Degraded Soils in Rice-Wheat Areas of Indo-Gangetic Plain and Their Economic Evaluation-A Case Study of Punjab State, India

G.S.Sidhu, S.P. Singh, C.S. Walia and ***R.P. Singh***

National Bureau of Soil Survey and Land Use Planning (ICAR), Delhi Regional Centre,
IARI Campus, New Delhi-110012
E-mail: gssidhu-ps@yahoo.com.

Abstract: Soil degradation status of Punjab state has been prepared by adopting GLASOD (Global Assessment of Soil Degradation) methodlogy as outlined by Oldeman, 1988. The results indicated that the soils in the study area suffered due to built up of water logging (1.3%), salinity-sodicity (3%), water erosion (13.3%). In combined almost 7.8 per cent soils affected by various types of soil degradational problems. The district wise value productivity based on economic evaluation of these degraded soils shows considerable inter district variation in the state at current and constant prices. It has been estimated that total losses due to degraded lands (about 8,96,000 ha) occurred was 484 million rupees and losses per hectare was Rs. 5,401 (based on current prices, 1994—1996). At constant prices (1979—1982), the total losses were Rs. 1,709 million and per hectare losses were Rs. 1,907. At state level the losses as per cent to total value productivity was 18. It may be inferred from the studies that soil degradation status can be used very effectively as the base data for computing the economic losses of different crops.
Keywords: soil degradation, economic evaluation, economic losses, Indo-Gangetic plain

1 Introduction

Rice and wheat are important food crops in Indo-Gangetic Plain (IGP) comprising Trans, Upper, Middle and Lower Gangetic Plains and jointly contribute 75 per cent of total food grain produced in the country. They cover the largest portion of irrigated area and account for 60 per cent of the total area under irrigation. Ninety per cent of the area is spread over in 119 districts of the IGP comprising the states of Punjab in west through Haryana, Uttar Pradesh, Bihar and West Bengal in the east. This area often called the "Green Revolution Belt" of the country. In IGP, Punjab state is having largest area under irrigation and the yields of rice and wheat crops are also highest in the region. The state covers only 1.5 per cent of the geographical area and 4 per cent of the total cultivated area of the country but contributes about 10 per cent of the total food grain production in India. Yields of rice and wheat along with other crops have increased greatly over the last three decades mainly due to expansion in irrigated area, increased area under high yielding varieties and enhanced use of fertilizers and other inputs. Introduction of irrigation and high fertilizer inputs resulted the chemical land degradation in form of water logging, salinity / sodicity etc. in these areas. Besides, the physical land degradation i.e. soil and water erosion also prevalent in some areas. Keeping this in view, the present studies have been undertaken to estimate the degradation status of soils and their economic evaluation to know the extent of losses due to different types of soil degradation.

2 Methodology

Soil degradation status of the study area has been prepared by adopting GLASOD (Global Assessment of Soil Degradation) methodology as outlined by Oldeman, 1988, based on soil resource data (Sidhu *et al.*) The extent of soil degradation was assessed which is mainly defined by type and degree of soil degradation. The type of soil degradation refers to the displacement of soil materials by water and wind, in-situ

[1] Division of Agricultural Economics, IARI, New Delhi-110012

deterioration by physical, chemical and biological processes. The degree of degradation refers to the present state of degradation e.g. slight, moderate, strong and extreme. Relative extent refers to the per cent area affected by a type of soil degradation within the mapped unit e.g. very occasional, common, frequent and dominant. The severity of soil degradation is expressed as: low, medium, high and very high by the combination of degree and the relative extent of the type of degradation process. The detailed procedure for estimating soil degradation status has been followed as outlined by Sehgal and Abrol (1994).

Quantitative technique for estimating economic losses of degraded lands: The model uses the extent of the degraded lands in each district/zone and multiplying with the per hectare total value of out put (standardized by district average yields and farm harvest prices of crops) and is termed as the economic/financial losses on account of land degradation (E_{ln})

$$E_{ln} = \sum_{d} \sum_{l} Xkdlk * \left[\left(\sum_{i} Y_{ik} \square P_{ik} \right) / N_{ak} \right]$$

Where,

Y_{ik} = The quantity of out put of i^{th} crop in the k^{th} district,

P_{ik} = The farm harvest price of i^{th} crop in the k^{th} district ,

A_{ik} = The area under i^{th} crop in the k^{th} district ,

V_{ik} = The value productivity of i^{th} crop in the k^{th} district (i.e. $Y_{ik} \bullet P_{ik}$),

V_k = The total crop value productivity in the k^{th} district (i.e. $\sum V_{ik}$),

N_{ak} = Net sown area in k^{th} district,

A_{vk} = Average total crop value productivity of k^{th} district [i.e.; ($\sum_{i} Y_{lik} \bullet P_{ik}$) / N_{ak}],

X_{dlk} = Area under d^{th} category of degraded land and l^{th} group of losses in the k^{th} district,

Q_{dlk} = Per cent share of area under d^{th} category of degraded land land l^{th} group of losses in k^{th} district i.e. [(X_{dlk} / $\sum_{d} \sum_{l} X_{dlk}$) • 100],

X_k = Total area under all categories and group of losses of degraded and for k^{th} district i.e. $\sum_{d} \sum_{l} X_{dlk}$,

E_{lk} = Economic/financial losses at district/zone level i.e. ($\sum \sum_{d} X_{l\ dlk} \bullet A_{vk}$), and,

E_{ln} = Economic/financial losses at national level i.e. ($\sum_{k} E_{lk}$),

In other words,

$$\sum_{d} \sum_{l} \sum_{k} X_{dlk} * A_{vk} = \sum_{k} X_k \bullet A_{vk,}$$

$$\sum_{d} \sum_{l} \sum_{k} X_{dlk} * \left[\left(\sum_{i} Y_{ik} \square P_{ik} \right) / N_{ak} \right]$$

The coefficient used for economic losses are given below

Extent	Average magnitude (% of TVP)	Range of magnitude
Slight	4	3—5
Medium	8	7—10
Severe	18	15—20

TVP=Total value productivity

3 Results and discussion

Soil degradation status: Results (Table 1) indicated the district wise distribution of different types and severity classes of soil degradation. About 17.8 per cent of total geographical area (TGA) of the state was affected by different types of soil degradation. About 13.3 per cent area is affected by different classes of water erosion, out of which highest area (6.8%) was under slight class, followed by moderate (2.5%), severe (1.7%), very severe (1.4%) and moderately severe (0.9%). About 3 per cent area affected by salt-

affected soils. Maximum area (1.8%) was under slightly salt-affected soils and moderately and severely

Table 1 District wise degraded lands under different categories in Punjab

(000' hectares)

Districts	Water erosion area					Salt affected area			Water logged area	Ravinous land area	Total degraded land Area	% to the total area of the district
	Slight	Moderate	Moderately Severe	Severe	Very Severe	Slight	Mode-rate	Severe				
Gurdaspur	58.2	40.4	10.4	1.7	--	3.8	2.5	--	--	4.6	121.7	34.1
Amritsar	16.4	1.3	--	--	--	1.5	6.1	3.4	--	3.0	31.7	6.2
Kapurthala	12.7	1.5	--	--	--	4.1	4.3	3.5	--	--	26.1	16.0
Jalandhar	13.4	7.2	--	--	--	4.4	0.5	--	--	--	25.5	9.6
Nawan Shahar	--	--	--	--	--	0.4	--	--	0.4	--	0.8	0.7
Hoshiarpur	49.7	33.1	22.6	56.5	43.0	0.4	--	--	4.6	--	209.9	63.4
Roopnagar	30.3	16.1	10.6	27.7	29.2	0.3	1.7	--	0.7	--	116.4	55.0
Ludhiana	13.4	9.8	--	--	--	1.2	1.0	--	--	--	25.4	6.7
Firozpur	53.0	0.3	--	--	--	19.8	5.5	--	14.1	--	92.6	15.8
Faridkot	35.9	2.1	--	--	--	10.0	4.7	1.7	2.4	--	56.9	38.7
Muktsar	--	--	--	--	--	10.2	0.4	0.9	35.2	--	46.6	17.9
Moga	25.1	--	--	--	--	6.1	0.9	0.2	--	--	7.3	4.3
Bathinda	--	2.4	--	--	--	4.9	0.2	2.2	0.2	--	34.9	10.3
Mansa	--	--	--	--	--	5.1	1.3	0.6	7.0	--	13.9	6.5
Sangrur	19.5	6.4	--	--	--	9.1	6.0	7.5	--	--	48.5	9.7
Patiala	13.7	5.4	1.0	1.4	0.1	8.2	3.2	2.4	--	--	35.5	9.8
Fatehgarh Sahib	--	--	--	--	--	2.2	0.04	--	--	--	2.3	2.0

(Source: Sidhu *et al.* 1995 & Reconciled data provided by NBSS & LUP, 2000)

salt-affected areas were 0.8 and 0.4 per cent respectively. Water logged soils covered about 1.3 per cent area. Water erosion area is mainly confined to the north-east sub-mountainous areas, whereas salt-affected areas are scattered throughout the central and south-west parts of the state.

3.1 Economic evaluation of degraded soils

The economic evaluation in term of estimation of economic losses resulting from various types of land degradation in Punjab state were done on the basis of productivity and wheat equivalent (Table 2). These losses were calculated on the basis at current rice and constant price (1980—1982) and are presented in Table 3. Three different types of scenario i.e. current scenario, scenario-I and scenario-II were considered. Scenario-I indicates higher economic losses by 10 per cent due to anticipated growth in agriculture and farm harvest prices. Scenario-II indicates lower economic losses by 10 per cent due to anticipated reclamation of degraded lands. At current prices, total losses estimated were about *Rs*. 4841 million (current scenario), *Rs*. 5325 million (Scenario-I) and *Rs*. 4355 (Scenario-I).At constant prices, the total losses were *Rs* 1,709 million (current scenario), *Rs* 1880 million (scenario I) and *Rs* 1538 (scenario II). Data on losses per hectare (Table 3) revealed that these losses ranged from *Rs*. 1071 to *Rs*. 9200 at current prices. The average losses per hectare was *Rs*. 5,401. At constant prices losses per hectare ranged from *Rs*. 368 to *Rs*. 3,263 and average losses were *Rs*. 1907. Losses per cent to total value productivity ranged from 5 to 39, while average value was *Rs*. 18. These results indicated that maximum losses were found in the lands having maximum areas and severity class of degradation and vice-versa.

Table 2 District-wise total value productivity in Punjab agriculture (at Farm Harvest Prices)

Districts	Current Prices (1994—1996)		Constant Prices (Base: 1979—1980 to 1981)	
	Productivity (*Rs*./ha.)	Wheat equivalent (tons/ha.)	Productivity (*Rs*./ha.)	Wheat equivalent (tons/ha.)
Gurdaspur	31,456	6.7	11,456	6.0
Amritsar	27,245	7.4	9,704	6.6
Kapurthala	39,764	10.7	14,085	9.4
Jalandhar	43,085	11.5	15,199	10.1
Nawan Shahar	32,818	9.3	11,757	8.3
Hoshiarpur	38,987	10.5	13,703	9.2
Roopnagar	39,097	10.9	13,867	9.6
Ludhiana	35,506	9.5	12,508	8.3
Firozpur	25,931	7.0	9,041	6.1
Faridkot	23,535	6.2	8,130	5.3
Muktsar	11,556	3.3	4,042	2.9
Moga	20,414	5.8	6,990	5.0
Bathinda	19,867	5.4	6,821	4.6
Mansa	18,932	5.0	6,660	4.4
Sangrur	26,867	7.3	9,507	6.4
Patiala	31,424	8.4	11,085	7.3
Fatehgarh Sahib	36,256	9.5	12,929	8.4
State Avg.	29,573	7.9	10,440	7.0
CV (%)	28.9	--	29.5	--

(Based on the output of farm harvest prices of crops, vegetables and fruits grown in the districts)

Table 3 Summary statement of economic losses, Punjab

Districts	Degraded land area (000'ha)	At current prices (1994—1996)		At constant prices (1979—1982)		Losses as per cent to total value productivity
		Total losses (*Rs*. mill.)	Per ha. Losses (*Rs*./ha)	Total losses (*Rs*. mill.)	Per ha. Losses (*Rs*./Ha.)	
Gurdaspur	122	398	3,273	145	1,192	10
Amritsar	32	151	4,759	54	1,695	17
Kapurthala	26	124	4,760	44	1,686	12
Jalandhar	25	79	3,113	28	1,098	7
Nawan Shahar	1	7	8,747	3	3,133	27
Hoshiarpur	210	1,842	8,775	647	3,084	23
Roopnagar	116	1,071	9,200	380	3,263	24
Ludhiana	25	78	3,072	27	1,082	9
Firozpur	93	347	3,745	121	1,306	14
Faridkot	57	142	2,490	49	860	11
Muktsar	47	211	4,535	74	1,586	39
Moga	7	16	2,160	5	740	11
Bathinda	35	37	1,071	13	368	5
Mansa	14	83	5,937	29	2,088	31
Sangrur	48	134	2,764	47	978	10
Patiala	35	116	3,275	41	1,155	10
Fatehgarh Sahib	2	5	2,091	2	748	6
Punjab	896	4,841	5,401	1,709	1,907	18

Based on the above studies it may be concluded that soil degradation status can be used very effectively as the base data for computing the economic losses of different crops. As such, the priority areas for amendment of degraded lands can be demarcated to enhance the agricultural production on sustainable basis.

References

Oldeman, L.R. (Ed.). 1998. Global Assessment of Soil Degradation (GLASOD), Guidelines for General Assessment of Status of Human Induced Soil Degradation. ISRIC, Wagnaingen

Sehgal, J. and I. P. Abrol,. 1994. "Soil Degradation in India: Status and Impact," Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi 110001, India; 80p.

Sidhu, G.S., C.S. Walia, Tarsem Lal, K.P.C. Rana and J. Sehgal,. 1995. "Soils of Punjab for optimizing land Use." NBSS Publ. 45 (Soils of India Series 4). National Bureau of Soil Survey and Land Use Planning, Nagpur, India, 75p + 2 sheets soil map (1:50,000 scale).

Table 4 Estimated economic losses resulting from various sources of land degradation in Punjab state

(*Rs.*' million)

Districts	At current prices			At constant 1980—1982 prices		
	Current Scenario	*Scenario Ⅰ	**Scenario Ⅱ	Current Scenario	Scenario Ⅰ	Scenario Ⅱ
Gurdaspur	398 (10.4)	438 (11.5)	358 (9.4)	145 (10.4)	159 (11.4)	130(9.4)
Amritsar	151. (17.4)	166 (19.2)	136 (15.7)	54 (17.5)	59 (19.2)	48 (15.7)
Kapurthala	124 (11.97)	137 (13.2)	112 (10.8)	44 (12.0)	48. (13.2)	40 (10.8)
Jalandhar	79 (7.2)	87. (8.0)	71 (6.5)	28 (7.2)	31 (7.9)	25 (6.5)
Nawan Shahar	7 (26.7)	8 (29.3)	6 (24.0)	3 (26.7)	3(29.3)	2 (24.0)
Hoshiarpur	1,842 (22.5)	2026 (24.8)	1658 (20.3)	647 (22.5)	712 (24.8)	583 (20.3)
Roopnagar	1,071 (23.5)	1178 (25.9)	964 (21.2)	380 (23.5)	418 (25.9)	342 (21.2)
Ludhiana	78 (8.7)	86 (9.5)	70 (7.8)	27 (8.7)	30 (9.5)	25 (7.8)
Firozpur	347. (14.4)	382 (15.9)	312 (13.0)	121 (14.4)	133 (15.9)	109 (13.0)
Faridkot	142 (10.6)	156 (11.6)	127 (9.5)	49 (10.6)	54 (11.6)	44 (9.5)
Muktsar	211 (39.3)	232 (43.2)	190 (35.3)	74 (39.3)	81 (43.2)	66 (35.3)
Moga	16 (10.6)	17 (11.6)	14 (9.5)	5 (10.6)	6 (11.6)	5 (9.5)
Bathinda	37 (5.4)	41 (5.9)	34 (4.8)	13 (5.4)	14 (5.9)	12 (4.9)
Mansa	83 (31.4)	91 (34.5)	74 (28.2)	29 (31.4)	32 (34.5)	26 (28.2)
Sangrur	134 (10.3)	147 (11.3)	121 (9.3)	47(10.3)	52 (11.3)	43 (9.3)
Patiala	116 (10.4)	128 (11.5)	104 (9.4)	41 (10.4)	45 (11.5)	37 (9.4)
Fatehgarh Sahib	5 (5.8)	5 (6.3)	4 (5.2)	2 (5.8)	2 (6.3)	2 (5.2)
Total	4,841 (18.36)	5,325 (20.01)	4,355 (16.4)	1,709	1,880 (20.1)	1,538 (16.4)

*Scenario I: Higher economic losses by 10 % due to anticipated growth in agriculture and farm harvest prices.

**Scenario I: Higher economic losses by 10 % due to anticipated reclamation of degraded land.

Figures in parenthesis are the per cent of the total value product from state agriculture.