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Reducing Farm Income Losses through Land Reclamation: A Case Study from Indo-Gangetic Plains

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Abstract

Soil sodicity is a major problem in arid and semi-arid regions of Indo-Gangetic plains in India. A large proportion of sodicity-affected soils in Indo-Gangetic areas occur on land inhibited by resource poor farmers. Several efforts have been made by the Central and State governments to check soil degradation and increase agricultural productivity through land reclamation programmes in salt-affected regions of India. The present study is an attempt to measure the impact of land reclamation on reduction in farm income losses. The study sourced data from published records and survey from farm households in Uttar Pradesh, India. Analysis revealed that land reclamation has contributed substantially to improve the soil health, crop productivity and farm income. All uncultivated degraded lands in pre-reclamation period have been put under cultivation in post-reclamation period and cropping intensity has significantly increased. The farm income losses were reduced substantially in post-reclamation period. The study has concluded that sodic land reclamation technology has made a significant contribution to livelihood security of resource-poor farmers in salt-affected regions. The study has suggested that a large part of agricultural land is being abandoned in India due to severe sodicity related problems and need to be reclaimed on priority basis to improve land productivity and farm income of resource poor farmers.

Key words: Gypsum, Farm income, Land degradation, Sodic soil, Land reclamation

Introduction

Land degradation due to sodicity is a major threat to agriculture in Indo-Gangetic plains. The sodic soils are widely distributed across the globe and occupy nearly 357.2 million hectares (Pessarakli and Szabolcs, 1999). India has 6.73 Mha of salt-affected soils, of which 3.72 Mha is sodic soils predominantly present in Indo-Gangetic plains (Mandal *et al*., 2010). Sodic soils are characterized by the occurrence of excess Na^+ that adversely affects soil structure and crop growth (Qadir and Schubert, 2002). The weathering of alumino-silicate minerals produces a continuous supply of sodium, potassium, calcium and magnesium salts in the catchment area. Due to arid and semi-arid climate, the water evaporates in post-rainy months leave sodium carbonates (Na_2CO_3) and bi-carbonates ($NaHCO_3$) on soil surface, which contribute to the formation of sodic soils in Indo-Gangetic plains (Chhabra, 1996). Indo-Gangetic plain lies between 21^0 55' to 32^0 39' N and 73^0 45' to 88^0 25' E comprising of the states of Punjab, Haryana, Uttar Pradesh and part of Bihar (North), West Bengal (South) and Rajsthan (North) is having about 2.7 Mha salt affected soils (NRSA, 1996).

Soil sodicity creates an inordinately high soil pH ranging from 8.5 to 11 in addition to the ion toxicity and high osmotic pressure (Bing-Sheng *et al.,* 2013). A high pH condition causes deficiencies of several important minerals which in turn inhibits the plant growth (Guan *et al*., 2009) and adversely affects the growth of early seedlings, grain yield (Chhabra, 1996; Sharma *et al*., 2010) and grain quality (Rao *et al.*, 2013).

India's foodgrain demand projections (Radhakrishna and Ravi, 1990; Kumar, 1998; Kumar *et al*., 2009) suggest that the need to produce more food to an expanding human population, which will result in an increase in the use of poor-quality waters and soils for foodgrain production (Yadav, 1981; Oster and Jayawardane, 1998; Qadir *et al.*, 2001). Plant growth in sodic soils is affected by high osmotic stress, ion toxicity and nutritional disorders which ultimately reduces crop yield (Qadir and Schubert, 2002).

A significant advancement in sodic land reclamation technology has been made at Central Soil Salinity Research Institute (CSSRI), Karnal (India) to use the degraded sodic soils with the addition of soil amendments to meet the food grains demand for growing population. The successful application of sodic soil reclamation technology at the farmers' fields has encouraged many states to launch ambitious programmes of land reclamation through Land Reclamation and Development Corporations by providing necessary inputs to augment the food and livelihood security of resource poor farmers.

However, studies on yield and income of major crops in sodic soils before and after soil reclamation has been very limited which is most important to determine measures for improving crop production practices and for long term sustainability of agriculture. Hence, this study was focused on assessing the impact of land reclamation on crop productivity improvement and reduction in farm income losses in sodicity affected regions of Indo-Gangetic plains.

Material and Methods

Study site

An intensive study was conducted in Santaraha village in Hardoi district of Uttar Pradesh, India. It is located at an elevation of 139 meters above mean sea level. Temperature in summer goes as high as 44 °C and in winter comes down to as low as 4°C. The rainy season prevails from mid-June to mid-September and annual rainfall varies from 629 to 818 mm.

The average size of land holding was 0.62 ha and the majority of the farmers were marginal category (Table 1). The crop production was an important activity contributing 68 per cent to the total household income. Many farmers (27%) supplemented their household income by engaging themselves or their family members as farm laborers. Farmers grew crops in *kharif* season (June–October) and *rabi* seasons (November–March). Transplanted rice (*Oryza sativa*) crop was most popular in *kharif* season. Wheat (*Triticum aestivum*) was grown after rice in *rabi* season. In 'moderate' soil sodicity (ESP 15–40), rice was grown in *kharif* season and land remained barren in *rabi* season. There was no crop cultivation in the severe soil sodicity condition due to extreme sodicity (ESP >40).

Table 1. Socio-economic profile of sample farmers

Particulars	Percentage / value
(I) General information	
(a) Family size (No.)	7
(b) Literacy level (%)	40
(c) Age (years)	48
(d) Average farm size (ha)	0.62
(e) Annual rainfall (mm)	629 - 818
(f) Temperature (°C)	4 - 44
(II) Classification of farm holdings (%)	
(a) Marginal (<1 ha)	84
(b) Small (1 to 2 ha)	16
(c) Medium (>2 to 10 ha)	0
(d) Large (> 10 ha)	0
(III) Sources of family income (%)	
(a) Crop production	68
(b) Livestock	2
(c) Service	1
(d) Business	2
(e) Others	27

Source: Survey data.

Field survey

The village has total agricultural land of 123 ha owned by approximately 197 farmers. The degraded land constituted 39 per cent of the total land holdings and has varying levels of soil sodicity. The land holdings have been classified into 'normal', 'slightly affected', 'moderately affected' and 'severely affected' by sodicity based on the extent of sodicity hazard (Table 2). Soil sodicity is usually quantified by the exchangeable sodium percentage (Van der Zee *et al.*, 2010). It also can be quantified by soil pH. Sodic soils have pH greater than 8.5. Several studies have shown that there is an intimate relationship between ESP and pH of the saturation paste (Kanwar *et al.*, 1963; Kolarkar and Singh, 1970; Abrol *et al.*, 1980). Since pH of the saturation paste can be easily determined in laboratory, this property can be used as an approximate measure of ESP, which is otherwise a cumbersome determination (Chhabra, 1996). The sodicity hazards were low in 'slight' sodicity soil category. Farmers grew both rice and

Table 2. Distribution of landholdings under different sodicity classes in Santaraha village

Soil sodicity category*	pH*	Approximate ESP*	Area (ha)	Area (%)
Normal	<8.5	<15	74.98	60.96
Slight	8.5-9.0	< 15	3.13	2.55
Moderate	9.1-9.8	15-40	13.53	11.00
Severe	>9.8	>40	31.36	25.49
Total	-	-	123	100.00

Source: * Mandal *et al.* (2010).

wheat in this category of the land. The sodicity hazards were high in 'moderate' sodicity soil class and farmers grew only rice crop. Farm lands were left fallow in 'severe' sodicity soil category lands due to extremely high pH and ESP. Out of total agricultural land of 123 ha, 74.98 ha (60.96%) was under 'normal' category, 3.13 ha (2.55%) was 'slight' category, 13.53 ha (11%) was 'moderate' category and 31.36 ha (25.49%) was categorized as 'severe' soil sodicity land category based on pH and ESP (Table 2). Hence, in this village, 48.03 ha (39.04%) of agricultural land were under varying levels of degradation due to sodicity.

Soil samples were collected within a soil depth of 0 – 15 cm before application of the soil amendments in 2011-12. Another set of soil samples was collected from each plot after two years of reclamation in 2013-14. The samples were air dried and ground to pass through a <2 mm sieve. The exchangeable sodium percentage (ESP) and pH were determined following the methods outlined in the USDA Handbook No 60 (Richards, 1954). Soil samples were analyzed at the Regional Research Station, Central Soil Salinity Research Institute, Lucknow, India and crop yields were recorded after harvesting of the crops from each selected plots.

The data on land holdings were collected from the registers of village level Water Users Associations maintained with the assistance of gross root officers of Uttar Pradesh Land Development Corporation, Government of Uttar Pradesh (Anonymous, 2012). One hundred fifty farm households were surveyed. The sample households comprised of 76% of the total farm households in the village. Information on various aspects of crop production and cropping intensity were collected from the selected farm households on standardized questionnaire. The costs and returns have been estimated based on 2013-14 prices. The cost of cultivation included all expenses incurred for crop production such as human labour, machine labour, seeds, fertilizers, irrigation, plant protection measures, overhead charges and imputed value of family labour. The overhead charges included repair, maintenance and depreciation of fixed assets, interest on working capital and fixed capital and land revenue paid to the state government. Gross income included the total value of main crop and by-products. Net income was calculated as the difference between gross income and cost of production.

The farm income losses caused by sodicity were estimated by subtracting the net income per ha in each soil sodicity class from the net income of 'normal' soil class for each crop. The potential farm income losses per ha were calculated by multiplying estimated farm income loss values with corresponding proportional areas of sodicity classes. The actual farm income loss per ha in *kharif* and *rabi* seasons has been estimated by multiplying potential farm income loss with the corresponding cropping intensities.

Results and Discussion

Sodic land reclamation technology

Reclamation of sodic land requires the removal of most of the exchangeable sodium ion and its replacement by calcium ion in the root zone (Abrol *et al.,* 1988). For successful crop growth in alkali soils, the ESP of the soil must be lowered by the application of soil amendments (Chhabra, 1996). In India, gypsum is the major source of soil amendment used to reclaim alkali soils. The use of other amendments like calcium chloride, sulphuric acid, phosphogypsum, press-mud, acid wash and molasses are limited (Chhabra *et al.,* 1980). CSSRI has developed a low cost technology to reclaim the sodic soils by adding only 25% gypsum requirement (GR) value combined with 10 t ha^{-1} press-mud which is a waste product of sugar factories and recommended fertilizer doses (Swarup and Yaduvanshi, 2004). This technology not only improves the productivity of rice based cropping system but also maintains soil fertility to an optimum level. Since, the degraded area was located near a sugar mill, the combination of 10 t ha^{-1} press-mud along with gypsum (25% GR value) were used to reclaim the degraded soils of Santaraha village.

The investment on reclamation depends on the quantity of gypsum required for reclamation, which depends on the amount of exchangeable sodium to be replaced in the soil. The actual quantity of gypsum required is calculated on the basis of laboratory tests carried out on the surface soil (0-15 cm). The total investment required to reclaim one hectare sodic land was varied between Rs 45755 in 'slight' sodic category land to Rs 54530 in 'severe' sodic category land. A sizable amount of money is required to reclaim severely affected land. It also requires larger quantity of gypsum due to higher ESP. The severely degraded lands were left uncultivated for many years and more investment required for farm development activities as farmers have to clear naturally grown trees and bushes on these lands. To level the land and make suitable for cultivation, 2-3 times extra ploughing is required as compared to 'slight' and 'moderate' land categories. The investment on amendments application, irrigation and flushing of salts was highest in severely affected sodic lands. If there are no canal or tube-well irrigation facilities, an additional amount of Rs. 25000 per ha investment on tube-well is required to create irrigation facility. This indicates that a large amount of capital is required to reclaim sodic land.

The marginal and small holders may not be able to invest a huge amount of money in reclaiming soidic land due to their low investment capacity. Hence, central and state governments provide subsidies to farmers ranged from 50 per cent to 90 per cent through different land improvement, sodic land reclamation and anti-poverty programmes. After the application of amendments and leaching of salts, a standard pakage of agronomic practices recommended by CSSRI needs to be followed to make the soil free from sodicity hazard. Rice is recommended for inclusion in crop rotation. The rice–wheat–sasbania or rice–berseem crop rotation continuously for 4 to 5 years is recommended for successful reclamation of alkali soils (CSSRI, 1998).

Effect of reclamation on sodicity level

Soil samples were analyzed in pre and post-reclamation periods to know the extent of reduction in soil pH and ESP (Table 3). The values of soil pH varied from 8.9 to 10.30 and ESP values ranged from 31 to 85 in pre-reclamation period. The high pH of these soils has been attributed to the presence of carbonate which is present in the soils affected with sodium carbonate (Abrol *et al.*, 1980). The main purpose of sodic soil reclamation is to reduce their exchangeable sodium content and make the soils suitable for crop production. Results indicated that amendments improved the soil properties in two years of reclamation when compared with the pre-reclamation period. The soil pH values were reduced by 8.09%, 8.82% and 11.75% in 'slight', 'moderate' and 'severe' sodicity land categories respectively, in post-reclamation period. Similarly, compared with pre-reclamation period, addition of amendments reduced the ESP values by 25.81% to 63.53% in post-reclamation period indicating remarkable reduction in sodicity level. However, previous studies showed that complete reclamation of sodic soils takes several years depending on status of surface soil and the crops grown in post-reclamation phase (Abrol and Bhumbla, 1979; Mehta *et al.*, 1980; Chhabra, 1996).

Table 3. Impact of amendments application on sodicity

Sodicity parameters	Slight	Moderate	Severe
Pre-reclamation period (2011-12)			
pH	8.90	9.30	10.30
ESP	31	42	85
Post-reclamation period (2013-14)			
pH	8.18	8.48	9.09
ESP	23	27	31
pH reduction (%)	8.09	8.82	11.75
ESP reduction (%)	25.81	35.71	63.53

Cropping intensity

Cropping intensity shows the extent of cultivated area used for crop production out of total net area sown in a year. The average cropping intensity during 2009-2012 was 122.93 per cent (Table 4). The cropping intensity in *rabi* season was low (47.95%) in pre-reclamation period because land under 'moderate' and 'severe' categories were left fallow due to high level of sodicity. Hence, cropping intensity decreased with increase in soil sodicity levels. All uncultivated degraded lands in pre-

Table 4. Cropping intensity (%) by soil sodicity classes

Soil sodicity class	Pre-reclamation period				Post-reclamation period		
	2009-10	2010-11	2011-12	Average	2012-13	2013-14	Average
Normal	198.57	198.47	198.47	198.50	198.47	198.47	198.47
Slight	196.86	191.44	191.44	193.25	199.73	199.73	199.73
Moderate	99.96	99.96	99.96	99.96	199.93	199.93	199.93
Severe	0.00	0.00	0.00	0.00	200.00	200.00	200.00
Average in *kharif*	74.47	73.73	73.73	73.98	99.77	99.77	99.77
Average in *rabi*	49.38	48.74	48.74	48.95	99.77	99.77	99.77
Annual average	123.85	122.47	122.47	122.93	199.54	199.54	199.54

reclamation period have been put under cultivation in post-reclamation period. Hence, the cropping intensity was 199.54 per cent and increased by 62.32%. The increased cropping intensity contributed to higher total farm production and income.

Crop yield

Yield loss is detrimental at a local scale because salt-affected soils are not uniformly distributed. The degree of sodicity varied across the farms with in the village. It was observed that the salt concentration in soil has steeply reduced the crop yield (Table 5). The rice yield decreased from 4.87 t/ha in 'normal' soils to 2.95 t/ha in 'slight' soil sodicity class, indicating 39.43 per cent decline. Several studies have shown that crop yield decreases with increase in the level of sodicity (Abrol and Bhumbla, 1979; Chhabra, 2002; Dwivedi and Qadar, 2011). The yield reduction was drastic (74.95%) in 'moderate' soil sodicity class. A large number of studies indicated that the sodicity inhibits shoot and root growth of rice seedlings and had less biomass when grown under sodic conditions (Chhabra, 1996; Van Aste *et al.*, 2003; Wang *et al.*, 2011).

Wheat yield decreased from 3.65 t ha^{-1} in 'normal' soil to 2.82 t/ha in 'slight' land class, depicting 22.74 per cent yield loss (Table 5). The yield loss of wheat was greater at the higher sodicity levels (Sharma *et al.*, 2010). Yield of wheat is highly dependent on the number of spikes produced by each plant. Sodic conditions negatively affect number of spikes produced per plant (Maas and Grieve, 1990) and the fertility of the spikelets (Seifert *et al.*, 2011; Fatemeh *et al.*, 2013). Sodic soils usually have poor availability of most micronutrients, which is generally attributed to high soil pH (Naidu and Rengasamy, 1993). In addition, poor physical properties of sodic soils, which directly limit crop growth through poor seedling emergence and root growth, also exhibit indirect effects on plant nutrition by restricting water and nutrient uptake and gaseous exchange (Curtin and Naidu, 1998) which ultimately result in reduced crop yield and quality (Grattan and Grieve, 1999).

There was no wheat production in 'moderate' and 'severe' soil sodicity classes. A high pH condition damages plants directly and causes deficiencies of nutritional minerals such as iron and phosphorus (Guan *et al.*, 2009). The 'severe' category of soil sodicity class remained barren in both the seasons due to high sodicity as ESP ranged from 65 to 90 and pH varied from 9.5 to 11. Heavy salt stress generally leads to reduced growth and even plant death (Qadar, 1998; Parida and Das, 2005).

The rice-wheat rotation is most common in Indo-Gangetic plains. It was noticed that land reclamation had a profound impact on productivity of rice and wheat. Before reclamation, the productivity of rice was 2.95 t ha^{-1} in 'slight' and 1.22 ha^{-1} in 'moderate' land categories. The productivity of rice increased to 4.71 t ha^{-1} in 'slight' soil sodicity category, depicting a gain of 60%. In 'moderate' soil sodicity category, rice productivity increased to 4.40 t ha^{-1}, indicating a remarkable increase of 261%. Hence, a significant yield gain was observed in rice after land reclamation. In the 'severe' soil sodicity category, rice production was 3.90 t ha^{-1}, which was barren in pre-reclamation period.

Before reclamation, wheat production was 2.82 t ha^{-1} in 'slight' land category and increased to 3.49 t ha^{-1} in post-reclamation period. The wheat yield was 3.17 t ha^{-1} in 'moderate' and 2.75 t ha^{-1} in 'severe' land sodicity categories in post-reclamation period which were uncultivated in pre-reclamation period. It suggested that a significant yield gain was observed

Table 5. Average yield (t ha^{-1}) of rice and wheat in the different sodicity classes

Year	Soil sodicity class			
	Normal	Slight	Moderate	Severe
Rice				
Pre-reclamation period				
2009 - 2010	4.81	2.92	1.21	0
2010 - 2011	4.94	2.98	1.25	0
2011 - 2012	4.86	2.95	1.20	0
Average	4.87	2.95	1.22	0
Yield loss (%)	-	39.43	74.95	100
Post-reclamation period				
2012-2013	4.94	4.63	4.30	3.83
2013-2014	4.99	4.78	4.49	3.97
Average	4.97	4.71	4.40	3.90
Yield loss (%)	-	5.24	11.48	21.45
Mean Difference between post and pre reclamation periods	-	1.76*	3.18*	-
Wheat				
Pre-reclamation period				
2009 - 2010	3.57	2.76	0	0
2010 - 2011	3.70	2.85	0	0
2011 - 2012	3.67	2.84	0	0
Average	3.65	2.82	0	0
Yield loss (%)	-	22.74	100	100
Post-reclamation				
2012-2013	3.67	3.43	3.02	2.63
2013-2014	3.81	3.54	3.32	2.86
Average	3.74	3.49	3.17	2.75
Yield loss (%)	-	6.82	15.24	26.60
Mean Difference between post and pre reclamation periods	-	0.67*	-	-

*Significant at (p=0.05)

Note: In pre-reclamation period, the severely sodicity affected lands were left fallow in both seasons and no crop production in 'moderate' classes during *rabi* season.

after land reclamation. The yield gain was highest in 'moderate' class (3.17 t ha^{-1}) followed by 'severe' (2.75 t ha^{-1}) and 'slight' (0.67 t ha^{-1}) sodicity classes.

The rice yield losses were ranged from 39.43% to 100% in pre-reclamation period compared with normal land. The yield losses were reduced and ranged from 5.24% to 21.45% in post-reclamation period. Similarly, wheat yield losses were varied from 22.74% to 100% in pre-reclamation period. The losses were substantially reduced and ranged from 6.82% to 26.60% after reclamation.

Hence, uncultivated degraded land could be used for crop production by application of amendments. The higher crop productivity in post-reclamation period was due to better soil condition for crop production. Several studies have proved that the application of gypsum decreases Na toxicity and improves soil structures which contribute to crop productivity improvement to a greater extent (Chhabra, 1996; Rasouli *et al.,* 2013). Therefore, soil reclamation played a great role in augmenting rice and wheat yields in degraded sodic soils.

Gross and net returns

Rice (k*harif* season crop) and wheat (*rabi* season crop) production costs and returns were estimated for each sodicity class (Table 6). The gross income of rice and wheat decreased with increase in soil quality deterioration. Net income decreased more sharply compared to gross income with increase in sodicity level, because the total cost of production remained almost uniform throughout the soil sodicity classes.

The net income from 'slight' land class was lower (Rs 6769 ha^{-1}) compared to net income (Rs 35575

Table 6. Costs and returns (Rs ha^{-1}) per season

Sodicity class	Gross return		Total cost		Net returns		Total net returns
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	
Pre-reclamation period							
Normal	77290	58320	41715	34614	35575	23706	59281
Slight	47120	45032	40351	31707	6769	13324	20094
Moderate	19470	-	37597	-	-18127	-	-18127
Post-reclamation period							
Normal	79278	59740	44442	34396	34836	25344	60180
Slight	75143	55548	44366	33732	30777	21815	52592
Moderate	68958	50670	44214	33088	24743	17582	42325
Severe	62275	43558	42964	31342	19311	12216	31527

Note: 'Moderate' sodicity category lands were kept fallow only in *rabi* season. 'Severe' sodicity category lands were kept fallow in both the seasons.

ha^{-1}) from 'normal' land during *kharif* season, depicting a loss of 80.97 per cent. The farmers incurred income loss (Rs 18127 ha^{-1}) in 'moderate' soil sodicity class. In *rabi* season, decline in the net income was 43.79 per cent in 'slight' soil sodicity class and the 'moderate' sodicity affected lands were kept fallow. The rate of income loss increased with higher levels of sodicity. Hence, it was clear that the soil sodicity adversely affected net income across soil sodicity classes and income losses were greater in higher sodicity levels.

The net return was Rs 20094 ha^{-1} in 'slight' soil sodicity category in pre-reclamation period and increased to Rs 52592 ha^{-1} in post-reclamation period, indicating a gain of 161.73%. Farmers incurred a loss in 'moderate' soil sodicity category during pre-reclamation period and income has steeply increased to Rs 42325 ha^{-1} after reclamation. The increased productivity contributed to higher net income across the soil sodicity categories. In the 'severe' soil sodicity category, net income was Rs 31527 ha^{-1} which was left fallow in pre-reclamation period. It indicated that income could be generated by reclamation of severely degraded barren land. Hence, land reclamation benefited farmers in terms of reduction in income losses and enhanced farm income.

Estimation of farm income losses

Farm income losses data are essential for management of degraded lands and planning agricultural policy. Such losses can influence livelihood and food security of resource poor farmers. The farm income losses were estimated by subtracting net income per ha in each soil sodicity class from net income of 'normal' soil class for each crop. The potential farm income losses per ha has been calculated by multiplying estimated farm income loss values with corresponding proportional areas of sodicity classes in accordance with Table 2.

The actual farm income losses per ha in *kharif* and *rabi* has been estimated by multiplying potential farm income losses with the corresponding cropping intensities. The average cropping intensities in *kharif* and *rabi* were 73.98 and 48.95 per cent, respectively, accordance with the cropping intensity data of Table 4. To estimate the actual income loss per ha in pre-reclamation period, the potential income losses figures for *kharif* and *rabi* were multiplied by the factors 0.7398 and 0.4895, respectively. In post-reclamation period, factors were 0.9977 both for *kharif* and *rabi* seasons.

The total potential and actual farm income losses per agricultural year per ha has been estimated by summing up *kharif* and *rabi* seasons income loss values (Table 7). The annual potential and actual losses per ha due to sodicity were Rs 24629 and Rs 15988, respectively. The potential annual farm income loss in Santaraha village was Rs 1182800 due to soil sodicity.

The scenario has changed after reclamation. The per hectare potential income loss was reduced by 61.58% and per hectare actual income loss was reduced by 40.95%. This indicates that at the village level, community income loss was reduced due to reduction in the barren land and improved crop productivity.

Table 7. Potential and actual income (Rs ha^{-1}) in pre and post reclamation periods

Year	*Kharif*		*Rabi*		Agricultural	
	Potential income loss	Actual income loss	Potential income loss	Actual income loss	Potential income loss	Actual income loss
Pre-reclamation period						
2009-10	15851	11805	8763	4327	24614	16132
2010-11	15879	11707	8884	4330	24763	16037
2011-12	15408	11360	9102	4436	24509	15796
Average	15712	11624	8916	4364	24629	15988
Post-reclamation period						
2012-13	5248	5236	4435	4425	9683	9661
2013-14	5095	5083	4147	4137	9242	9221
Average	5172	5160	4291	4281	9463	9441

Conclusion

Land reclamation made a remarkable impact on crop productivity and farm income. The crop yield gap and income loss were substantially reduced after reclamation due to reduction in the sodicity level and land became suitable for crop production. Several efforts have been made by the Central and State governments to check soil degradation and increase agricultural productivity through land reclamation programmes in salt-affected regions of India. Still, a large part of agricultural land is being abandoned in India due to severe sodicity related problems and need to be reclaimed on priority basis to improve land productivity and farm income of resource poor farmers.

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