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Saline soil reclamation through subsurface drainage in Karnataka - An economic impact analysis

R. RAJU[1], K. THIMMAPPA[1], A. L. PATHAN[1] AND SIDDAYYA[2]

[1]ICAR-Central Soil Salinity Research Institute, Karnal-132001, Haryana
[2]National Institute of Rural Development and Panchayati Raj, Hyderabad - 500 030
E-mail: R.Raju@icar.gov.in

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Abstract: Soil salinity is a major problem in canal command areas which affects the fertility of the land. The village Ugar Budruk in Athani taluk of Belgaum district in Karnataka faced a major challenge of soil salinity and waterlogging since 25-30 years. Approximately 70 per cent of cultivable area of the village was affected by soil salinity and the land which was highly productive once, was partially cultivated or left barren for many years. With the effort of progressive farmers of the village about 925 ha saline land has been reclaimed through installation of subsurface drainage technology. The per hectare cost of land reclamation was estimated to ₹ 52000. The post reclamation study implied that about 77 per cent of the land was non-saline. The mean soil salinity was reduced from 6.6 to 2.52 dS/m during post-SSD showing 163 per cent reduction in soil salinity. The improved land productivity contributed to a significant increase in crop yield lead to increase in farmers income to a maximum extent. The pre-SSD benefit-cost ratio of 0.56 and 0.51 were increased to 1.24 and 1.19 during post-SSD, respectively for planted and ratoon sugarcane production. The increase in benefit-cost ratio for planted and ratoon sugarcane production were about 120 and 134 per cent respectively. Though the installation of saline soil reclamation technology requires high cost, the effectiveness of the technology made the Karnataka farmers to install the technology on their own cost.

Key words: Impact, Karnataka, Saline soil, Subsurface drainage

Introduction

Indian agriculture is affected by several factors that causes land degradation. Soil salinity is one of the major factor which adversely affects the productivity of agricultural land. In India saline soils were spread in 2.95 mha area. Out of which Karnataka has 1893 ha which accounts to 0.06 per cent of the country's saline soils (Sharma *et al.,* 2015). No crop can be grown on severely salt affected soils without proper treatment (Tripathi, 2011). Reclamation of these soils were not only important from the farmers point of view but also essential to increase the foodgrains production at the national level to feed the rapid growing population of the country. Most of the studies by Joshi *et al.* (1987), Datta and Joshi (1993), Datta *et al.* (2004), Mathew (2004) and Shekhawat (2007) indicated that the subsurface drainage (SSD) technology for saline land reclamation is technically viable, economically feasible and socially acceptable by all the categories of farmers (Chinnappa and Nagaraj, 2007 and Tripathi, 2011). Subsurface drainage removes excess salts and water from the root zone through leaching to create favourable conditions for crop production (Gajja *et al.,* 2002). With the effort of progressive farmers of Karnataka about 925 ha saline land has been reclaimed through installation of subsurface drainage. The current study has made an attempt to analyse an impact due to the technological intervention on improvement in soil and water quality, crop productivity and hence increase in farmers income in Karnataka.

Material and methods

The current study was based on the primary data obtained during 2014-15 from beneficiaries of subsurface drainage areas of village Ugar Budruk located in Athani Taluk of Belgaum District in Karnataka. The project area farmers reported that approximately 70 per cent of the cultivable area was affected by soil salinity and water-logging since 25 to 30 years. To reclaim these affected lands, subsurface drainage system was installed during 2009-10 to 2011-12. The total area under drainage covers 925 ha and about 644 farm families were getting the benefits of land reclamation. The total cost of the project was Rs. 499.51 lakhs. The cost components were mainly divided into project cost and overhead cost which accounts to 98 per cent and 2 per cent, respectively (Table 1). The major share of 77 per cent cost was absorbed by drainage installation process, *i.e.,* laying of corrugated pipes and cost of the materials and their fittings. The respective shares of these items were 39 per cent and 38 per cent. The cost of envelop material and their fitting accounts to 16 per cent of the total cost of the project. The overhead cost includes cost required to create awareness among the stakeholders as well as the key officials who were directly involved in project implementation.

The total cost of the project was shared by the Department of Land Resources, Government of India (60%), Department of Watershed Development, Government of Karnataka (20%) and the contribution made by the beneficiary farmers (20%). The approximate per hectare cost of saline land reclamation through installation of subsurface drainage was estimated to ₹ 52,000 and the life of the project was considered as 50 years.

The study includes both primary and secondary data collected from different sources. The primary data were collected from 120 sample farmers of subsurface drainage project area. By using pre-designed interview schedule, primary data was collected from the stakeholders through personal interview method. The data collected from respondents pertains to their socio-economic status, farm inputs requirement and the yield of the major crops. The costs of all inputs and output

Table 1. Cost contribution of subsurface drainage installed in Ugar Budruk

Sl. No.	Particulars	Total cost (₹ in Lakhs)	Per cent to total
A	Project cost		
1	Project preparation, survey & designing	11.10	2.22
2	Laying of corrugated pipes	195.80	39.20
3	Construction of pucca structure	11.88	2.38
4	Cost of PVC pipes and fittings	191.00	38.24
5	Cost of envelop material and their fixing	81.10	16.24
	Sub Total (A)	490.88	98.27
B	Overhead cost		
1	Training to farmers and Dept. officials	5.63	1.13
2	Meteorological station	3.00	0.60
	Sub Total (B)	8.63	1.73
	Grand Total (A+B)	499.51	100.00
	Cost contribution		
1	Department of Land Resources, Government of India	303.15	60
2	Department of watershed development, Government of Karnataka	98.18	20
3	Beneficiary farmers	98.18	20
	Total	499.51	100
	Installation cost of Subsurface drainage (₹/ha)	52000	
	Project Life (years)	50	
	Total Area reclaimed (ha)	925	
	Total farmers beneficiaries (No.)	644	

parameters pertaining to crop production were based on average values of the sampled farms. The cost concepts, *viz.* cost A_1, A_2, B_1, B_2, C_1 and C_2, were adapted to explain the economics of crop enterprises. Cost A_1 included all the direct expenses incurred on crop production in cash and kind, where as cost A_2 includes cost A_1 plus rent paid for the leased-in land. Cost B_1 included cost A_2 plus interest on the value of the fixed assets (excluding land). Cost B_2 covered cost B_1 plus rental value of the owned land (minus revenue). Cost C_1 included cost B_1 plus imputed value of family labour. The costs of hired and family labour were estimated on the basis of average market rates prevalent for hiring labour in the locality where as cost on machinery was charged as per the existing hiring rates for various agricultural operations. Interest on working capital charged at the rate of 8 per ecnt per annum where as cost of fixed capital was charged at the rate of 10 per cent of the total fixed assets, excluding the value of land. The methods of cost estimation used in the study was in line with Tripathi *et al.* (2005), Anon; (2008), Tripathi *et al*. (2013) and Raju *et al.* (2015). The costs and returns were estimated by considering the actual quantity of input used by the farmers and quantity of output harvested by them during respective years were multiplied with the prices of input and output prevailing during 2014-15.

The study was supported by secondary data wherever necessary. To study the economic impact due to technological intervention in the project area, benefit-cost ratio was estimated to obtain returns from the investment on subsurface drainage technology. The average values of input and output were compared with the situation of pre-SSD (2008-09) and post-SSD (average value of 3 years data of 2012-13 to 2014-15) installation. To study the status of soil salinity in the project area, soil samples were collected and analyzed and its salinity (dS/m) and pH were recorded.

Results and discussion

Impact on soil salinity

Based on soil sample analysis results were classified into different categories as presented in Table 2. The study reveals that about 77 per cent of the farms of the drainage area showed non-saline with mean salinity of 1.09 dS/m. About 17 per cent and 7 per cent area showed slightly saline and moderately saline respectively, with a salinity of 5.04 and 12.04 dS/m in that order. The study did not show presence of strongly saline soils in the drainage area. The mean soil salinity was reduced from 6.6 dS/m in pre-SSD to 2.52 dS/m during post-SSD showing 163 per cent reduction in soil salinity during post-SSD. The previous studies showed that it takes 3 to 4 years to enhance land productivity through subsurface drainage. The improvement in soil salinity indicate that subsurface drainage system is a viable management option for saline soil reclamation (Datta *et al.,* 2004).

Economics of sugarcane cultivation

The cost of sugarcane production was estimated and presented in Table 3. The study reveals that the cost of seed material remains same during pre and post-SSD depicting the same quantity of seed materials were used in both the periods. The cost of fertilizer use was more during post-SSD indicating the better growth of crops due to reclamation process and hence more quantity of fertilizes were applied due to which about 24.44 per cent and 40 per cent increase in fertilizer cost during post-SSD for planted and ratoon crops. There was no changes

Table 2. Soil salinity (dS/m) and pH of selected samples in the project area

Soil salinity class	ECe range(dS/m)	Samples Number	Mean Per cent	ECe (dS/m)	pH
Non saline	<4.0	23	76.67	1.09	8.48
Slightly saline	4.0-8.0	5	16.67	5.04	8.28
Moderately saline	8.1-16.0	2	6.67	12.04	8.01
Severely saline	>16.0	-	-	-	-
Total		30	100.00	2.52	8.41

Mean soil salinity during pre-SSD was 6.6 dS/m.

Source: Mandal *et al.* (2011)

Table 3. Cost of sugarcane cultivation during Pre and Post-SSD in the sample farms Rs./ha

Particulars	Pre-SSD		Post-SSD		Per cent change	
	Planted	Ratoon	Planted	Ratoon	Planted	Ratoon
Seeds	18525	0	18525	0	0.00	0.00
Application of FYM	11115	7410	13832	10374	24.44	40.00
Fertilizers	22971	24453	25194	28652	9.68	17.17
Chemical use	3458	3458	3458	3458	0.00	0.00
Human Labour	27664	20550	30035	23317	8.57	13.46
Bullock Labour	8892	8892	8892	8892	0.00	0.00
Machine Labour	15438	3211	17167	3211	11.20	0.00
Irrigation charges	16179	16179	16179	16179	0.00	0.00
Land revenue, cesses and other taxes	618	618	618	618	0.00	0.00
Depreciation, repair & maintenance charges	1328	531	1550	679	16.74	27.91
Miscellaneous charges	1482	988	2470	1976	66.67	100.00
Interest on working capital	5054	3430	5455	3867	7.94	12.73
COST A_1	132722	89720	143373	101222	8.03	12.82
Rent paid for leased-in land	0	0	0	0	0	0
COST A_2	132722	89720	143373	101222	8.03	12.82
Interest on value of owned capital assets	5928	5928	7904	7904	33.33	33.33
COST B_1	138650	95648	151277	109126	9.11	14.09
Rental value of owned land	18476	11411	52166	35864	182.35	214.29
COST B_2	157125	107059	203444	144990	29.48	35.43
Imputed value of family labour	6916	5138	7509	5829	8.57	13.46
COST C_1	145566	100785	158786	114955	9.08	14.06
COST C_2	164041	112197	210953	150820	28.60	34.42

in chemical use during pre and post-SSD. The cost of human labour was increased during post-SSD due to better crop performance requires more labour towards maintenance including weed management, application of irrigation water, etc. The bullock labour cost was same during both the periods as the same number of operations were carried out. Irrigation charges remains same in both the periods because the irrigation schemes were operated by Water Users Association, each farmer will get water on rotation basis and the charges were fixed on per acre and per season basis. There was no changes in the land revenue and other charges as it is fixed by the Government from time to time. Every farm requires repair and maintenance charges and depreciation of fixed assets and hence the charges towards the same were increased by 16.74 and 27.91 per cent respectively, for planted and ratoon crop production. In total, the production cost (cost A_1) was increased by 8 per cent and 12.82 per cent respectively, for planted and ratoon sugarcane production during post-SSD. Cost A_2 remains same as Cost A_1 because there is no leased-in land business in the drainage area. The value of cost B_1 has showed little increase compare to cost A_1. This was mainly due to addition of interest on value of owned capital assets. The increase in cost B_2 was due to increase in the rental value of owned land.

The study reveals a significant increase in cost B_2 which was mainly due to increase in rental value of land during post-SSD. In pre-SSD period the land was affected by salinity and was not suitable for crop production. Hence, some lands were cultivated partially and much of the area was left barren. In post-SSD due to installation of subsurface drainage the land productivity has been increased and hence fetching higher rental value. However, in the project area there is no rental system (leased-in or leased-out) of land but due to shortage of labour and other reasons, the crop can be cultivated on sharing basis. The crop-sharing is based on the land quality in terms of its productivity. The crop-sharing may be one-fifth, one-fourth, one-third and so on based on the land quality, *i.e.,* highly fertile, good quality land, medium quality land, etc. The crop-sharing increases with the decrease of land quality. In the current study, the rental value of the land was estimated on one-fifth crop-sharing basis and hence, during post-SSD the cost B_2 was increased by 29.48 and 35.43 per cent respectively for planted and ratoon sugarcane crop. In the current study, cost C_2 was used to estimate the total cost of cultivation. During pre-SSD cost C_2 remains at ₹ 1,64,041 and ₹ 1,12,197 for planted and ratoon crops and during post-SSD it was stood at ₹ 2,10,953 and ₹ 1,50,820 respectively. The overall increase in cost was 28.60 and 34.42 per cent respectively, for planted and ratoon sugarcane cultivation. The major contribution in increase in post-SSD cost was the rental value of the land.

Impact on yield and income

The significant increase in yield and net income from sugarcane cultivation was observed in the study area during post-SSD (Table 4). The yield of planted sugarcane crop during pre and post-SSD installation was 42 t/ha and 119 t/ha respectively and yield of ratoon sugarcane crop was 26 t/ha and 82 t/ha respectively, during pre and post-SSD installation. The per cent increase in yield due to reclamation was 182.35 and 214.3 respectively, for planted and ratoon sugarcane crops.

The per hectare net income obtained over different cost were ₹ -40,344 to ₹ -71,663 for planted crop and ₹ -32,663 to ₹ - 55,140 for ratoon crop during pre-SSD which were increased

Table 4. Economics of sugarcane cultivation during pre and post-SSD on the sample farms

Particulars	Pre-SSD		Post-SSD		Per cent change	
	Planted	Ratoon	Planted	Ratoon	Planted	Ratoon
Yield (t/ha)	42	26	119	82	182.35	214.29
Gross income (₹ /ha)	92378	57057	260832	179322	182.35	214.29
Net income (₹ /ha) over						
Cost A_1	-40344	-32663	117459	78100	391.14	339.11
Cost A_2	-40344	-32663	117459	78100	391.14	339.11
Cost B_1	-46272	-38591	109555	70196	336.76	281.90
Cost B_2	-64747	-50002	57388	34332	188.63	168.66
Cost C_1	-53188	-43728	102046	64367	291.86	247.20
Cost C_2	-71663	-55140	49879	28502	169.60	151.69
Benefit-cost ratio over						
Cost A_1	0.70	0.64	1.82	1.77	161.38	178.57
Cost A_2	0.70	0.64	1.82	1.77	161.38	178.57
Cost B_1	0.67	0.60	1.72	1.64	158.78	175.47
Cost B_2	0.59	0.53	1.28	1.24	118.07	132.06
Cost C_1	0.63	0.57	1.64	1.56	158.84	175.55
Cost C_2	0.56	0.51	1.24	1.19	119.56	133.80
Cost of sugarcane production (Rs/t) over						
Cost A_1	3161	3459	1209	1242	-61.74	-64.10
Cost A_2	3161	3459	1209	1242	-61.74	-64.10
Cost B_1	3302	3688	1276	1339	-61.36	-63.70
Cost B_2	3742	4128	1716	1779	-54.14	-56.91
Cost C_1	3467	3886	1339	1410	-61.37	-63.71
Cost C_2	3907	4326	1779	1850	-54.46	-57.23

to ₹ 1,17,459 and ₹ 49,879 for planted sugarcane and ₹ 78,100 to ₹ 28,502 for ratoon crops during post-SSD installation. The increase in net income was largely related to the increase in crop yield due to improvement in land productivity with the intervention of subsurface drainage technology. The benefit-cost ratio was increased from 0.7 to 1.82 for planted crop and 0.64 to 1.77 for ratoon crop over cost A_1. Similarly, benefit-cost ratio over cost C_2 were increased from 0.56 to 1.24 for planted sugarcane and 0.51 to 1.19 for ratoon sugarcane production. The per tonne cost of sugarcane production was reduced to significant extent from ₹ 3161 to ₹ 1209 for planted and ₹ 3459 to ₹ 1242 for ratoon sugarcane production during post-SSD. Similarly, the cost of production over cost C_2 were reduced from ₹ 3907 to ₹ 1779 and ₹ 4326 to ₹ 1850 respectively, for planted and ratoon sugarcane production in the drainage area. The overall reduction in per tonne cost of sugarcane production was about 54 to 61 per cent for planted and 56 to 64 per cent for ratoon crops. This reduction was mainly attributed to increase in yield due to technological intervention made for saline soil reclamation in the drainage area. The increase in yield due to land reclamation lead to reduction in the cost of production. It indicates the worthiness of the subsurface drainage technology for reclaiming water-logged saline soil in the study area (Datta *et al.,* 2004).

Summary and conclusions

The saline soil reclamation study revealed that due to the intervention of subsurface drainage technology the land productivity has increased significantly. About 77 per cent land was non-saline. Overall 163 per cent reduction in soil salinity was observed during post-SSD. The mean yield of sugarcane has been increased by 200 per cent. The farmers obtained per hectare net income of ₹ 49,879 and ₹ 28,502 respectively, from planted and ratoon sugarcane production compared to a loss of ₹ 71,663 and ₹ 55,140 in that order in pre-SSD. The benefit-cost ratio of 1.24 and 1.19 was recorded for planted and ratoon sugarcane crop compared to less than one during pre-SSD. The per tonne cost of sugarcane production in post-SSD was reduced to ₹ 1779 and ₹ 1850 from ₹ 3907 and ₹ 4326 during pre-SSD. The overall reduction in cost was 54 and 57 per cent respectively, for planted and ratoon sugarcane production. The higher benefit-cost ratios indicate the economic viability of drainage technology. The land value has been increased upto 500 per cent. The effectiveness of the subsurface drainage technology in saline soil reclamation attracted large number of farmers in Karnataka to install the technology on their own cost, though the cost of installation at the individual level is very high.

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