Indian Farming 75 (11): 48-51; Novermber 2025

Subsurface drainage technology for restoring crop productivity in waterlogged saline soils

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Waterlogged saline soils are severely affecting crop production in irrigated areas of the country and appropriate technologies need to be adopted for their reclamation. Subsurface drainage (SSD) is proven technology for reclamation of such soils and about 1,10,000 ha area has been reclaimed in India using this technology. However, very high installation cost, non-availability of adequate trencher machines and need of region/soil specific design requirements has resulted in its adoption at very slow pace. The brief information of SSD technology covering its benefits, components, installation, and a few case studies of its performance in different parts of the country is presented in this article.

Keywords: Crop productivity, Food security, Sub-surface drainage technology, Waterlogged saline soils

LAND degradation poses significant threat for sustaining agricultural production in the country and climate change is further aggravating its impact on crop production. In the past, irrigation has played an important in Indian agriculture for safeguarding the nation's food security by ensuring availability of adequate irrigation water to high yielding varieties through extensive canal network. But at the same time, land drainage, an equally important aspect of integrated water resource management was simply ignored. This has resulted in severe problem of secondary soil salinization in canal command areas, mainly due to seepage from canals and over irrigation. The adoption of inefficient water management practices has also led to the waterlogging and soil salinity problems. Waterlogged saline soils occur on about 2 million hectares area in arid and semi-arid alluvial north western states of India and more than 1 million hectares each in coastal and black cotton soil (Vertisol) regions of the country. However, in India, area covered under subsurface drainage system is only about 80,000 ha; and the faster pace of adoption is required to achieve the land degradation neutrality goal by 2030. Subsurface drainage (SSD) is a successful technology for reclamation of waterlogged-saline soils and has given promising results across the soil types of the country. Apart from lowering water table to the desired level, it also removes excess soluble salts and thereby creates favourable condition for the crop growth.

Components of subsurface drainage system

However, proper design, installation and operation of drainage system is necessary to get desirable results. Further, sub surface drainage is science as well as art of removal of excess water, and thus, site-specific changes in lateral spacing should be adopted to improve the efficiency of the system and minimize cost of installation. Considering these factors, the wider adoption of this technology needs to be undertaken through advance design and installation methods, appropriate policy decisions, and financial support to the farmers.

Subsurface drainage consists of network of underground pipelines to remove excess water from agricultural fields. Depending upon the function, the pipes are classified as lateral, collector and main drains and different structures like manholes, sump and outlets are other parts of the system.

Table 1. Different components of modern-day SSD system

Component	Function	Specification
Lateral pipes	Primarily control the ground water table by intercepting water coming in root zone	Perforated single wall corrugated UPVC as per BIS 9271 80 mm most commonly used size 65 and 100 mm pipe sizes are also available
Collector pipes	Collects the water from individual lateral drains and convey it to the main drain/outlet	Double wall corrugated (DWC) HDPE pipes as per BIS 16098 Part 2: 2013 are generally preferred, size varies from 100 to 400 mm In severely waterlogged soils to avoid floating of the pipes, perforated UPVC pipes should be used, size varies from 100 to 355 mm
Pipe Main Drain	Used in large drainage projects where natural stream is far from outlet	DWC HDPE as per IS 16098 Part 2: 2013 Size can be up to 550 mm depending discharge and different dia. pipes may be used in project
Sump/ manholes	Manholes help in inspection and Sump collects water at outlet	Pre-fabricated RCC pipes are used Diameter of pipes are 0.9 and 1. 2 m Pipe lengths used are of 2.5, 3.75 and 5 m
Envelope	To trap entry of soil/foreign material in pipe to avoid its chocking and to improve hydraulic performance of drains	Non-woven poly propylene synthetic geotextiles (Thickness > 2.5 mm and O_{90}> 300 micron) for light and medium textured soils Non-woven poly propylene/ polyester fabric with needle punched geotextile for heavy textured soils Woven nylon 60 mesh socks for perforated collector pipes
Outlet	To safely dispose of highly saline effluents	Gravity outlets are used if deep surface drain is available nearby Otherwise, pumped outlets with suitable pump

Semi-mechanized installation

Fully-mechanized installation

Installation of sub surface drainage network

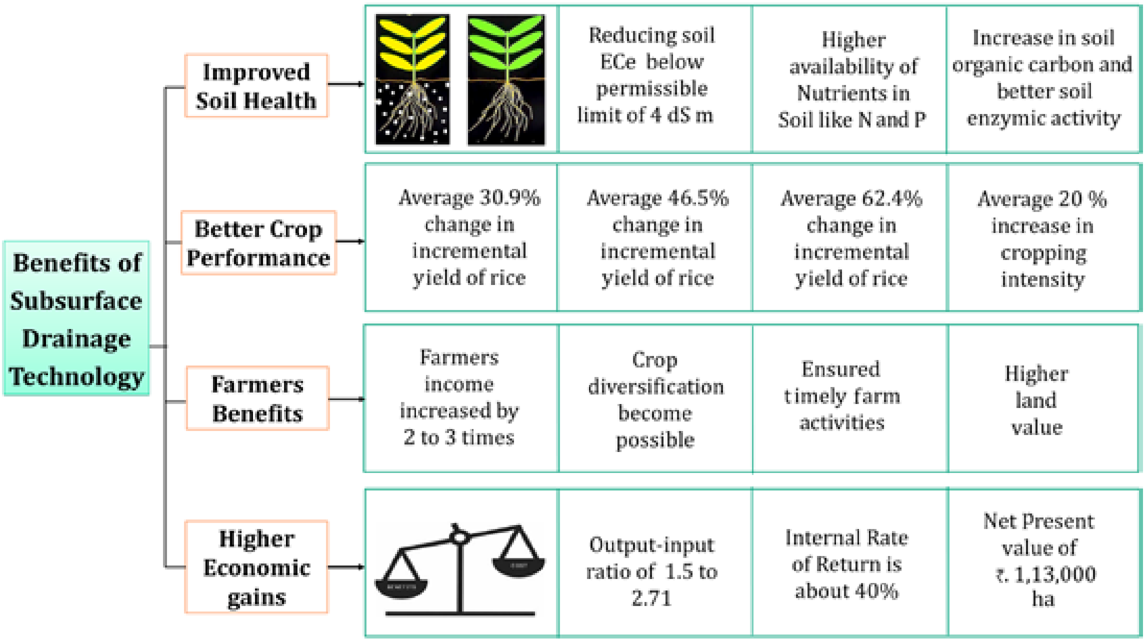
The installation of SSD system network consists of laying of perforated lateral and collector pipes, manhole and sump as per design. The installation work consists of excavation of trench, providing proper grade to the trench bottom, placement of drain pipes and backfilling of the trench. Depending upon the degree of involvement of machinery in these operations, installation procedure is classified as semi-mechanized and fully mechanized. In semi mechanized installation, trench of required dimensions is excavated using hydraulic excavator and subsequently desired grade is given manually. Backfilling is also done manually immediately after lowering the pipes. While in fully mechanized installation, grade control and pipe laying is carried out simultaneously by the drainage trencher machine which uses inbuilt laser guided grade control system. Subsequently trench is backfilled by bulldozer.

Design parameters of SSD for different regions: The drainage coefficient and drain spacing are the main design parameters of SSD system.

Table 2. Design parameters of SSD system

Drainage Coefficient (mm/d)			Drain Spacing (m)	
Climate	Range	Optimal	Soil Texture	Spacing
Arid	1–2	1	Light	100–150
Semi-Arid	1–3	2	Medium	50–100
Humid	2–5	3	Heavy	20–50

Benefits of SSD technology: The SSD system has multiple benefits in crop production such as improved soil health, enhanced crop yield, increase in farmers' income and higher economic gains.

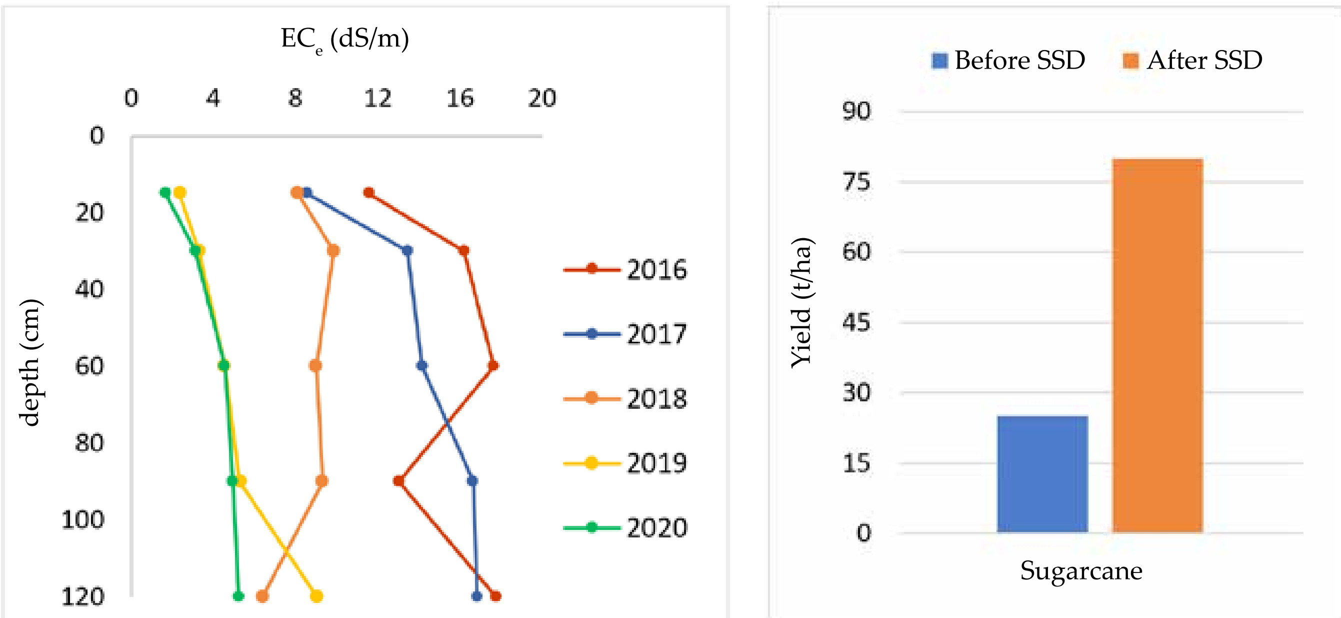


Case studies on SSD

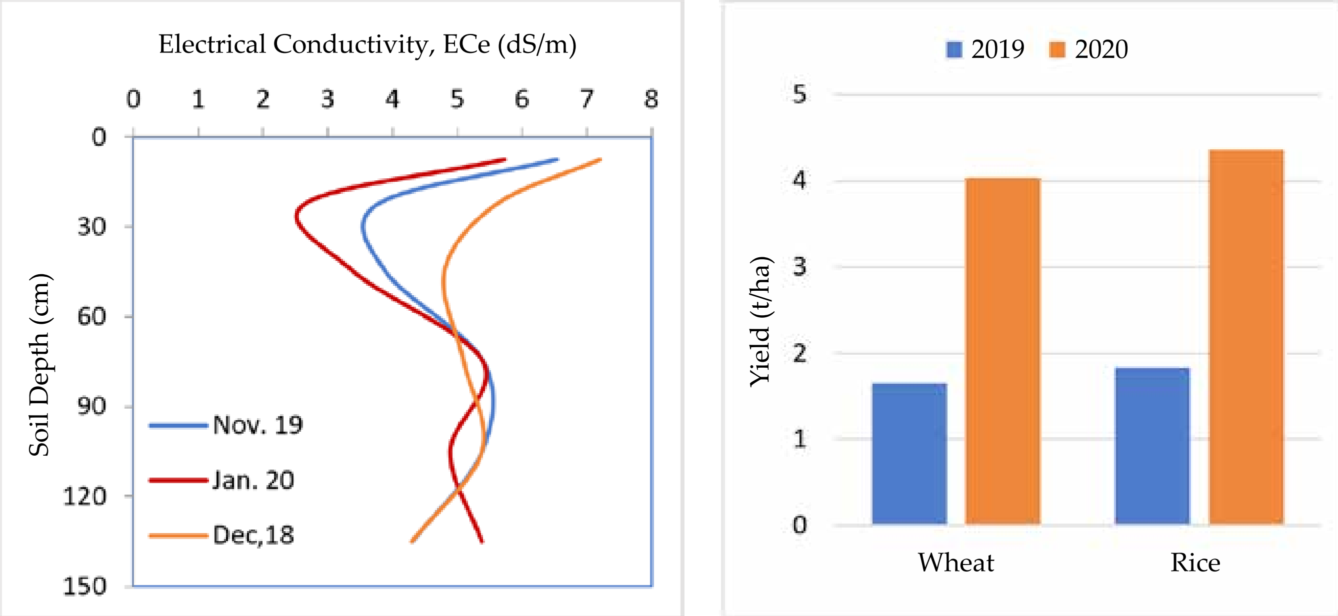
SSD in vertisols of Gujarat: Subsurface drainage system was installed in Adadara village of Bharuch district, having highly saline waterlogged black soil (ECe more than 10 dS/m in all soil layers) in order to reduce soil salinity and improve crop productivity. Prior to SSD installation, farmers of the village literally abandoned sugarcane cultivation due to highly unfavurable crop growth conditions and very low yield (~25 t/ha). SSD was installed in the month of February 2017 with a lateral spacing of 35 m and data pertaining to soil, water and crop was collected at regular intervals. Depth wise temporal variation in soil salinity is pictorially depicted, where in, drastic reduction in soil salinity (up to 86%) was observed.

The average electrical conductivity of soil (ECe) was less than 4 dS/m in surface layer (0—30 cm) whereas in subsurface layers (30–120 cm), it varied from 4 to 5.2 dS/m. This improvement in soil salinity was mainly attributed to timely efforts from the farmer to ensure proper drainage outflow from the sump. Forage crop was cultivated immediately after SSD installation and subsequently decrease in soil salinity by SSD system made sugarcane cultivation possible with significantly higher yield (80 t/ha) resulting into yield enhancement of more than 200%. Moreover, waterlogged conditions improved with water table going below 1 m. Overall, successful operation of SSD system for 4 years led to effective desalinization of the soil profile and hence improved soil quality, productivity and enhanced farm income.

SSD in alluvial soils of Haryana: The study was carried out at Kahni site of Rohtak district of Haryana (India) where subsurface drainage system was installed in 2016 in 160 ha land with 4 SSD drainage blocks. The depth of collector varied from 2.25–2.6 m and spacing of



Temporal variation in soil salinity and crop performance at Adadara SSD site



Reduction in soil salinity and enhanced crop productivity at Kahni SSD site

lateral pipe was 60 m. The collector pipe was connected with sump, installed in each SSD block near to surface drain. The excess water present in sub soil collected from the entire field through installed perforated pipe network to the sump and that was pumped in to the surface drain. Hence, salts were flushed out from the soil profile and created favourable environment for plant. The drainage effluent carried away from the agricultural field through surface drainage network.

A continuous change in salinity with time was recorded in whole soil profile which reveals an effective flushing of salts from the soil profile and disposal of drainage effluent away from the affected area. The soil salinity in sub soil (20–60 cm) reduced to normal (<4 dS/m) by the end of 3rd year of SSD installation. Interestingly, this area was waterlogged and operation of SSD ensured flushing of salt out of crop root zone by controlling groundwater level and facilitating leaching process. The reduced salt load in soil translated into improved performance of rice-wheat crops. An average yield of rice was recorded as 4.36 t/ha, and corresponding surface (0–15 cm) soil salinity ranged between 3.4 to 5.70 dS/m after successful operation of SSD system of 2 consecutive years. While, before installation of SSD, average rice yield was merely 1.83 t/ha, and thus yield enhancement of 138% was achieved. In wheat, average yield was found to be 1.65 and 4.03 t/ha, respectively for before and after the introduction of SSD, resulting into yield enhancement of 144%.

SUMMARY

Properly designed and maintained subsurface drainage system helps in removal of excess water and salts from the soil profile and subsequently enhances crop yield. The adoption of optimum drain spacing as per the soil hydraulic properties and adequate pumping in case of pumped outlet are the main factors governing the speed of reclamation of waterlogged saline soils. Moreover, availability of trencher machine and integration of laser guided grade control system in semi-mechanized installation is very much essential to increase the pace of installation of SSD system in India. Also adequate financial support should be provided to the farmers through government schemes or subsidies for early and wider application of this technology in severely affected areas.

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