too. The main threat to agriculture is diminishing resource base. Resources are threatened in two ways: by depletion and by contamination. Both problems have an impact far beyond agriculture, in that the resulting loss of food production and environmental damage threaten and diminish quality of life.

Objectives and Methodology

With these and associated considerations, all along with their repercussions in view, following objectives were framed for the present paper: (i) to study the utilisation pattern of land, water and agro-chemicals in perspective; (ii) to reschedule the resource use pattern for sustainable production; and (iii) to suggest the suitable policy measures for sustainable agriculture.

Table 1 *Water, Fertiliser Requirements (Recommended), Pesticide Consumption and Gross Returns*

Crop	*Recommended water requirement (metre ha)*	*Recommended fertiliser requirement (kg/ha)*			*Pesticide consumption (%)*	*Gross returns (Rs/ha)*
		N	*P*	*K*		
Paddy	1.300	150	75	60	14.00	7230
Jowar	0.225	40	20	-	-	-
Bajra	0.225	40	20	-	2.50	2275
Maize	0.350	150	60	60	1.00	4697
Wheat	0.325	150	60	60	5.50	10903
Barley	0.225	112	60	30	1.00	5710
Gram	0.115	15	40	-	1.50	4855
Groundnut	0.275	15	50	25	-	7276
Rapeseed	0.175	40	20	-	4.50	9896
Cotton	0.450	150	60	60	22.50	13555
Sugarcane	1.450	150	-	-	7.00	20141
Potato	0.350	150	50	100	1.50	22896
Redgram	0.200	15	40	-	1.00	6525
Greengram	0.200	15	40	-	1.00	4121
soybean	0.200	25	80	-	-	7500
Lentil	0.200	-	15	40	-	4188

Notes: 1. N-Nitrogen, P-Phosphorous, K-Potash.
2. The gross returns were rounded to nearest figure.

The paper is based primarily on secondary data that include Statistical Abstracts of Haryana for the years 1981-82 to 1996-97, publications of Department of Agriculture and Irrigation, Government of Haryana and of Haryana Agricultural University, Hisar.

The gross returns from the different crops were calculated by taking average productivity of a particular crop for the triennium ending 1996-97 and multiplying by post-harvest price for the year 1996-97. The crop-wise detailed information has been depicted in Table 1. The average input prices considered for water (Rs/metre ha), fertilisers (Nitrogen, Phosphorous and Potash in Rs/kg of nutrient) and pesticides (Rs/kg or Rs/litre) were Rs 1,580, Rs 6.65, Rs 7.75, Rs 2.80 and Rs 195 respectively.

To make gradual switchover with systematic replacement and to imbibe the possible gamut in its entirety covering underlined objectives of sustainable agriculture, linear programming technique (LPT) was applied, so as to make the rescheduling of resources on sustainable lines. The crops, which require more of water and agro-chemicals, were substituted with those requiring less of it with 10, 15, and 20 percent area reduction (Table 2). The crops were substituted having importance in maintaining and improving soil status.

Table 2 *Area Replacement and Substitution of Crops*

Area reduction (10%, 15% and 20%) crop	*Area substitution (% distribution) crop*
Paddy	Soybean + Redgram + Greengram (40) (30) (30)
Wheat	Gram + Rapeseed + Potato + Lentil (25) (25) (25) (25)
Cotton	Groundnut + Maize + Redgram (40) (30) (30)

The existing area of a crop considered here accounts for the average area of the crop during the years 1994-95, 1995-96 and 1996-97. For the pesticides consumption, the average consumption of 1994-95 to 1996-97 were taken in to account and then based on the opinion survey of the entomologist, the crop-wise consumption were worked out. To estimate the optimum crop combinations at various levels as outlined, the linear programming technique was employed.

Besides crop acreages, water and fertiliser availabilities were used as restrictions to work out the possible alternative optimum crop plans at various levels of switch over. The water and fertiliser availability was worked out on the basis of their requirements at existing cropping pattern. The input-output prices as well as productivity levels were assumed to remain the same in all the plans. The optimal plans over existing plans and at 10, 15 and 20 percent area adjustment in the existing cropping pattern were worked out all along with changes in water, fertiliser requirement and in gross returns. The pesticides consumption was worked out on the basis of crop acreages under alternative optimal plans. Henceforth, these optimal plans will be referred to as existing optimal plan and the suggested optimal plan I, II and III respectively.

Agricultural sustainability status is a prerequisite for identifying the strong and weak linked aspects of sustainable development of agriculture for a particular area. This also focuses on priority hint for policy attention and orientation of programmes towards sustainable development of a region. Based on these considerations, for ascertaining the agricultural sustainability status, sustainable livelihood security index (SLSI) approach was employed. The concept of SLSI is a livelihood option, which is ecologically secure, economically efficient and socially equitable. In an operational context, the sustainable development of agriculture (SDA) requires the SLSI, to be a composite of three indices, viz., Ecological Security Index (ESI), Economic Efficiency Index (EEI) and Social Equity Index (SEI), so that it can take stock of both the conflicts and synergy between ecology, economic and equity aspects of SDA.

In the present investigation, ecological security is reflected by three variables, namely, proportion of geographical area under forest, per capita utilizable ground water potential in metre hectare and population density per square kilometre. The economic efficiency is represented by land productivity in Rs/ha, labour productivity in Rs/ha And cereal output per capita in kilogram. The social equity is reflected by people below poverty line in percent, female literacy in percent and current ground water use as percentage of its ultimate potential.

Results and Discussion

Land Use Pattern

The various facets of land use pattern for the period from 1980-81 to 1996-97 have been presented in Table 3. As is evident from the data, there has not been any perceptible change in the area under forest during the period under investigation. The forest area which showed the sign of rising trend up to 1991-92 failed to maintain it and went down to the ever lowest figure of 115 thousand hectares in 1996-97, much lower than the 132 thousand hectares in 1980-81. On an average, forest area in Haryana accounts for less than 4 percent of geographical area. Barring 1987-88 and 1992-93 more than 80 percent of the area has been put under crops. This is much higher figure compared to many states. More than a half of the net sown area (except few years) has been double-cropped. The cropping intensity recorded as high as 168.69 percent during the year 1988-89.

Cropping Pattern

The overall account of share of different crops in the total cropped area for the Haryana state has been depicted in Table 4 for the years 1980-81 to 1996-97. In order of share in the gross cropped area, the first four crops were wheat, bajra, gram and paddy during the year 1980-81. The order changed to wheat, paddy, cotton, rapeseed and bajra in the year 1996-97. Cereal-based cropping pattern sharing more than 50 percent acreage does warn overall risk of crop specialisation in the long run on a few crops instead of many crops, thus farmers prone themselves to disaster and thereby

Table 3 *Land Use Pattern Of Haryana*

(in '000 ha)

Year	*Total Area*	*Forest Area*	*Land not available for cultivation*	*Permanent pastures and other grazing land*	*Culturable waste*	*Current fallow*	*Net area sown*	*Area sown more than once*	*Total cropped area*	*Cropping intensity (%)*
1980-81	4,405	132	434	30	30	177	3,602 (81.77)	1,860	5,462	151.64
1981-82	4,405	134	425	25	41	120	3,660 (83.09)	2,166	5,826	159.18
1982-83	4,394	136	417	27	48	170	3,596 (81.84	1,710	5,306	147.55
1983-84	4,394	130	405	27	47	185	3600 (81.93)	2,088	5,688	158.00
1984-85	4,391	132	402	27	46	168	3616 (82.35)	1,896	5,512	152.43
1985-86	4,391	166	392	28	23	168	3,613 (82.28)	1,988	5,601	155.02
1986-87	4,391	169	390	28	23	158	3,622 (82.49)	2,040	5,662	156.32
1987-88	4,391	166	405	30	23	528	3,233 (73.63)	1,453	4,686	144.94
1988-89	4,391	166	398	26	25	209	3,564 (81.16)	2,448	6,012	168.69
1989-90	4,380	168	391	21	29	175	3,593 (82.02)	2,058	5,651	157.28
1990-91	4,378	169	417	23	21	169	3,575 (81.66)	2,344	5,919	165.57
1991-92	4,385	170	379	25	43	256	3,508 (80.00)	2,062	5570	158.78
1992-93	4,376	171	405	31	33	240	3,492 (79.79)	2,361	5,853	167.61
1993-94	4,374	167	413	29	38	209	3,513 (80.31)	2,302	5,815	165.53
1994-95	4,369	110	498	27	14	156	3,559 (81.46)	2,430	5,989	168.28
1995-96	4,398	110	494	24	23	156	3,586 (81.54)	2,388	5,974	166.59
1996-97	4,399	115	480	24	23	137	3,615 (82.18)	2,459	6,074	168.02

Note: Figures in parentheses are percentage to total area.

Table 4 *Cropping Pattern of Haryana*

(percent to total cropped area)

Year	*Paddy*	*Jowar*	*Bajra*	*Maize*	*Wheat*	*Barley*	*Gram*	*Other pulses*	*Ground-nut*	*Rapeseed and mustard*	*Cotton*	*Sugarcane*	*Vegetables*	*Total Cropped area ('000 ha)*
1980-81	8.86	2.51	15.93	1.30	27.08	2.28	13.22	1.33	0.11	5.48	5.79	2.07	0.71	5,462.00
1981-82	8.66	2.02	14.62	1.20	26.81	2.06	17.97	1.52	0.14	3.48	5.66	2.50	0.71	5,826.00
1982-83	9.22	2.18	14.67	1.06	32.48	1.55	9.59	0.98	0.14	3.06	7.48	2.77	0.68	5,306.00
1983-84	9.85	2.67	14.76	0.95	31.52	1.32	11.39	1.27	0.12	3.44	7.12	2.33	0.60	5,688.00
1984-85	10.11	2.78	13.58	1.12	32.93	1.22	11.28	1.28	0.15	5.82	5.34	2.10	6.78	5512.00
1985-86	10.43	2.06	11.59	0.98	30.37	1.56	13.58	1.52	0.18	6.48	6.14	1.86	0.81	5601.00
1986-87	11.09	2.67	13.67	0.96	31.48	1.22	10.79	1.20	0.12	5.01	6.72	2.21	0.67	5662.00
1987-88	9.91	2.86	10.34	0.87	36.94	1.33	4.27	1.39	0.12	6.97	8.88	3.04	1.01	4686.00
1988-89	10.01	2.57	13.07	0.72	30.39	1.06	10.73	1.38	0.05	6.37	7.20	2.17	0.71	6012.00
1989-90	11.35	1.82	11.10	0.73	32.86	0.91	9.30	1.38	0.04	7.74	8.34	2.42	0.82	5651.00
1990-91	11.17	2.19	10.28	0.59	31.26	0.85	10.97	1.57	0.04	8.00	8.29	2.50	0.73	5919.00
1991-92	11.44	1.84	9.98	0.52	32.42	1.01	5.51	1.08	0.04	11.45	9.08	2.91	0.86	5570.00
1992-93	12.09	2.02	10.87	0.53	33.54	0.90	6.63	0.94	0.04	9.60	9.10	2.36	0.66	5853.00
1993-94	12.98	1.55	8.74	0.51	34.28	0.66	6.97	0.91	0.04	9.91	9.68	1.92	0.77	5815.00
1994-95	13.29	1.84	9.50	0.45	33.15	0.83	6.67	0.94	0.04	9.67	9.29	1.98	0.66	5989.00
1995-96	13.89	2.11	9.63	0.43	33.01	0.68	6.31	0.89	0.04	9.62	10.91	2.40	0.67	5974.00
1996-97	13.67	2.12	9.39	0.42	33.21	0.56	5.68	0.82	0.03	10.09	10.74	2.67	0.66	6074.00

set the stage for potential widespread crop losses. In addition to increasing danger of widespread losses, paddy, cotton and wheat being resource exhaustive crops put a severe drain on natural resources like water and soil micro-nutrients, thus posing a big question mark on long-term sustainability of the existing resource use pattern.

Utilisation Pattern of Irrigation Water

The assured supply of irrigation water in most of the areas had remained the mainstay of agricultural development. The details of percentage of area irrigated to net area sown have been presented in Table 5. It is evident from the data that over the years, the area under irrigation had increased further. From 59.20 percent area under irrigation in 1980-81, a high of 79.80 percent was recorded in 1987-88. The year 1987-88 was a drought year, which, on the one hand, might have resulted in decrease in net sown area, and increase in percentage area under irrigation to net area sown, on the other. Keeping surface and ground water resource potentials into consideration, the area coverage under irrigation has reached a high peak.

Table 5 *Irrigated Area Of Important Crops*

(in %)

Year	*Irrigated area of important crops*						*Total area irrigated to net area sown*
	Paddy	*Bajra*	*Wheat*	*Gram*	*Cotton*	*Sugarcane*	
1980-81	97.13	11.84	93.10	43.08	98.29	91.07	59.20
1981-82	95.72	13.50	92.96	32.10	98.03	89.59	61.40
1982-83	98.26	15.93	94.06	41.27	97.38	92.39	65.50
1983-84	90.79	14.42	94.02	26.25	96.47	91.18	60.80
1984.85	98.33	11.63	95.62	20.11	97.76	92.24	60.50
1985-86	98.80	12.93	95.40	25.10	99.97	95.01	62.20
1986-87	98.73	15.36	96.33	33.88	99.29	95.62	64.80
1987-88	99.50	27.33	97.98	65.43	98.94	94.87	79.80
1988-89	98.89	13.87	97.54	21.07	99.28	95.64	71.00
1989-90	99.30	21.20	97.83	29.86	99.45	96.42	73.90
1990-91	99.02	15.45	97.56	21.72	99.47	96.08	72.90
1991-92	99.51	19.04	98.13	28.69	99.64	96.36	76.00
1999-93	99.57	17.45	97.91	22.94	99.62	96.34	75.30
1993-94	99.60	19.68	98.19	20.49	99.64	96.43	75.80
1994-95	99.62	15.29	98.39	20.00	99.64	96.43	76.40
1995-96	99.28	17.74	98.33	18.57	99.34	97.22	77.00
1996-97	99.63	15.59	98.31	18.84	99.24	98.15	76.50

Area Irrigated of Important Crops

Table 5 further delineates that the bajra crop, with 11.84 percent area under irrigation in 1980-81, reached to 15.54 percent in 1996-97, with all-time high of 27.23

percent in 1987-88. In case of gram also area irrigated fluctuated over the years with a downward trend, it reached a high of 65.45 percent in 1987-88. This might be on account of shifting of bajra and gram acreage to the more assured crops of paddy and wheat with increased availability of irrigation water. The trend in percentage area under irrigation under paddy, wheat, cotton and sugarcane follow the path of sustenance. This might be due to stability, responsiveness to modern technology/ inputs and high returns from these crops. With icreased irrigation coverage, most of irrigation water was shared amongst paddy, wheat, cotton, sugarcane and the like crops while crops like bajra and gram got reduced area under irrigation.

Use of Agro-Chemicals

With the advent of the Green Revolution, the use of modern inputs, especially agro-chemicals, has increased manifold, owing to responsiveness of high yielding strains to irrigation, chemicals, etc. The consumption pattern of major plant nutrients, viz., nitrogen, phosphorous and potash as well as pesticides, as portrayed in Table 6, has not been proportionate and it is continuing in the same fashion from total consumption of 64.08 kg/ha in 1980-81. The consumption pattern, which shows an increasing trend (barring potash), has reached a high of 212.34 kg/ha in 1996-97 with contribution of nitrogen, phosphorous and potash being 172.66, 38.81 and 0.86 kg/ha respectively.

Table 6 *Consumption of Agro-Chemicals*

Year	*Fertilisers (kg /ha)*				*Pesticides (kg/litre/ha)*
	N	*P*	*K*	*Total*	
1980-81	52.02	8.70	3.36	64.08	0.060
1981-82	59.06	8.85	2.95	70.86	0.062
1982-83	60.12	10.38	2.70	73.20	0.073
1983-84	72.09	14.73	3.80	90.62	0.076
1984-85	75.43	15.55	2.11	93.09	0.086
1985-86	82.04	19.27	1.70	103.01	0.100
1986-87	90.29	22.63	1.61	114.53	0.110
1987-88	93.01	27.32	1.51	121.84	0.114
1988-89	107.63	33.56	1.67	142.86	0.125
1989-90	112.05	35.92	1.06	149.03	0.132
1990-91	125.32	39.02	1.42	165.76	0.147
1991-92	132.47	40.31	0.72	173.50	0.150
1992-93	132.47	40.31	0.71	173.50	0.149
1993-94	149.93	42.51	0.11	192.35	0.148
1994-95	159.15	42.24	0.75	202.75	0.143
1995-96	164.94	37.53	0.89	203.37	0.142
1996-97	172.66	38.81	0.86	212.34	0.139

The overall emerging picture of the consumption pattern of nitrogen, phosphorous and potash indicates the increasing trend over the years in respect of nitrogen, followed by phosphorous, through potash consumption has decreased. The consumption of pesticides has also increased over the years with upward inclination upto 1991-92. Thereafter, it exhibited declining trend. The ever increasing trend in pesticide consumption, which has put a question mark on the sustainability of the present system, has shown some sense of relief after 1991-92 depicting declining trend. Indiscriminate use of pesticides wipes out the natural enemies of pests and encourages the development of resistant strains of the pests.

Ground Water Quality, Change in Water Table and Extent of Problematic Areas

Table 7 demonstrates that the overall repercussions associated with farm activities have changed the scenario of ground water quality, water table and increase in problematic areas. The ground water quality limits the scope of crop choice. Nearly 55 percent water seems to be unfit for crop production. The problems are further accentuated with increasing acreages under problematic areas, mainly due to non-judicious use of water.

Table 7 *Ground Water Quality, Change in Water Table and Extent of Problematic Area*

Particulars		*Haryana*
Ground water quality (%)	Good	37
	Normal	8
	Sodic	18
	Saline	11
	Saline sodic	26
Saline/alkaline area ('000 ha)		526

Thus, the foregoing discussion discerns the fact that the acreage under plough has reached its peak, and further addition to area under plough appears to be remote. Even, it is likely to decrease with increased urbanisation. The cropping pattern, despite emphasis on diversification, had tilted towards resource exhaustive paying crops. There has been the irrational use of crucial farm inputs, viz., irrigation, fertilisers, pesticides, etc., with intensive agriculture. Creation of intensive irrigation facilities and excessive use of canal water have resulted in the problems of waterlogging, soil salinity, soil sodicity, etc. The problems of wind/water erosion and flood deposition are no more uncommon. The changing quality of ground water, with rise and fall in water table, has had already sounded alarm. The negative impacts of agro-chemicals, especially fertilisers, pesticides, etc., have been well documented. The nitrate poisoning, the toxic residues in food and fodder chain, the threat to beneficial soil micro fauna and flora by adverse alteration in physio-chemical structures of the soil have all come to the fore. Thus, the strain and adverse impact of the existing order of agricultural production environment and natural resources has already reached an alarming situation. All in all, this has ended in increase in direct and indirect costs associated with farming.

Rescheduling of Resource Use Pattern for Sustainable Production

The most important criterion for the farmers, considering a change in farming practices, is the likely economic outcome. Wider adoption of sustainable farming methods requires that they should at least be as profitable as existing methods along with non-monetary advantages, such as preservation of rapidly deteriorating soil and water resources. Although sustainable agriculture encompasses the multifaceted activities, the major stress here is laid on crop component, its diversification, crop-mix and their visual impact on land and water use and on consumption of agro-chemicals. Based on these considerations and priority approaches, the linear programming technique (LPT) was employed to work out the alternate optimal crop plans, in a way to make the switching changes smooth and sweeping towards sustenance.

Table 8 *Existing and Suggested Crop Plans (in '000 ha)*

Crop	*Existing plan*	*Existing optimal plan*	*Suggested optimal plans*		
			I	*II*	*III*
Paddy	646.70	648.02	655.27	658.90	625.79
Bajra	597.50	494.68	494.68	494.68	494.68
Maize	34.97	136.47	49.86	6.50	-
Wheat	1837.70	1761.22	1733.37	1719.43	1705.51
Barley	52.67	-	-	-	-
Gram	493.93	493.93	539.86	562.84	585.82
Lentil	-	-	45.94	68.91	91.89
Rapeseed	516.37	645.52	535.55	480.57	425.56
Cotton	489.33	489.33	489.33	489.33	489.33
Sugarcane	148.87	148.87	148.87	148.87	148.87
Potato	12.17	12.17	58.11	81.09	104.06
Redgram	-	-	34.08	51.12	68.16
Greengram	-	-	19.40	29.10	38.80
Soybean	-	-	25.87	38.80	51.74

Note: Jowar-predetermined crop with acreage of 700 ha in each plan.

In order of acreage, the major crops in the existing crop plan were wheat, paddy, bajra, rapeseed, gram, cotton and sugarcane (Table 8). In the existing optimal plan, there was no change in gram, cotton, sugarcane and potato acreages. Barley disappeared from the plan whereas paddy, maize and rapeseed acreages increased. The changing crop acreages, under different suggested optimal plans, give simultaneously vivid picture of constant acreage under bajra, cotton and sugarcane to the tune of 494.68 thousand hectares, 489.33 thousand hectares and 148.87 thousand hectares respectively. Barley escapes its inclusion. The acreages under gram, potato, redgram, greengram, soybean and lentil got substantially increased in the subsequent plans, while there was up-down trend for paddy, maize and rapeseed. Wheat saw the downing path, from 1,837.70 thousand hectares to 1,705.51 thousand hectares in the optimal plan III. Paddy witnessed a downfall to a low of 625.79 thousand hectares from 646.70 thousand hectares in the optimal plan III.

The increased acreage under pulses, oilseeds and other leguminous crops with decreased acreage under paddy, wheat and cotton in the optimal plans made a better change for crop rotation and the crop-mix. Finally, it will help in attaining the ultimate objective of lessening the use of irrigation water and agro-chemicals, thereby paving the path for sustainable agriculture.

Changing Pattern of Input Use

Resource use pattern at existing crop plan being followed and the changing scenario emerged from existing optimal as well as suggested optimal plans are discussed in this section. Table 9 reveals that except suggested optimal plan III, in all other plans, the water requirement has remained the same, as it was in the existing plan (2,183.97 thousand metre hectares).

Table 9 *Changing Pattern of Input Use*

(in '000 ha)

Particulars	*Existing plan*	*Existing optimal plan*	*Suggested optimal plans*		
			I	*II*	*III*
Water use (million ha)	2183.97	2183.97	2183.97	2183.97	2149.97
	(100.00)	(100.00)	(100.00)	(98.40)	
Fertiliser use (kg)	952668.69	950739.63	939800.78	934330.05	928308.26
	(100.00)	(99.80)	(98.65)	(98.07)	(97.44)
Nitrgen	533323.79	532428.36	520979.34	515254.18	509528.21
	(100.00)	(99.83)	(97.69)	(96.61)	(95.54)
Phosphorous	236025.80	234992.17	235502.34	235756.77	235460.95
	(100.00)	(99.56)	(99.78)	(99.89)	(99.76)
Potash	183319.10	183319.10	183319.10	183319.10	183319.10
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Pesticides (kg)	3014.72	3135.55	3133.73	3132.86	3144.81
	(100.00)	(104.01)	(103.95)	(103.92)	(104.31)

Note: Figures in parentheses show the change over the existing plan.

It came down to 2,149.07 thousand metre hectares in the optimal plan III. Usual precedence of gradual reduction in fertiliser requirement in the subsequent plans seems to be virtual possibility with maximum reduction of 2.56 percent in the optimal plan III, i.e., from 9,52,668.69 thousand kg to 9,28,308.26 thousand kg Barring the potash consumption in the subsequent optimal plans, the nitrogen and phosphorous consumption got reduced to 5,09,528.21 thousand kg (4.46%) and to 2,35,460.95 thousand kg (0.24%) respectively in the suggested optimal plan III. The pesticide consumption pattern exhibits up-down-up trend. From 3,014.72 thousand kg in the existing plan, it reached to 3,135.55 thousand kg in the existing optimal plan and from there to 3,144.81 thousand kg in the suggested optimal plan III, indicating thereby an increase of 4.31 percent over the existing plan. Although there is some increase on pesticides front, on account of increasing potato acreage and status quo in case of cotton and sugarcane acreages, yet these increases are far below the prescribed threshold limits. Consequent upon the changed crop acreages in the optimal crop plans, the input use pattern of farm inputs, viz., water and agro-chemicals, gives the picture of reducing phenomenon. This will in turn reduce the dependency in subsequent plans on crucial farm inputs and will improve soil fertility and productivity, enhance biotic activity and arrest the adverse hydrological changes. Resultantly, it will be a signpost for better environment.

Saving Benefits Accrued

The changed pattern of accrued benefits due to savings in water and agro-chemicals has been depicted in Table 10. As is evident, the accrued saving benefits for Haryana tread a varied path. Only the optimal plan III shows the savings in water requirement to the tune of Rs 55,142 thousands. In the subsequent optimal plans, the fertiliser savings got increased and reached to a high of Rs 1,62,611.20 thousands in the optimal plan III. Similarly, the nitrogen and phosphorous savings reached to a high of Rs 1,58,240.61 thousands and 4,377.59 thousands respectively. The pesticide saving pattern exposes the negative trend in all the optimal plans, with little bit difference. The maximum additional burden of Rs 25,367.55 thousands towards pesticides was observed for optimal plan III. As a result, the total saving benefits accrued in the existing optimal plan turned out to be a negative sum of Rs 9,596.61 thousands. Benefits in subsequent plans show the increasing trend with a peak figure of Rs 1,92,392.65 thousands in the suggested optimal plan III.

Table 10 *Saving Benefits Accrued*

(Rs in '000)

Particulars	*Existing optimal plan*	*Suggested optimal plan*		
		I	*II*	*III*
Water	-	-	-	55142.00
	(-)	(-)	(-)	(34.90)
Fertiliser	13965.24	86147.40	122247.89	162618.20
	(1929.06)	(12867.91)	(18338.64)	(24360.43)
Nitrogen	5954.61	82090.59	120162.91	158240.61
	(895.43)	(12344.45)	(18069.61)	(23795.58)
Phosphorous	8010.63	4056.81	2084.98	4377.59
	(1033.63)	(523.46)	(269.03)	(564.85)
Potash	-	-	-	-
	(-)	(-)	(-)	(-)
Pesticides	-23561.85	-23206.95	-23037.30	-25367.55
	(-120.83)	(-119.01)	(-118.14)	(-130.09)
Total	-9596.61	62940.45	99210.59	192392.65

Notes: Figures in parentheses show the quantities saved in '000 metre ha and '000 kg over the existing plan.

The reduced use of crucial farm inputs, viz., water and agro-chemicals will open a new window for economic, social and for ecological considerations. Thus, in a way, it will add to economic (saving) benefits with reduced use of purchased inputs. The harmful and hazardous effects will be curtailed. Further it will help in building soil structure and texture.

Changing Pattern of Returns

With changes in acreage under different optimal plans, the input use pattern as well as return pattern underwent a change. The emerged out pattern of return has been presented in Table 11. It reveals that the gross returns from the crop production activity in the subsequent suggested optimal plans decreased marginally: from Rs 4,39,54327.20 to Rs 4,33,19,608.68 thousands. The saving benefits accrued over the existing plan turned out to be a negative sum of Rs 9,596.61 thousands in the existing optimal plan. Thereafter, it showed an upward trend through successive optimal plans with a maximum savings benefits of Rs 1,92,392.65 thousands in the optimal plan III. The resulted positive changes in saving benefits helped in arresting the downward trend in gross returns plus saving benefits in successive optimal plans. The least reduction of 0.12 percent was observed in the optimal plan III, wherein the gross returns plus savings benefits reduced to a sum of Rs 4,39,00,848.83 thousands.

Table 11 *Changing Pattern Of Returns (Rs in '000)*

Particulars	*Exiting plan*	*Exiting optimal plan*	*Suggested Optimal Plans*		
			I	*II*	*III*
Gross returns (crops)	43954327.20	43319608.68	43560559.64	43681131.28	43708456.18
	(100.00)	(98.56)	(99.10)	(99.38)	(99.44)
Saving benefits (water, fertilisers, pesticides)		-9596.61	62940.45	99210.59	192392.65
Gross returns + saving benefits	43954327.20	43310012.07	43623500.09	43780341.87	43900848.83
	(100.00)	(98.53)	(99.25)	(99.60)	(99.88)

Note: Figures in parentheses show the change over the existing plan.

The findings of Table 11 further reveal that with an initial minor setback, it picked up in the successive optimal plans exhibiting more or less a status quo. Moreover, the changed pattern of returns will have to be viewed not only from economic consideration. Over and above it has much more tc its fold, the said and unsaid quantification, qualitativeness on food front, ecological dimensions and sustainable growth parameters.

Agricultural Sustainability Status

The relative agricultural sustainability status for Haryana, indicated by the values and ranks of their SLSI and SLSI* as well as ESI, EEI and SEI, has been displayed in Table 12. The values of ESI, EEI and SEI range from 0.27 to 0.67, which indicates that the agricultural systems of Haryana show wider variation in their ecological and social aspects than in economic aspects. The SLSI and SLSI* ranged between 0.480 to 0.503 and 0.500 to 0.507 respectively. The slight upward movement of SLSI* is due to the effect of weighing procedure. The relatively narrower range of SLSI and LSSI* as compared to their component indices indicates that the performance is not consistent across the three aspects of sustainable development of agriculture. Based on the component sub-indices, it can be stated that the state was better placed at ecological aspects, and it was poor at economic and social aspects. As such, there do not appear to be appreciable significant deviations in the values of sub-indices as well as of SLSI and SLSI* in different plans. In terms of results obtained, there is need for policy focus and orientation of programmes on economic as well as social aspects. Thus, the priority areas have been identified, from policy and action points of view.

Table 12 *Relative Agricultural Sustainability Status*

Particulars	*Existing Plan*	*Suggested Optimal Plan*		
		I	*II*	*III*
Ecological Security Index (ESI)	0.73	0.73	0.73	0.72
Rank	1	1	1	1
Economic Efficiency Index (EEI)	0.33	0.35	0.36	0.38
Rank	2	2	2	2
Social Equity Index (SEI)	0.38	0.40	0.40	0.41
Rank	2	2	2	2
Sustainable Livelihood Security Index (SLSI)	0.480	0.493	0.496	0.503
Rank	1	1	1	1
Weigthed Sustainable Livelihood Security Index (SLSI*)	0.500	0.501	0.501	0.507
Rank	1	1	1	1

Conclusions

The paper concludes that area under forests does not show any appreciable increase over the years. However, intensity of cropping has increased. The cropping pattern vividly exhibits the acreage concentration of the resource exhaustive crops like paddy, wheat, cotton and sugarcane and most of irrigation water was shared amongst these crops. Fertiliser consumption pattern discerns the increasing trend at disproportionate rate over the years. Consumption of nitrogenous fertilisers increased at much faster rate than that of phosphatic and potashic fertilisers. All in all, the continuing crop and input use patterns have resulted in accentuating the area under problematic soils and disturbing the hydrological balance. However, the input use pattern of water and agro-chemicals exhibits the reducing trend under successive optimal plans. The benefits brought about by savings in water and agro-chemicals are likely to open a new window for economic, social and ecological frontiers. On economic front, the optimal plans promise the bright outlook for gross returns as well as for accrued saving benefits. In a way, the optimal plans make sure to accommodate the economic, ecological and social aspects, paving the path for sustainable ways and means. The successive optimal plans are marked by slow but upbeat trend of sustainable livelihood security index. This stamps the economic, ecological and social footing of the envisaged optimal plans.

In order to respond dynamically to current challenges and the new and unfamiliar needs for promoting sustainable agricultural development, following policy measures have emerged:

1. Incentives and regulatory policies to compensate for externalities related to natural resources, e.g., water pricing, watershed management and problem soils.
2. Adjustments/changes, e.g., diversification, crop rotations in crop plans must be facilitated in order to achieve a balanced crop-mix to make progress towards profitable and environmentally sustainable production systems.
3. Effective enforcement of procedures for review and approval of the safety of existing and new agricultural chemicals and other agents used in agricultural production.
4. Information about sustainable agricultural practices and new policies to encourage wider adoption must be disseminated to farmers to strengthen the cause of sustainable agriculture.
5. Region-wise centres for sustainable agriculture should be established with multidisciplinary teams of physical, biological and social scientists for creation of data bank on sustainable parameters which will help make more informed choices.

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