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Adoption of Subsurface Drainage Technology for Saline Soil Reclamation in Karnataka – An Economic Impact Analysis

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Abstract

The farmers of Ugar Budruk village in Athani Taluk of Belgaum district in Karnataka have been facing a major challenge of soil salinity and waterlogging for more than 25 years. About 70 per cent of cultivable area of the village is affected by soil salinity and hence it is being partially cultivated or left barren for many years. With the effort of progressive farmers of the village and financial support from the Government about 925 ha saline land has been reclaimed through installation of subsurface drainage and about 650 farmers have been benefited with the reclamation process. The land reclamation cost has been estimated to ₹ 52,000 per hectare. The post reclamation study implied that after drainage approximately 77 per cent of the land became non-saline showing significant reduction in soil salinity. About 376 ha waterlogged saline area has been brought under cultivation. During post- subsurface drainage period the entire cropping pattern has changed and sugarcane has occupied about 70 per cent of the cultivated area. The additional increase in cropping intensity was observed to be about 24 per cent. The improved land productivity contributed to a remarkable increase in crop yield due to which farmers income has been increased by about 195 per cent. The benefit-cost ratio of sugarcane production increased from 0.54 before drainage to 1.21 after drainage, indicating 126.32 per cent increase. Majority of the farmers highlighted that improvement in land quality and yield increase was the major reason for adoption of the technology. However, some farmers reported that lack of institutional support and lack of adequate finance with them followed by lack of technical know-how were the major reasons for non-adoption of the technology.

Key words: Karnataka, Saline soil, Waterlogged area, Subsurface drainage, Impact analysis

Introduction

India has about 6.73 million ha salt-affected soils, spread in 14 states and Andaman and Nicobar Islands. Out of which approximately 2.95 m ha area is under saline soils. Karnataka has 1,893 ha saline soils which accounts to 0.06 per cent of the country's total saline soils (NRSA, 1996). The estimates of CADA (2013), revealed that the extent of waterlogged and saline area in Karnataka is about 2.70 million ha. Irrigated agriculture is affected by several factors causing land degradation. Soil salinity, one of the major factors, adversely affects the productivity of irrigated agricultural land. No crop can be grown on severely salt-affected soils without proper drainage treatment (Tripathi, 2011). Reclamation of these soils is not only important from the farmers' point of view, but also essential to increase the foodgrain production at the national level to feed the growing population of the country. Most of the studies conducted by Joshi *et al.* (1987), Datta and Joshi (1993), Datta *et al.* (2004), Mathew (2004), Shekhawat (2007) and Raju *et al*. (2016) 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 Nagraj, 2007; 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 while getting the financial support from central as well as state government have reclaimed about 925 ha saline land through installation of SSD technology. The current study has made an attempt to analyze the impact due to the technological intervention on improvement in land productivity and increase in farmer's income in Karnataka.

Materials and Methods

Study area

The current study is based on the data obtained from subsurface drainage areas of Ugar Budruk village located in Athani Taluk of Belgaum District in Karnataka. The project area of Ugar Budruk village is located at 74°47′ E longitude and 16°40′ N latitude (Fig. 1). The soils are predominantly Vertisols (deep black soils) and Entisols (alluvial soils). The climate of the study area is semi-arid type with average annual rainfall of about 509 mm (GoK, 2016-17). The major sources of irrigation are open wells (29.50%), followed by lift irrigation (20.80%) and tubewells (18.23%).

Salient features of SSD project at Ugar Budruk in Karnataka

The farmers of the study area reported that approximately 70 per cent of the cultivable area was affected by soil salinity and waterlogging for 25 to 30 years. To reclaim these lands, subsurface drainage system was installed during 2009-10 to 2012-13. The drainage system was installed with natural outlet. In total there were 22 outlets with 3 closed drains and 35 chambers. The SSD was installed in 1 to 2 m depth with 30 m spacing of lateral pipes and the approximate project life is 50 years (Table 1). The total area under drainage covers 925 ha and about 650 farm families were getting the benefits of land reclamation.

The total cost of the project was ₹ 49.95 million, which 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 cost per hectare of saline land reclamation through installation of subsurface drainage has been estimated at ₹ 52,000 (Table 2).

Data source

Both primary and secondary data were utilized for the study. The primary data were collected from 120 sample farmers of subsurface drainage project area through personal interview by using pre-designed interview schedule. The data collected from respondents pertains to their socio-economic status, farm inputs requirement, yield of the major crops and constraints faced by the farmers in adoption and non-adoption of SSD technology. The study was supported by secondary data wherever necessary.

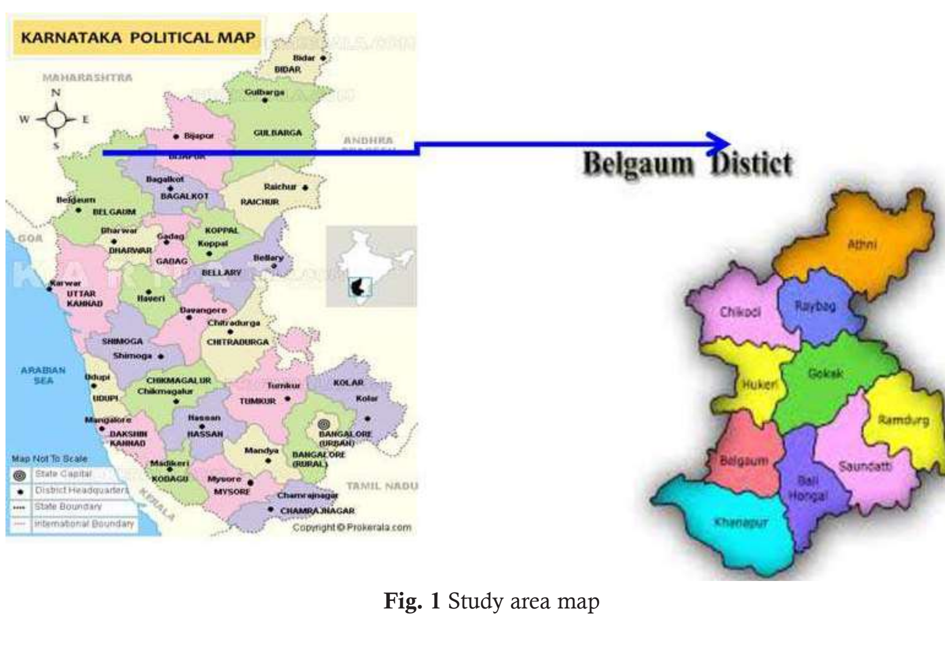

Fig. 1 Study area map

Table 1. Salient features of subsurface drainage installed in Ugar Budruk village

Parameters	Description
Area under subsurface drainage (ha)	925
Total farmers (beneficiaries) covered (No.)	650
Type of drainage system	Pipe drainage with natural outlet
Type of pipes	Perforated PVC pipes
Total No. of outlets/Blocks (closed drains)	22 (3)
Total chambers (No.)	35
Years of installation	2009-10 to 2012-13
Project life (in years)	50
Pipe size (mm)-diameter	Lateral: 80 mm, Collector: 80-250/315 mm
Depth (m) of SSD	Lateral: 1 to 2 m, Collector: 2 m (average 1.2 m)
Spacing (m)	30

Table 2. Cost contribution of subsurface drainage installed in village Ugar Budruk

Sl. No.	Particulars	Total cost (₹ in millions)	Per cent to Total
A.	Total Project cost		
1	Deptt. of Land Resources (Govt. of India), MoRD	30.315	60
2	Deptt. of Watershed Development (Govt. of Karnataka)	9.818	20
3	Beneficiary farmers	9.818	20
	Total	49.951	100
B.	Approximate cost of SSD installation (₹ ha^{-1})	52,000*	

*The approved SSD (sub-surface drainage) cost is excluding overhead cost from the total cost (overhead cost on HRD components including training to farmers and resource persons, contingency, etc.)

Cost and returns estimation

The costs of all inputs and output 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 estimated for the study. Cost A_1 included all the direct expenses incurred on crop production in cash and kind, where as cost A_2 included 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 cent 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), CSO (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 input and output prices prevailing during 2015-16.

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 before (2008-09) and after drainage installation (2015-16).

Garrett ranking technique

The Garrett ranking technique was used to analyze the opinion of the farmers regarding the adoption of subsurface drainage technology. The study was also focused on identifying the reasons for not adopting the subsurface drainage technology by other farmers (Sita Devi and Ponnarasi, 2009). The per cent position of each rank was found out by using the formula indicated below:

$$\text{Per cent position} = \frac{100\,(R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} = Rank given by i^{th} factor by the j^{th} individual

N_j = Number of factors ranked by the j^{th} individual

Results and Discussion

Impact on cropping pattern and cropping intensity

The study revealed that sugarcane was the major crop grown in the study area during pre- and post-SSD period followed by oilseeds and cereals. Horticulture, vegetables and pulses crops occupied smaller area (Table 3). The area under sugarcane increased from 30.95 per cent in pre-SSD to 69.55 per cent in post-SSD indicating about 124.72 per cent increase. Oilseeds and cereals occupied major portion of the cultivable area during pre-SSD period, as the land was not suitable for sugarcane production due to waterlogging and soil salinity. After reclamation, the crop scenario in the project area was significantly changed and about 376 ha additional area was brought under sugarcane production.

The improved condition of the land allowed farmers to grow sugarcane as a cash crop and hence the maximum area under sugarcane lead to decrease in area under other crops. The area under pulses, cereals, oilseeds and horticulture crops was reduced by 100.00, 94.12, 63.62 and 62.55 per cent, respectively. The area under vegetables has showed an increase of 4.81 ha in post-SSD installation. Though this increase is phenomenal, the suitability of land after reclamation and increase in prices of vegetables influenced the project area farmers to grow vegetables in their fields. Overall, during post-SSD, the uncultivated area has been reduced by 40 per cent and it was observed that the reclamation process brought an additional 376 ha area under cultivation. This indicates that after installation of subsurface drainage in the project area land use was intensified, cropping pattern changed in favour of more remunerative crops and crop yields increased (Datta *et al.*, 2000; Raju *et al.,* 2015).

The cropping intensity of the drained area has been increased significantly during post-SSD installation (Table 3). Cropping intensity was increased from 62.64 per cent to 77.62 per cent during post-SSD period. Overall, about 23.91 per cent increase in cropping intensity was observed after the installation of subsurface drainage in the region. The increase in cropping intensity shows a positive impact of drainage technology on reclamation of saline soils.

Economics of sugarcane cultivation

The study reported that the cost of some of the inputs remains same during before and after the installation of subsurface drainage viz., seed materials, chemical use, bullock labour, irrigation

Table 3. Cropping pattern and cropping intensity of study area in pre- and post-SSD installation

Crops	Pre-SSD		Post-SSD		Per cent change	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Sugarcane	776.83	30.95	1745.87	69.55	969.04	124.74
Cereals	228.02	9.08	13.41	0.53	-214.61	-94.12
Pulses	46.00	1.83	0.00	0.00	-46.00	-100.00
Vegetables	12.72	0.51	17.53	0.70	4.81	37.81
Oil seeds	427.64	17.04	155.57	6.20	-272.07	-63.62
Horticulture	42.51	1.69	15.92	0.63	-26.59	-62.55
Uncultivated land	937.73	37.36	561.81	22.38	-375.92	-40.09
Total cultivable land	2510.00	100.00	2510.00	100.00	-	-
Cropping intensity		62.64		77.62		23.91

SSD stands for sub-surface drainage

charges and land revenue and other charges. The cost of seed material and chemical use indicated that the same quantities of inputs were used for sugarcane cultivation in both the periods. Similarly, the bullock labour cost remains same during both the periods as the same number of operations were carried out. Irrigation charges remained same in both the periods because the irrigation schemes were operated by water users association, each farmers got water on rotation basis and the charges were fixed on per acre and per crop (season) basis. There was no change in the land revenue and other charges as it is fixed by the Government on timely basis.

The cost of fertilizer use was 13.54 per cent more after drainage (Table 4) indicating better growth of crops due to reclamation process demands for more quantity of fertilizes and hence cost increased. The cost of human labour was increased after drainage installation due to better crop performance requires more labour towards maintenance for weed management, application of irrigation water, etc. The depreciation of fixed assets and repair and maintenance charges were increased by 19.93 per cent after drainage.

The cost estimation of sugarcane cultivation (Table 4) revealed that the cost A_1 was increased by 9.96 per cent after drainage. Cost A_2 remained same as Cost A_1 because there was no leased-in land business in the drainage area. The value of cost B_1 showed little increase compared to cost A_1. This was mainly due to the addition of interest on value of owned capital assets. The study revealed significant increase in cost B_2 which was mainly due to increase in rental value of land after drainage. The rental value of the land was estimated on one-fifth crop-sharing basis and hence, after drainage, the cost B_2 was increased by 31.89 per cent. In the current study, cost C_2 was used to estimate the total cost of cultivation. The cost C_2 remained at ₹ 1,38,119 and ₹ 1,80,886 during before and after drainage, showing an overall increase of 30.96 per cent. The major contribution in increase in cost after drainage was the rental value of the land.

Impact on yield and income

After the installation of subsurface drainage, a significant increase in yield and net income from sugarcane cultivation was observed in the study

Table 4. Cost (₹) of sugarcane cultivation during before and after SSD in the sample farms

Particulars	Before drainage	After drainage	Per cent change
Seeds	9263	9263	0.00
Application of FYM	9263	12103	30.67
Fertilizers	23712	26923	13.54
Chemical use	3458	3458	0.00
Human labour	24107	26676	10.66
Bullock labour	8892	8892	0.00
Machine labour	9324	10189	9.27
Irrigation charges	16179	16179	0.00
Land revenue, cesses and other taxes	618	618	0.00
Depreciation, repair and maintenance charges	929	1115	19.93
Miscellaneous charges	1235	2223	80.00
Interest on working capital	4242	4661	9.88
COST A_1	111221	122298	9.96
Rent paid for leased-in land	0	0	0
COST A_2	111221	122298	9.96
Interest on value of owned capital assets	5928	7904	33.33
COST B_1	117149	130202	11.14
Rental value of owned land	14944	44015	194.55
COST B_2	132092	174217	31.89
Imputed value of family labour	6027	6669	10.66
COST C_1	123176	136871	11.12
COST C_2	138119	180886	30.96

Table 5. Economics of sugarcane cultivation before and after SSD on the sample farms

Particulars	Before drainage	Afterdrainage	Per cent increase (+) or decrease (-)
Yield (Mg ha^{-1})	34	100	194.55
Gross income (₹ ha^{-1})	74718	220077	194.55
Net income (₹ ha^{-1}) over			
Cost A_1	-36503	97779	367.86
Cost A_2	-36503	97779	367.86
Cost B_1	-42431	89875	311.81
Cost B_2	-57375	45860	179.93
Cost C_1	-48458	83206	271.71
Cost C_2	-63402	39191	161.81
Benefit-cost ratio over			
Cost A_1	0.67	1.80	169.59
Cost A_2	0.67	1.80	169.59
Cost B_1	0.63	1.68	166.67
Cost B_2	0.56	1.26	124.72
Cost C_1	0.60	1.60	166.72
Cost C_2	0.54	1.21	126.32
Cost of Sugarcane production (₹ Mg^{-1}) over			
Cost A_1	3310	1226	-62.98
Cost A_2	3310	1226	-62.98
Cost B_1	3495	1307	-62.59
Cost B_2	3935	1747	-55.59
Cost C_1	3676	1375	-62.60
Cost C_2	4116	1815	-55.91

area (Table 5). Before drainage the yield of sugarcane crop was 34 Mg ha^{-1} which was increased to 100 Mg ha^{-1} after drainage. Overall a remarkable 194.55 per cent increase in yield was observed in the project area.

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 0.67 (before drainage) to 1.80 (after drainage) over cost A_1. Similarly, benefit-cost ratio over cost C_2 was increased from 0.54 (before drainage) to 1.21 (after drainage). The per tonne cost of sugarcane production was reduced to significant extent from ₹ 3,310 (before drainage) to ₹ 1,226 (after drainage). Similarly, the cost of production over cost C_2 was reduced from ₹ 4,116 to ₹ 1,815 Mg^{-1} sugarcane production in the drainage area. The overall reduction in per mega gram cost of sugarcane production was about 62.98 per cent and 55.91 per cent over the cost A_1 and cost C_2, respectively. This reduction was mainly attributed to increase in yield due to technological intervention for saline soil reclamation in the project area. It indicates the worthiness of the subsurface drainage technology for reclaiming waterlogged saline soil in the study area (Datta *et al.,* 2004; Tripathi *et al*., 2011; Raju *et al*., 2015).

Returns over cost

The returns over cost were calculated for the sugarcane cultivation before and after the installation of subsurface drainage (Table 6). The study revealed that the per hectare gross returns

Table 6. Returns over cost before and after drainage in sugarcane cultivation

Particulars	Before SSD (₹ ha^{-1})	After SSD (₹ ha^{-1})	Per cent change
Gross returns	74718	220077	194.55
Farm business income	-42254	97779	331.41
Family labour income	-49170	89875	282.78
Net income	-55543	83206	249.81
Farm investment income	-48627	91110	287.37

from sugarcane production were higher by ₹ 2,20,077 after drainage as compared to before drainage of ₹ 74,718. The other methods viz., farm business income, family labour income, net income and farm investment income also showed higher income after drainage installation. This could be inferred that after drainage installation the efficiency of production was high, which can be attributed to higher yield obtained by installation of subsurface drainage in their farm.

Reasons for adoption and non-adoption of subsurface drainage systems

Reasons for adoption of subsurface drainage

The reasons for adoption of subsurface drainage technology as reported by the respondents were analysed by using Garrett ranking technique and results are presented in Table 7. The reasons for adoption in order of their ranking were: land improvement and yield and income increase, influenced by successful/neighbouring farmers, recommendation of agricultural scientist/ extension persons, by own experience and the lack of knowledge about other practices.

The study revealed that majority of the subsurface drainage farmers (89.62%) gave preference for adoption as it not only improves land quality but also increases yield and income followed by most of them were influenced by successful/neighbouring farmers (74.51%) who adopted SSD in their field. Majority of subsurface drainage farmers have contact with agricultural department and from the experts they obtained awareness and knowledge about reclamation and hence technology was adopted as recommended by agricultural scientist/extension person (63.24%). Some farmers indicated that they were well aware of subsurface drainage technology and hence adopted by their own interest (49.27%). Some of the farmers who adopted subsurface drainage were those who has no knowledge on other methods for saline soil reclamation (38.45%).

Reasons for non-adoption of subsurface drainage

The reasons for non-adoption of subsurface drainage as perceived by the farmers are presented in Table 7. Among the various reasons, lack of institutional support was the major reason followed by lack of adequate finance available with farmers. The other reasons for non-adoption were lack of knowledge on SSD, lack of technical expertise for management of the technology and lack of cooperation among neighboring farmers for installing the main line for removal of drain water.

The majority of farmers opined that lack of institutional support in providing finance or subsidy was the major constraint faced by them (90.25%) in adopting subsurface drainage technology. Lack of adequate finance for adoption of subsurface drainage (84.36%) was another major constraint faced by the farmers. It was clearly observed that majority of farmers were not aware of the technology package of subsurface

Table 7. Reasons for adoption and non-adoption of subsurface drainage system

Particulars	Garret's score	Rank
Reasons for adoption		
Land improvement and yield increase	89.62	I
Influenced by neighboring farmer	74.51	II
Recommendation of agril. scientist /extension person	63.24	III
By own interest	49.27	IV
Lack of knowledge about other practices	38.45	V
Reasons for non-adoption		
Lack of institutional support	90.25	I
Lack of adequate finance	84.36	II
Lack of knowledge	70.50	III
Lack of technical expertise	65.85	IV
Lack of cooperation among neighbouring farmers	47.19	V

drainage. Many farmers expressed their view that lack of knowledge (70.50%) was the main constraint in adoption of subsurface drainage system. Majority of the farmers desired to adopt the technology but technical knowhow was not available to them (65.85%). Technical support and supplies of requisite materials was another reason reported by farmers in non-adoption of subsurface drainage. Findings of the present study were similar as reported by Ajore and Singh (1997) on lack of technical know-how as one of the constraints in adoption of reclamation technology. Lack of cooperation among neighboring farmers (47.19%) was another reason reported by the farmers for non-adoption of SSD. This prevented many farmers from adopting the technology because the neighboring farmers do not cooperate for laying main drain pipeline in their fields, which is necessary to discharge the drain water. The drained water has to be passed through neighboring fields for which drain canal and a pipeline has to be laid.

Conclusions

The saline soil reclamation study revealed that the intervention of subsurface drainage technology has significantly increased the land productivity in the study area. About 77 per cent land reclaimed was non-saline, showed a significant reduction in soil salinity after the installation of subsurface drainage. The yield of sugarcane has been increased by 195 per cent. The net income of the farmers increased by 367.86 per cent over cost A_1 and 161.81 per cent over cost C_2. The benefit-cost ratio increased remarkably by 169.59 per cent over cost A_1 and 126.32 per cent over cost C_2. The per tonne cost of sugarcane production after drainage was reduced by 62.98 per cent and 55.91 per cent, respectively, over cost A_1 and cost C_2. The higher benefit-cost ratio indicates the economic viability of drainage technology.

The effectiveness of the subsurface drainage technology in saline soil reclamation attracted large number of farmers in Karnataka to install the technology with their own investment, though the cost of SSD installation at the individual level is very high. The study suggests that the Government support in financing for SSD installation in waterlogged and salinity affected areas not only boosts the adoption rate of the technology, but also helps in upliftment of the resource poor farmers who are affected by waterlogging and soil salinity.

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