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# Adverse Effect of Land Degradation on Farm Productivity and Income in North-West India

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**ABSTRACT**

India has about 147 Mha degraded land. Soil salinity is one of the major land degradation problems in Indian agriculture which adversely affects the crop productivity in about 2.95 Mha area. Several studies reported the adverse effect of land degradation in India as well as in the world. This study has made as attempt to estimate production and monetary losses due to soil salinity in Haryana. Haryana state has 95765 ha saline area, out of which 77061 ha (80.47 per cent) is under cereals production. Rice (*kharif* season) and wheat (*rabi* season) crops occupies prominent place among the cereals production in Haryana. Hence these crops were assumed as representative crops and the damage due to salinity was assessed. The annual potential and actual losses per ha due to soil salinity was ₹10807 and ₹9314, respectively. The total monetary loss arises due to soil salinity in the project area is ₹3.67 million. In view of doubling farmers' income by 2022, the policy makers has to give more emphasis on land degradation aspects particularly saline soil reclamation which is a major concern of worry by the salinity affected farmers of Haryana as well as India.

**Keywords**
Degradation, damage assessment, Haryana, salinity

**JEL Codes**
O13, Q15, Q18

## INTRODUCTION

One of the major agenda of the Government of India on farming policies in recent years towards doubling farmers' income by 2022 is "Improving farm incomes by increasing productivity". But soil degradation is one among the several factors that hinders Indian agriculture. Soil degradation has become a serious problem in both rainfed and irrigated areas in India. It is estimated to be occurring on 147 Mha of land (Anonymous, 2005). Soil salinity is one of the major land degradation problems in Indian agriculture which adversely affects the productivity of agricultural land. The saline soils are characterized by the presence of excess neutral soluble salts like chlorides and sulphates of sodium, calcium and magnesium. Sodium chloride is the dominant salt. High soil salinity is often accompanied by high water table, often within 2 m of soil surface. Sub-soil waters are generally salty and, therefore, their use for irrigation presents major constraints to crop production. In general, these soils have good physical properties but poor natural drainage. The formation of saline soils is generally associated with the rise in water table due to introduction of irrigation and inadequate drainage. To mitigate the adverse effect of soil salinity on crop yield, the farmers irrigate frequently using canal water and ground water. Due to differences in environmental parameters in the farming systems, such as groundwater quality, soil types and uneven distribution of irrigation water, income losses to the farming community are not uniform (Datta & Jong, 2002). This study highlights the economic losses due to land degradation by the problem of soil salinity, which threatens the sustainability of agricultural production in Haryana state.

India has 2.95 Mha area affected by soil salinity (Sharma *et al.,* 2015). Out of 1Mha of irrigation induced waterlogged saline area in north-west India, approximately 0.5 Mha are in the state of Haryana (Datta and Jong, 2002). In the Indo-Gangetic basin in India, the crop yield losses on salt-affected lands were 40 per cent in wheat, 45 per cent in rice, 48 per cent in sugarcane and 63 per cent in cotton (Tripathi, 2009). India is losing a huge amount of money from degraded lands. This cost is documented by declining crop productivity, land use intensity, changing cropping patterns, high input use and

declining profit (Datta *et al.*, 2002, 2004; Thimmappa *et al.*, 2014). Recent estimates in Haryana (Sharma *et al.*, 2015) showed that saline soils are spread in the area of 95765 ha and total losses resulting from salinization was 118469 tonnes in terms of production and ₹1238071609 in terms of monetary loss. The maximum area of 77061 ha (80.47 per cent) in the state is under cereals production (Sharma *et al.*, 2015) and the respective production and monetary losses occurred from cereals production were 68272 tonnes (57.65 per cent) and ₹881675758 (71.21 per cent). The district wise details of area under salinity, production and monetary losses are presented in Table 3. In Haryana, the cereals production, i.e., rice and wheat are the major crops of *kharif* and *rabi* seasons. Fatehabad district, in which the subsurface drainage project is located, is the base for our study. The district has 1787 ha area under soil salinity and has highest area under cereals production. Hence, the production and monetary losses for rice and wheat crops were assumed to be proper representation of our diagnosis, and the damage assessment has been estimated from rice and wheat crops.

## MATERIALS AND METHODS

### General features of the study area

The study area, village Banmandori is located in the Bhattu block of Fatehabad district in Haryana state. Total area under subsurface drainage is 277 ha, which covers 152 farmers. Waterlogging and salinity problems both occur in the study area. Waterlogging is more predominant in *kharif* and soil salinity in *rabi* seasons. The socio-economic profile of the sample farmers reveals that average family size is seven persons and literacy rate is 60 per cent (Table 1). Majority farmers belong to medium age (43 years) category. The annual rainfall of the district for last 10 years ranges between 75 to 426 mm and the mean temperature varies between 5.5 to 41.6°C. Farmers deriving their family income mainly from crop production (52 per cent) and livestock (22 per cent). Approximately 72 per cent of the study area farmers belong to the small and marginal category. The average farm size of the sample farmers were 1.47 ha.

**Table 1: Socio-economic profile of the sample farmers**

| Particulars | Percentage/Value |
|---|---|
| **General information** | |
| Family size (No.) | 7 |
| Literacy level ( per cent) | 60 |
| Age (years) | 43 |
| Average farm size (ha) | 1.47 |
| **Sources of family income (Per cent)** | |
| Crop production | 52 |
| Livestock | 22 |
| Other Sources | 19 |
| **Classification of farm holdings (Per cent)** | |
| Marginal (<1 ha) | 49 |
| Small (1-2 ha) | 23 |
| Medium (4-10 ha) | 8 |

### Analytical Approach

To assess the damage caused by varying degrees of water logging and soil salinity and their effect on land productivity and farm income, both primary and secondary data were considered and analysed. General indicator for water logging is depth of the water table and for soil salinity; it is the electrical conductivity (ECe) of the saturated (soil) paste. Ground water quality also expressed in terms of electrical conductivity (EC). Crop productivity is measured by recording crop yields. Land productivity was assessed by determining cropping intensity and cropping pattern (Datta *et al.*, 2004).

To assess the soil salinity, soil samples were collected from sample plots and soil analysis was made. Later, the data sets have been classified according to degree of soil salinity at the harvest of the crops. Soil salinity of one acre sample plots have been grouped into four classes (Mandal *et al.*, 2010) i.e., normal soil (0-4 dS/m), slightly saline (4.1-8.0 dS/m), moderately saline (8.1-16 dS/m) and severely saline (>16 dS/m). Many common agricultural crops, including rice and wheat, are not affected in the range of 0-4 dS/m. We used this class as the non-affected standard. No crops were grown on land with an ECe above 16 dS/m (Datta and Jong, 2002, and Raju *et al.*, 2016).

Land holding distribution of the study area as per soil salinity classes (Table 2) reveals that out of 1370 ha land area of the village, 1030 ha (75.18 per cent) land was normal. The remaining 340 ha (24.82 per cent) area was affected by soil salinity, out of which 187.18 ha (13.66 per cent) land has slight salinity, about 57.08 ha (4.17 per cent) land has moderate salinity and 95.74 ha (6.99 per cent) area is severely saline. In severe saline land no crop has been grown for many years.

**Table 2: Distribution of landholding under different soil salinity classes in village Banmandori**

| Soil salinity classes | ECe range (dS/m) | Area (ha) | Area (per cent) |
|---|---|---|---|
| Normal | 0-4 | 1030.00 | 75.18 |
| Slightly saline | 4.1-8.0 | 187.18 | 13.66 |
| Moderately saline | 8.1-16.0 | 57.08 | 4.17 |
| Severely saline | >16 | 95.74 | 6.99 |
| Total | | 1370.00 | 100.00 |

*Source: Mandal et al. (2010)*

## RESULTS AND DISCUSSION

### Area under soil salinity, monetary and production losses in Haryana

About 95765 ha area is under soil salinity in Haryana (Table 3). The districts having maximum area under salinity were Gurgaon (17.66 per cent), Rohtak (17.52 per cent), Hissar (16.12 per cent) and Jhajjar (10.49 per cent). The district with least salinity were Bhiwani (0.22 per cent), Rewari (0.58 per cent), Sirsa (0.60 per cent) and

Kaithal (0.89 per cent). In terms of production losses, Gurgaon, Rohtak and Hisar showed maximum loss of 15.76, 15.29 and 14.84 per cent, respectively. The districts with least production losses were Bhiwani, Sirsa and Rewari with loss of 0.05, 0.07 and 0.19 per cent, respectively to the states total. The monetary loss was maximum in Hisar and Gurgaon districts with 27.18 per cent and 19.22 per cent respectively. The estimates showed about 0.11 million tonnes of foodgrain production loss brings a monetary loss of ₹ 123.81 million in Haryana.

**Cropping Pattern**

The cropping pattern of study area during both *kharif* and *rabi* seasons is depicted in Table 4. The major *kharif* crops were cotton (51.51 per cent) followed by rice (11.45 per cent) and guar (16.01 per cent) and in *rabi* season, wheat (71.10 per cent) was the most important crop followed by mustard (13.83 per cent). The fallow land remains almost same for both *kharif* (10.88 per cent) and *rabi* (11.46 per cent) seasons. The fallow land in the study area is rather high due to waterlogging and salinity problem.

**Cropping Intensity**

The cropping intensities according to soil salinity classes are shown in Table 5. The average cropping intensity of village Banmandori for the period 2010-2014 are 86 per cent each in *kharif* and *rabi* seasons and thus it is 172 for the whole agricultural year.

**Crop yields**

Average crop yields have been determined for each soil salinity classes (Tables 6 and 7). Rice and wheat has been assumed to represent the *kharif* crop and *rabi* crops,

**Table 4: Cropping pattern in *kharif* and *rabi* seasons in the study area**

| *Kharif* crops | Percentage | *Rabi* crops | Percentage |
|---|---|---|---|
| Cotton | 51.51 | Wheat | 71.10 |
| Rice | 11.45 | Mustard | 13.83 |
| Guar | 16.01 | Barley | 1.31 |
| Bajra | 3.96 | Oats | 0.88 |
| Groundnut | 4.04 | Berseem | 0.24 |
| Fodder | 1.05 | Castor | 0.15 |
| Other crops | 1.10 | Other crops | 1.02 |
| Fallow land | 10.88 | Fallow land | 11.46 |
| Total | 100.00 | Total | 100.00 |

respectively. Starting from lowest salinity class (slightly saline) to the higher salinity class (severely saline) the yield of rice and wheat crops decreases significantly. The yield reduction in rice was 27 per cent for slightly saline and 51 per cent for moderate saline soils compared to normal soils. Similarly, the yield reduction in wheat was 20 per cent and 43 per cent, respectively for slight and moderately saline soils as compared to normal soils in the region. Severe saline soils have 100 per cent yield reduction for both rice and wheat, as no crops were grown on such soils.

In all categories of salinity affected land the yield reductions of rice and wheat crops were similar. There are small variations from year to year in the less affected areas. However, the yield variation in the moderately affected land was larger for both rice and wheat. This may be due to the extreme conditions of salinity and to the fact that the farmers are inclined to give most attention to crops grown

**Table 3: District-wise area under salinity, production and monetary losses in Haryana**

| Districts | Area (ha) | Per cent to total | Production loss (t) | Per cent to Total | Monetary loss (₹) | Per cent to Total |
|---|---|---|---|---|---|---|
| Ambala | 1350 | 1.41 | 2148 | 1.81 | 14059276 | 1.14 |
| Bhiwani | 209 | 0.22 | 62 | 0.05 | 480375 | 0.04 |
| Faridabad | 3735 | 3.90 | 6673 | 5.63 | 42445020 | 3.43 |
| Fatehabad | 1787 | 1.87 | 1998 | 1.69 | 24203569 | 1.95 |
| Gurgaon | 16910 | 17.66 | 18669 | 15.76 | 238004621 | 19.22 |
| Hisar | 15440 | 16.12 | 17577 | 14.84 | 336530998 | 27.18 |
| Jhajjar | 10045 | 10.49 | 10149 | 8.57 | 69540779 | 5.62 |
| Jind | 7132 | 7.45 | 5910 | 4.99 | 68772579 | 5.55 |
| Kaithal | 855 | 0.89 | 1304 | 1.10 | 14765725 | 1.19 |
| Karnal | 6776 | 7.08 | 11644 | 9.83 | 90009013 | 7.27 |
| Kurukshetra | 7259 | 7.58 | 6871 | 5.80 | 83535402 | 6.75 |
| Panipat | 1684 | 1.76 | 6019 | 5.08 | 49948243 | 4.03 |
| Rewari | 556 | 0.58 | 224 | 0.19 | 2819665 | 0.23 |
| Rohtak | 16774 | 17.52 | 18114 | 15.29 | 109265751 | 8.83 |
| Sirsa | 579 | 0.60 | 84 | 0.07 | 1048507 | 0.08 |
| Sonepat | 4674 | 4.88 | 11023 | 9.30 | 92642086 | 7.48 |
| Yamunanagar | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Total | 95765 | 100 | 118469 | 100 | 1238071609 | 100 |

*Source: Sharma et al. (2015)*

Table 5: Cropping intensity by soil salinity class

| Soil salinity classes | 2010-11 | 2011-12 | 2012-13 | 2013-14 | Average |
|---|---|---|---|---|---|
| Normal | 198 | 197 | 197 | 196 | 197 |
| Slight | 187 | 189 | 189 | 182 | 187 |
| Moderate | 175 | 176 | 181 | 177 | 177 |
| Severe | 126 | 129 | 129 | 127 | 128 |
| Annual Average | 172 | 173 | 174 | 171 | 172 |
| Average in *kharif* | 87 | 87 | 87 | 83 | 86 |
| Average in *rabi* | 85 | 86 | 87 | 88 | 86 |

Table 6: Average yield (t/ha) of rice in different soil salinity

| Year | Soil salinity classes | | | |
|---|---|---|---|---|
| | Normal | Slight | Moderate | Severe |
| 2010-11 | 4.21 | 3.13 | 2.08 | 0 |
| 2011-12 | 4.33 | 3.18 | 2.13 | 0 |
| 2012-13 | 4.27 | 3.11 | 2.05 | 0 |
| 2013-14 | 4.45 | 3.21 | 2.17 | 0 |
| Average | 4.32 | 3.16 | 2.11 | 0 |
| Yield loss (per cent) | | 27 | 51 | 100 |

Table 7: Average yield (t/ha) of wheat in different soil salinity

| Year | Soil salinity classes | | | |
|---|---|---|---|---|
| | Normal | Slight | Moderat | Severe |
| 2010-11 | 4.65 | 3.74 | 2.73 | 0 |
| 2011-12 | 4.78 | 3.75 | 2.55 | 0 |
| 2012-13 | 4.86 | 3.89 | 2.77 | 0 |
| 2013-14 | 4.89 | 3.87 | 2.82 | 0 |
| Average | 4.80 | 3.81 | 2.72 | 0 |
| Yield loss (per cent) | | 20 | 43 | 100 |

on the relatively better soils and crops (Datta *et al.*, 2002).

**Cost of cultivation and cost of production**

The average cost of cultivation (₹/ha) as well as cost of production (₹/t) was determined for each soil salinity classes separately for rice (Table 8) and wheat (Table 9). The cost of cultivation was almost uniform throughout the salinity classes. It ranges between ₹380003 to ₹40739 for rice and ₹35371 to ₹38670 for wheat. This may be due to approximately same quantity of inputs used and similar number of farm operations were performed across the soil salinity classes. However, the cost of production showed a significant difference across the soil salinity classes. This was mainly due to reduction in yield affected by higher salinity in the region. The cost of production in rice was higher by 40 per cent and 91 per cent in slight and moderate salinity, respectively, as compared to the normal soil class. Similarly, the cost of production of wheat was higher by 28 per cent and 61 per cent, respectively, for slight and moderate salinity classes as compared to the normal soil class in the region.

Table 8: Average cost of production of rice crop in various salinity classes

| Year | Normal | | Slight | | Moderate | | Severe | |
|---|---|---|---|---|---|---|---|---|
| | ₹/ha | ₹/t | ₹/ha | ₹/t | ₹/ha | ₹/t | ₹/ha | ₹/t |
| 2010-11 | 39665 | 9422 | 42015 | 13423 | 36321 | 17462 | 0 | 0 |
| 2011-12 | 41113 | 9495 | 41652 | 13098 | 37562 | 17635 | 0 | 0 |
| 2012-13 | 40582 | 9504 | 41483 | 13339 | 38264 | 18665 | 0 | 0 |
| 2013-14 | 41597 | 9348 | 42351 | 13193 | 39865 | 18371 | 0 | 0 |
| Average | 40739 | 9441 | 41875 | 13262 | 38003 | 18032 | 0 | 0 |
| Increase in cost (Per cent) | | | | 40 | | 91 | | |

Table 9: Average cost of production of wheat crop in various salinity classes

| Year | Normal | | Slight | | Moderate | | Severe | |
|---|---|---|---|---|---|---|---|---|
| | ₹/ha | ₹/t | ₹/ha | ₹/t | ₹/ha | ₹/t | ₹/ha | ₹/t |
| 2010-11 | 38420 | 8262 | 39370 | 10527 | 33670 | 12333 | 0 | 0 |
| 2011-12 | 38798 | 8117 | 39338 | 10490 | 34904 | 13688 | 0 | 0 |
| 2012-13 | 38018 | 7823 | 39248 | 10089 | 35700 | 12907 | 0 | 0 |
| 2013-14 | 39444 | 8066 | 39366 | 10172 | 37211 | 13195 | 0 | 0 |
| Average | 38670 | 8065 | 39331 | 10316 | 35371 | 13021 | 0 | 0 |
| Increase in cost (Per cent) | | | | 28 | | 61 | | |

**Table 10: Average costs and returns per season by soil salinity classes**

| Soil salinity class | Gross return (₹/ha) | | Total cost (₹ /ha) | | Net return (₹ /ha) | |
|---|---|---|---|---|---|---|
| | *Kharif* | *Rabi* | *Kharif* | *Rabi* | *Kharif* | *Rabi* |
| Normal | 66883 | 69528 | 40739 | 38670 | 26143 | 30858 |
| Slight | 48941 | 55281 | 41875 | 39331 | 7066 | 15951 |
| Moderate | 32666 | 39389 | 38003 | 35371 | -5337 | 4018 |
| Severe | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 11: Potential and Actual damage caused by soil salinity**

(₹/ha)

| Year | *Kharif* | | *Rabi* | | Agricultural year | |
|---|---|---|---|---|---|---|
| | Potential damage | Actual damage | Potential damage | Actual damage | Potential damage | Actual damage |
| 2010 | 6508 | 5662 | 3933 | 3343 | 10441 | 9005 |
| 2011 | 6447 | 5609 | 4350 | 3741 | 10797 | 9350 |
| 2012 | 6372 | 5543 | 4457 | 3878 | 10829 | 9421 |
| 2013 | 6824 | 5664 | 4338 | 3817 | 11162 | 9482 |
| Average | 6538 | 5620 | 4270 | 3695 | 10807 | 9314 |

**Gross and Net Returns**

The gross costs and returns were estimated for both *kharif* (for rice crop) and *rabi* (for wheat crop) seasons separately for each salinity classes (Table 10). The land productivity was estimated as sum of the total *kharif* and *rabi* seasons crop productivities.

Gross returns for both the seasons were decreased across the salinity classes. However, the net returns decreases more sharply than the gross returns because the cost of production remains uniform throughout the salinity classes. In *kharif* season, the net returns from slightly saline land was ₹ 7066 depicting 73 per cent lesser income than normal land, whereas moderate salinity showed a loss of ₹ 5337 per ha. Similarly, in *rabi* season, net income was lower for both slight and moderate saline soils respectively by ₹15951 per ha and ₹ 4018 per ha compare the net income from to normal soils (₹30858 per ha). Thus, net returns decreases more sharply with increasing salinity, indicates the adverse effect of salinity on net income.

**Damage assessment**

The land productivity data (Table 10) were used to assess the damage caused by soil salinity. The damage in terms of farm income losses were estimated by subtracting the per ha net income of each soil salinity classes from the net income of the normal class for each crop (Datta and Jong, 2002; Datta *et al.*, 2004; Thimmappa *et al.*, 2014). The potential damage per cultivable area has determined by calculating the weighted average of the damage suffered in all categories of affected land as per Table 2.

The actual farm income losses per ha in *kharif* and *rabi* seasons has been estimated by multiplying potential farm income losses with the corresponding cropping intensities. The average cropping intensities for *kharif* and *rabi* seasons were 86 per cent each as presented in Table 5. To calculate the actual income loss per hactare, the potential income loss figures for *kharif* and *rabi* seasons were multiplied by the factor 0.86.

The total loss for agricultural year was estimated by summing the losses occurred in both *kharif* and *rabi* seasons (Table 11). The annual potential and actual losses per ha due to soil salinity was₹10807 and ₹9314 per ha, respectively. So, the total annual monetary loss arises due to soil salinity in the study domain, village Banmandori is ₹3.67 million.

## CONCLUSIONS

Soil salinity is one of the major land degradation problem not only in India, but in the world too. The estimates showed an annual potential and actual losses per ha due to soil salinity was ₹10807 and ₹9314, respectively. So, the total annual monetary loss arises due to soil salinity in village Banmandori is ₹3.67 million, which is one of the salinity affected area in Haryana. The study confirms that the salinity results in a considerable decrease in net returns from crop production, and farmers' income thus affecting the wellbeing of the rural population. In view of doubling farmers' income by 2022, the policy makers has to give more emphasis on land degradation aspects particularly saline soil reclamation which is a major concern of worry by the farmers of Haryana as well as India.

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