Sustainable Agriculture, Poverty and Food Security

Edited by

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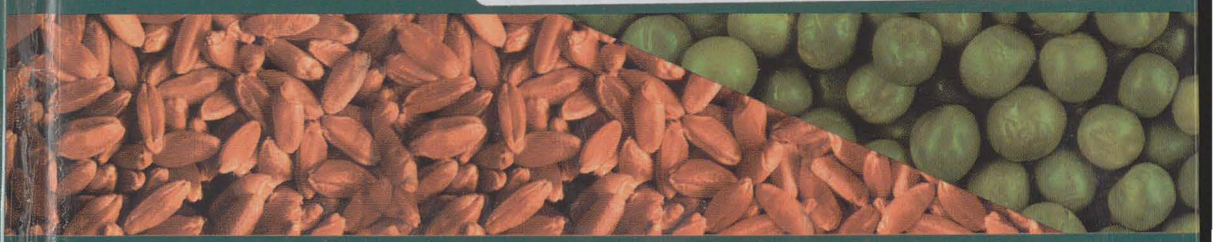

Volume 2

ISBN 81-7033-725-9 (set)

Published by
Prem Rawat for ***Rawat Publications***
Satyam Apts., Sector 3, Jain Temple Road, Jawahar Nagar, Jaipur - 4 (India)
Phone: 0141 651748 / 657006 Fax: 0141 651748
e-mail : info@rawatbooks.com
www.rawatbooks.com

Delhi Office
G-4, 4832/24, Ansari Road, Daryaganj, New Delhi 110 002
Phone: 011-3263290

Typeset by Rawat Computers, Jaipur
Printed at Chaman Enterprises, New Delhi

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Emerging Environmental Issues and Policy Options in the Agrarian Economy of Indian Punjab

Joginder Singh

Punjab is one of the smallest states of India occupying only 1.53 percent of the geographical area of the country. The state, popularly known as the food basket of India, is contributing 20 percent of wheat, 9 percent of rice and 14 percent of cotton of the country's total output apart from sizeable share in the production of other crops. Thus, the country, which was in the grip of serious food shortage till early sixties, has now been able to generate even surpluses in spite of meeting the needs of its rapidly growing population. The technology encompassing intensive cultivation, high use of agro-chemicals, greater requirement of water and rapid growth of farm mechanization has resulted in manifestation of several adverse effects on environment and ecological balance. The present paper examines some such inter-temporal developments of Punjab agriculture and emerging ecological issues and to suggest some policy options.

Land Utilisation

Out of the total geographical area of 5,033 thousand hectares, about 85 percent is net area sown (Table 1). The uncultivable land has been reclaimed overtime and fallow land has been brought under plough, making more and more area available for cultivation. The fallow land is on the decline from 313 thousand hectares in 1960-61 to merely 62 thousand hectares in 1997-98; the cropping intensity also went up from 125.95 percent to 184.51 percent during this period. The coverage of land by higher cropped area and decline in fallow land is essential not only to make proper use of this scarce resource but also to check the erosion of soil to the possible extent. The area under forests is also increasing though at a slow pace but mere 5-6 percent area under forests is much less than the requirement for maintaining ecological balance in spite of the fact that the semi-hilly tract (*kandi* belt) of the state has vast potential of

fruit and forest tree plantation. The social forestry is not economical as compared to common crops. But plantation along roads, rail tracts and river banks and even on marginal lands can be done more vigorously.

Table 1 *Land Utilization in Punjab (Area in 000' ha)*

Category	*1960-61*	*1980-81*	*1997-98*
Geographical area	5033 (100.00)	5033 (100.00)	5033 (100.00)
Area under forests	35 (0.70)	216 (4.29)	261 (5.19)
Unculturable & barren land	224 (4.45)	95 (1.89)	67 (1.33)
Land put to non-agricultural uses	449 (8.92)	436 (8.66)	335 (6.66)
Unculturable land excluding fallow land	255 (5.07)	49 (0.97)	42 (0.83)
Fallow land	313 (6.22)	45 (0.89)	62 (1.23)
Net area sown	3757 (74.65)	4191 (83.27)	4266 (84.76)
Cropped area	4732	6763	7871
Cropping intensity (%)	125.95	161.37	184.51

Note: Figures in parentheses indicate % of total geographical area.
Source: Statistical Abstract of Punjab

Land use has important ecological implications. The changes from one use to another are often made to achieve better economic use of land resource. However, many of these changes have detrimental effect on the natural environment, i.e., conversion of pastures into agricultural land, industrial setting in prime agricultural area, increase in urbanisation, etc. It is, therefore, imperative that while formulating land use plans, the potential environmental conflicts between alternative land uses need to be given due consideration.

Production Pattern

In view of serious food problem, which the country faced after independence, production of cereals was considered on priority. Punjab made significant contribution by changing the crop pattern and productivity improvement of cereal crops, specifically wheat and rice. As may be seen from Table 2, rice, which occupied merely 6.04 percent of the total cultivated area in 1960-61, registered a steep rise of 54.13 percent in 1997-98. It did not confine only to traditional paddy belt but also spread over to all the districts wherever adequate irrigation facilities were available. Similarly, the area under wheat increased from only 37.26 percent in 1960-61 to 78.41 percent of total cultivated area in 1997-98. On the other hand, area under maize, millets, sorghum, groundnut, gram, barley and lentil has fallen rapidly. However, cotton, sugarcane, pulses, rapeseed and mustard, potato and other vegetables have shown wide fluctuations from year to year. The production pattern in the Punjab State has, therefore, become predominantly a monoculture of rice-wheat rotation because of higher profitability of these crops in comparison to other competing crops, resulting from faster increase in the productivity of rice and wheat crops and effective procurement price. The economic considerations in the choice of crops have thus overruled the natural resource endowments.

Table 2 *Shift in Cropping Pattern in Punjab*

(Area in 000ha)

Crop	1960-61		1980-81		1997-98	
	Area	%	Area	%	Area	%
Rice	227	6.04	1183	28.23	2279	54.13
Maize	327	8.70	304	7.25	168	3.99
Millets & Sorghum	129	3.43	70	1.67	4	0.10
Groundnut	67	1.78	83	1.98	9	0.21
Cotton	447	11.90	649	15.49	727	17.27
Sugarcane	133	3.54	71	1.69	129	3.06
Sesamum	8	0.21	17	0.41	14	0.33
Kharif pulses	25	0.67	58	1.38	65	1.54
Wheat	1400	37.26	2812	67.10	3301	78.41
Gram	838	22.31	258	6.16	13	0.31
Barley	66	1.76	65	1.55	39	0.93
Rapeseed & mustard	107	2.85	136	3.25	70	1.66
Lentil	30	0.80	20	0.48	5	0.12
Sunflower	0	0.00	0	0.00	99	2.35
Potato	9	0.24	40	0.95	52	1.24
Other vegetables	23	0.61	37	0.88	64	1.52
Fruits	42	1.12	29	0.69	90	2.14
Fodder & other crops	854	22.73	931	22.21	577	13.71
Total cultivated area	3757		4191		4234	

Note: % indicates the area as percent of total cultivated area
Source: Statistical Abstract of Punjab

Depletion of Water Resource

The spectacular increase in agricultural production in Punjab has been made possible due to expansion of irrigation network covering 95 percent area in 1995-96 as compared to only 54 percent in 1960-61. The problems relating to water management require separate focus in the three different agro-climatic zones of Punjab:

(1) The sub-mountanous (kandi) zone has undulating topography. The annual rainfall is more than 1,000 mm. Due to denudation of upper hills resulting from overgrazing and deforestation, there is high run-off of water resulting from flash floods and heavy soil erosion. During the last two decades, the number of tubewells has almost doubled providing irrigation to 80 percent of the total irrigated area, while the surface water (through canals) has not been well channelised (Table 3).

Table 3 *Area Irrigated and Number of Tubewells in Different Zones of Punjab*

Zone	*Area 000ha. Irrigated by*		*Number of tubewells*
	Canals	*Tubewells*	
Submontane			
1975-76	86.6 (26.7)	238.3 (73.3)	34461 (16.5)
1995-96	87.5 (20.0)	349.6 (80.0)	67160 (7.5)
Central Plains			
1975-76	430.0 (25.7)	1246.1 (74.3)	138725 (66.5)
1995-96	429.1 (21.4)	1576.1 (78.6)	732385 (81.4)
South-West			
1975-76	815.7 (71.3)	328.7 (28.7)	35579 (17.0)
1995-96	966.7 (70.9)	396.9 (29.1)	100455 (11.1)
State			
1975-76	1332.3 (42.4)	1813.1 (57.6)	208765 (100.00)
1995-96	1483.3 (29.0)	2322.6 (61.0)	900000 (100.00)

Note: Figures in parentheses indicate percentage to the total of the corresponding year.

(2) The central (sweet water) zone, comprising the major part of the state, is highly productive and has well-knit system or irrigation, mainly in terms of tubewells. The paddy-wheat is the major crop rotation followed in this belt. The water table in this zone is falling with an average rate of 0.23 metre per year during the last 15 years (Gupta et al., 1995). This would need additional power requirement at the rate of 10 percent per metre fall in the ground water. If the decline in water table continues at the existing rate, 200 thousand centrifugal pumps would have to be replaced by submersible pumps which, at current price, would cost Rs. 20 billion. The over-exploitation of water is due to the increase in the number of tubewells from 1.92 lakh in 1970-71 to 10.90 lakh in 1997-98. According to an estimate, Punjab has irrigation potential of 6.55 million hectare as compared to 7.67 million hectare of cropped area, of which 7.1 million hectare is irrigated, leaving thereby, a net deficit of 0.55 million hectare (Prihar and Khepar, 1997). The state government's decision to make electricity for irrigation completely free since 1997-98 has further contributed to the problem of declining water table due to indiscriminate use of water. Therefore, the prevalent production pattern does not seem to be sustainable in the long run. In the light of foregoing observations, it is required that:

(a) The early transplanting of paddy which consumes more water needs to be curbed.

(b) Paddy growing needs to be discouraged in some areas, suitable for cultivation of other crops such as cotton, maize, fodders and soybean having lesser water requirements. This would result in water conservation substantially (Table 4).

(c) Water rationing is desirable even in paddy belt to avoid excessive use of this scarce resource.
(d) Cultivation of *basmati* (superior quality rice) needs to be encouraged which would drastically reduce the water utilisation on the one hand generate export potential on the other.
(e) Strenuous efforts need to be put to increase water use efficiency by lining of canals and water courses, water harvesting tanks in water scarce areas and improved agronomic practices to check seepage and evaporation etc.
(f) Inheritance of property law needs to be modified to prevent progressive fragmentation of landholdings and thus check fast increase in the number of tubewells.
(g) Above all, the scarce water resource to be used judiciously should be suitably priced.

Table 4 *Effect of Replacement of Rice on Water Balance*

Replacement Crop	*Area (000 ha)*	*Irrigation water required (000 ha meter)*		*Net amount of water saved (000 ha meter)*
		Existing	*Alternative*	
Maize	250.0	182.5	150.0	32.5
Groundnut	50.0	36.5	25.0	11.5
Kharif Pulses	50.0	36.5	22.5	14.0
Soyabean	50.0	36.5	30.0	6.5
Kharif fodders	100.0	73.0	60.0	13.0
Total	500.0	365.0	287.5	77.5

Source: Sondhi and Khepar (1995).

(3) The south-western zone, popularly known as cotton belt, has brackish underground water. As may be seen from Table 3, the use of canal water and underground water through tubewells has – increased overtime. The fast declining productivity of cotton due to menace of pests has resulted in increase in area under rice in the zone causing problems such as:
(a) The use of underground water has increased accumulation of salts on the soil surface making it unfit for cultivation. The higher inflow of canal water in the area has caused rise in water table and even waterlogging in some pockets of this zone.
(b) The high humidity resulting from paddy cultivation and waterlogging of soil has encouraged the builtup of insect-pests, endangering the cultivation of cotton in the belt.

Soil Nutrition

The high nutritional requirements of paddy and wheat – the major crop rotation in the state – has exhausted the soil of nutrients. As a result of this, Punjab, which has just 2.98 percent of cultivated area and 4.2 percent of the cropped area, accounts for

about 10 percent of total chemical fertiliser consumption in the country. The state is adding 1,005 thousand tonnes of nitrogen, 287 thousand tonnes of phosphorus and 22 thousand tonnes of potassic fertilizers to the soils annually. On per hectare basis, the consumption went up to 168 kg of nutrients in 1997-98 in the state as compared to only 77 kg for the country as a whole (Table 5). Statistics show that recently the consumption of nitrogen has increased but that of phosphorus and potash is on the decline. In an analysis of soils and wheat plants from five villages of Ludhiana district, 34 percent soils were found low in Zinc. The analysis of rice plants showed that 88 and 82 per cent samples were below sufficiency level in Zinc and Cu, respectively (Singh, 1992). Further, the standing water and burning of paddy straw restrict the aerobic activities in the soil. The puddling of field for paddy has further disturbed soil texture and structure. Therefore, in the traditional paddy growing areas, there is deceleration in the growth of productivity not only of rice but also of some other crops (Singh et al., 1977). The basmati rice, which has export potential, is becoming less and less profitable. The transplanting of basmati rice has to be done as late as in the month of August while the farmers have tendency to transplant non-basmati rice as early as in April. Thus, the pest population, particularly the stem borer, builds up and attacks the basmati crop, resulting in its poor yield. There is need to encourage basmati cultivation in isolated potential areas and through effective price support, not only because of its high export potential but also keeping in view its low water and fertiliser requirements. The organic farming by application of farmyard manure, compost, green manuring, recylcing of crop residues and including leguminous crops in the crop sequence are essential to supplement the chemical fertilisers.

Table 5 *Consumption of Agro-Chemicals in Punjab*

Year	*Consumption (000,tons)*				*Consumption (kg/ha)*				*Pesticides*	
	N	*P*	*K*	*Total*	*N*	*P*	*K*	*Total*	*Tons*	*Kg./ha*
1960-61	5	0	0	5	1.1	0.0	0.0	1.1	624	0.132
1970-71	175	31	7	213	30.8	5.2	2.2	37.5	2215	0.390
1980-81	526	207	29	762	77.8	30.6	4.3	112.7	3200	0.473
1990-91	877	328	14	1220	117.1	43.7	1.9	162.7	6500	0.867
1995-96	1020	227	16	1263	132.4	29.5	2.1	163.9	7600	0.986
1996-97	962	229	17	1208	123.0	29.3	2.2	154.5	7300	0.934
1997-98	1..5	287	22	1314	128.5	36.7	2.8	168.1	7100	0.908

Source: Statistical Abstracts of Punjab.

Pest Problem

The insect-pest problem in case of rice was comparatively less but with an increase in area under the crop and long spreading of its growing period, it has augmented. Thus, the rice revolution has brought about many second-generation insect-pest problems (Dhaliwal et al., 1985). The stem borer and leaf folder are the conspicuous examples of pest menace in paddy in the state. The stem borer is a particular constraint in the

cultivation of basmati rice. The weeds have posed a serious threat to paddy-wheat rotation in the state. The *Phalaris minor* and *Avena ludoviciana* are the predominant weeds of these crops. As much as over 93 percent of the area under paddy and wheat is covered by the use of herbicides due to high cost of mechanical methods of weeding.

The large-scale cultivation of rice, the growing of un-recommended varieties like Pusa 44 and Indrasan, the practice of early transplanting of rice, indiscriminate use of pesticides, developing resistance of pests to the existing pesticides, etc., are some of the factors responsible for increasing the pest problem with regard to rice in the state.

A number of studies have highlighted the existence of pesticide residues, beyond the maximum tolerable limit, in case of soil, food commodities, milk and milk products and animal feed (Dhaliwal and Arora, 1996). The use of pesticides (technical grade material) in Punjab was only 624 tonnes in 1960-61, which increased to 7,300 tonnes in 1996-97. Thus, the use per hectare of cropped area increased from 132 gm to 934 gm during this period (Singh, 1997). Recently, the use of pesticides has shown decline in the wake of increasing awareness among farmers and consumers about their ill-effects.

The use of recommended pesticides, in proper doses and at appropriate time, is essential. It requires proper education, extension efforts and supply of proper pesticides against the specific pests. Apart from integrated pest management programmes, there is need to make sincere efforts to try organic pesticides and encouraging pest predators. Discouraging early transplanting of rice can go a long way to solve this problem. Carrying out o regular monitoring surveys to foresee the intensity of pest problems, effectiveness of different pesticides and pesticide residue problems is a desirable step.

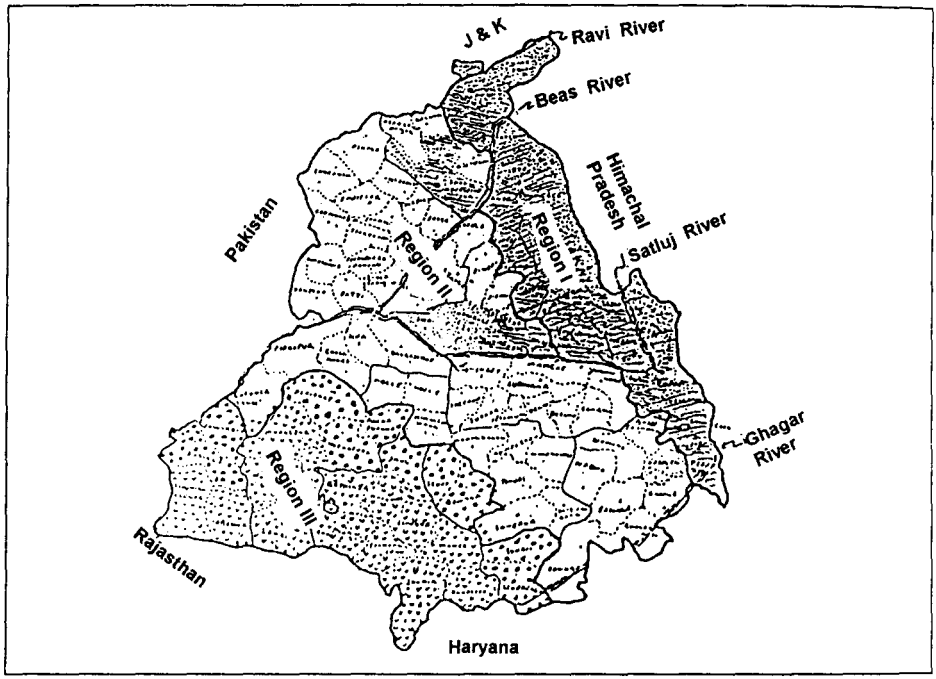
Lack of Proper Use of Biomass

In the context of changing cropping pattern, a huge biomass in the form of by-product is not properly utilised. In Punjab, about 75-80 percent area under paddy is machine-harvested, leaving behind huge quantities of organic matter in the fields. Wheat straw is used as animal feed, whereas the paddy straw, being inferior in feeding quality, hardly used for fodder. At present, nearly three-fourths of the crop residuals (70-80 million tonnes) of rice is disposed of by burning due to lack of suitable agro-industries in the state, resulting in harmful effects of biomass burning on soil microbial activity. The gases like carbon monooxide and carbondioxide cause health hazards for human, animals and plants. Crop residue, a renewable resource, is an important component in an ecosystem stability of agricultural land. Developing techniques for making effective use of these crop residuals in industries such as card board, paper and plywood, etc., is a major challenge.

Climatic Changes

The warming of atmosphere and increase in relative humidity, as a consequence of change in agriculture parameters, were also evidenced. The annual temperature trend over time for Ludhiana district, representing central Punjab, indicates a warming

Figure 1 *Map of Punjab State of India showing Different Agro-climatic Regions*



trend of atmosphere whereas the five-year moving average of rainfall pattern shows that it to be slightly above normal in recent years (Hundal and Kaur, 1996).

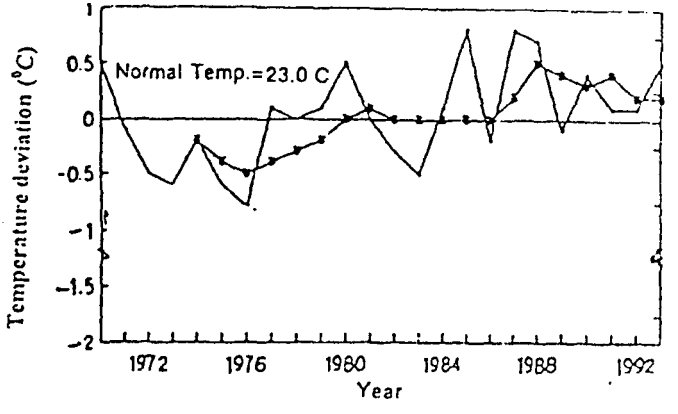
The experimental data also showed that the maximum and minimum temperature, if increased on daily basis from normal temperature by 1°, 2° and 3°C, would advance the maturity of wheat by 6, 13 and 18 days, reduce the biomass by 11.5, 20 and 28.5 percent, and lowering the grain yield by 8.1, 18.7 and 25.7 percent respectively. Similar effects on rice, maize and groundnut crops were also observed.

However, precipitation above normal is not going to have phenomenal change in yield due to already lack of moisture stress in the region. There has also been rise in the relative humidity as a result of fast introduction of rice in the cropping pattern of the state (Fig. 2). Due to burning of paddy straw air pollution is on the rise as high as 263 micrograms against the recommended level of 140 micrograms of suspended particular matter per cubic metre in the residential area of Ludhiana in 1999. This is the cause of various diseases like tonsillitis, asthma, cancer, etc.

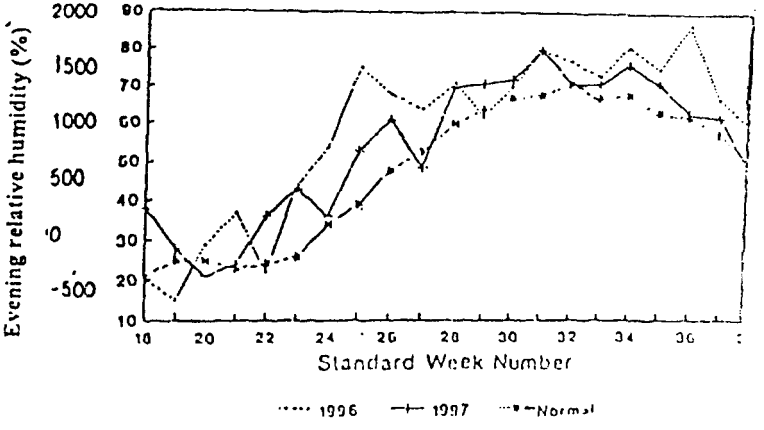
Policy Options

From the foregoing discussion it emerged that the prolonged dominant monoculture of paddy-wheat rotation has resulted in deceleration of agricultural growth. Therefore, the need for diversification of crop production has time and again been emphasised during the latter years. At the existing level of crop technology and price policy, it does not seem that equally remunerative alternatives are available to replace

Figure 2 *Deviations in Temperature from Normal at Ludhiana (Punjab)*



b) Evening relative humidity at Ludhiana (Punjab)



acreage under paddy-wheat rotation to a considerable extent, to correct the water balance and check other adverse effects on environment.

A three-pronged strategy may be suggested to tackle the ecological and other related problems created by the monoculture of paddy-wheat rotation:

- Firstly, by evolving equally/more remunerative alternatives to existing paddy-wheat rotation with emphasis on bio-technology research for improved varieties of alternative crops and development of high-value products etc. This is a long run solution.
- Secondly, by favourable policy measures, making alternative crops more remunerative through various economic incentives.
- Thirdly, by searching solutions within the existing cropping pattern, i.e., reducing water requirement of rice by avoiding early sowing and decreasing the use of standing water replaced by wetting, recharging the ground water,

replacing rice varieties with less water demanding ones in selected areas, judicious use of pesticides, expanding the integrated pest management practices and promoting balanced use of fertilisers and developing efficient agro-technology for crop residue recycling as a alternative to burning.

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