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IMPACT ASSESSMENT OF DRAINAGE WATER MANAGEMENT IN SALT AFFECTED SOILS OF GODAVARI WESTERN DELTA ON A PILOT SCALE IN INDIA

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Abstract: A.P. Water Management Project, Andhra Pradesh was planned with implementing various improved irrigation, drainage water management practices and is executed using object oriented project planning technique under financial assistance from FAO. Drainage is an effective tool in combating the negative effects of salinity and water logging. Five years of operational pilot research were conducted in farmer's fields of Kalipatnam pilot area by installing a sub-surface drainage (SSD) system with a drainage coefficient of 1 mm·day^{-1} to control the increasing levels of soil salinity levels in Godavari Western Delta of India on a pilot scale. There has been significant decrease in the soil salinity in the range of 33% in the pilot area through leaching of salts to the tune of 59 t·ha^{-1} from the system during 2005 - 2009. Productivity levels were increased by 15 - 25% in kharif season and 25 - 40% in rabi season. An economic analysis showed that SSD system is cost effective and benefit cost ratio was worked out be 3.3 with a payback period of 2.18 years with internal rate of return of 27.19%. Potential impact has been found significantly in soil quality, crop performance, improvement in family income, land value and gender issues were also addressed.

Key words*: Sub surface drainage system, drainage effluent, drainage coefficient, salt load, internal rate of return, leaching, seawater intrusion*

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INTRODUCTION

The sustainability of irrigated agriculture is under threat due to widespread occurrence of water logging and soil salinity. Drainage can be viewed as the "price to pay" for the sustainability of irrigated agriculture if considered in a holistic approach in the framework of integrated in water management improvement strategies and as part of rural development at large. Drainage is an effective tool in combating the negative effects of salinity and water logging. Sub-surface drainage system is the only option to realize the full potential of crop production by creating artificial drainage to control the soil salinity and managing the water table below the root zone. Rapid irrigation development has resulted in a range of environmental problems. Many of these relate to salinity in soil and/or water resources, often associated with a lack of drainage facilities. It is estimated that nearly 8.4 million ha of irrigated area in India is affected by soil salinity and alkalinity, of which about 5.5 million ha is also waterlogged [5]. An area of 40036 Ha of Godavari Western Delta (GWD) in Andhra Pradesh is saline prone and water logged due to high intensity rainfall with deficiency of drainage capacity, unfavorable out-fall condition, obstructions in drainage stream and tidal actions [2]. In order to suggest suitable reclamation technology for combating twin problems of water logging and soil salinity, a Kalipatnam pilot area at the tail end of Kalipatnam Main Channel (KMC) distributory of the Gostanadi & Velpuri (G&V) Canal of Godavari Western Delta, India, comprising of farmer's field to carry out operational research was selected and suitable interventions were designed, constructed and practiced and its potential impact on the society were analyzed.

MATERIAL AND METHODS

For identifying the problems in the pilot area, Participatory Learning & Action (PLA) was conducted to the farmers of the Kalipatnam pilot area in association with the local Non-Governmental Organization (NGO).

Major problem identified in the pilot area was lower crop yields that was caused due to number of reasons viz., drainage congestion due to tidal fluctuations of salt stream, induced soil salinity due to sea water ingress, repeated transplantations, improper outlet conditions and insufficient carrying capacity of drains. The recommendations of the Indo-Dutch Network Project were followed for the installation of the sub-surface drainage system for salinity control in canal commands [6]. Various details of pre-drainage investigations in the pilot area were presented in Tab. 1. Based on these pre-drainage investigations composite type of layout was selected to install the closed subsurface drainage system. On western side of collector pipe, 7 laterals of about 225 m were installed and on eastern side 7 laterals of about 275 m lengths were installed at a spacing of 50m. The design characteristics for the SSD system in Kalipatnam were presented in Tab. 2 and design layout is presented in Fig 1.

Recommended design characteristics were evaluated for installation of sub-surface drainage system in the pilot area [7] [8]. Daily observations on irrigation and drainage water quality and quantity were recorded. Sub surface drainage effluent quality and quantity were also recorded on daily basis. Water table fluctuations and ground water quality were recorded on fortnightly basis.

Table 1. Pre-drainage investigations of the pilot area

S.No.	Parameters	Results
1	Hydraulic conductivity	0.33 $m \cdot day^{-1}$
2	Average annual Rainfall	1246 mm
3	Evaporation	1430 mm
4	Drainage coefficient	1 $mm \cdot day^{-1}$
5	Depth to water level	0.0 – 0.9 m
6	Depth to impervious layer	7.0 m
7	Irrigation water EC	Up to 0.4 $dS \cdot m^{-1}$
8	Tidal range in Upputeru	0.0 to 0.9 m
9	EC of soil	4.0 to 16.3 $dS \cdot m^{-1}$
10	Soil type	Saline Sodic
11	Soil texture	Loamy sand to sandy clay
12	SAR	14.88 to 21.14
13	ESP (%)	15.47 to 23.03
14	Cropping pattern	Rice – Rice- Fallow
15	Method of irrigation	Flooding
16	No. of Farmers	28
17	No of land holdings	36

Table 2. Salient features of design parameters of sub-surface drainage system

Drain spacing	50m
Drain depth	0.8m
Slope of the Collector line	0.03%
Slope of field drains	0.1%
Envelope	Nylon mesh
Pipe material For laterals For collector	 Corrugated PVC (80mm diameter) Rigid PVC (160 mm diameter)
Design discharge	1$mm \cdot day^{-1}$
Drainage outlet condition	Pumped outlet of capacity 9.5 $l \cdot s^{-1}$

During every summer, in-situ hydraulic conductivity measurement were taken and soil samples were collected and analyzed for their physico-chemical properties. Yields patterns were recorded on grid basis (100 X 100 m interval for entire pilot area) and farmers were interviewed for yield assessment. Average of both were calculated for yield estimation. Various improved water management practices in the frame work of IWRM in different pilot area scenario have been monitored using different logical indicators to draw a meaningful conclusion for the long term effects of interventions. The long term strategy is to stimulate agricultural growth and promote rural development through improved water and land management, enhanced efficiency of irrigation and drainage networks, increased attention to environmental protection and improved rural infrastructure.

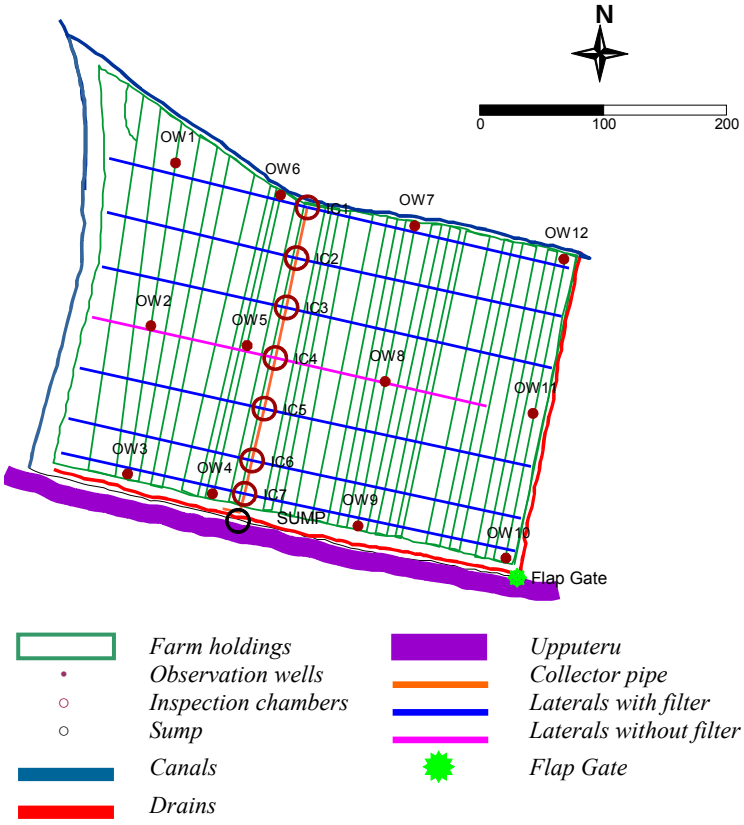

Figure 1. Layout of sub-surface drainage system in Kalipatnam Pilot area

RESULTS AND DISCUSSION

The recorded data was compiled and analyzed for quantitative assessment of impact of sub-surface drainage system. The impact of the system on pilot area was observed through various means viz., soil hydrological parameters, desalinization of soil profile, relation between drain volume and drain water salinity, crop performance, financial viability, change in land value and changes in the socio-economic aspects of the farmers.

Crop performance

Before installation of sub surface drainage system in the pilot area, the cropping pattern followed was paddy-paddy-fallow. The same pattern has been followed till now. The productivity patterns usually vary from kharif to Rabi seasons due to vagaries of the availability of photosynthetic active radiation from the sunlight. Rabi yields are generally higher owing to long duration of solar radiation. It was estimated that there was a 46.05 per cent increase in the yields during Kharif season (3.8 - 5.5 $t \cdot ha^{-1}$) and a 50

per cent increase in yields during Rabi season (5.3 - 8.0 t·ha^{-1}). Yield increase was mainly attributed due to reduction in soil salinity in the root zone due to leaching process enhanced by sub-surface drainage system. Similar positive effect on crop yields were obtained in paddy, sugar cane, kharif fodder, sugar beet and tobacco crop through the subsurface drainage technology and yields were increased by 46, 49, 50, 56, 43 and 23 per cents respectively [3].

Soil quality

The impact of sub-surface drainage system on soil salinity has been presented in Tab. 4. The data on soil salinity levels of before the installation of SSD (summer, 05) and one year, two years and four years (summer, 06, 07, 08 and 09) after installation of Sub surface drainage system from the 48 grid points at four different depths (0-15 cm, 15- 30 cm, 30-60 cm and 60-100 cm) have been analyzed presented in Tab. 3.

A perusal of data indicated that there was considerable reduction in soil salinity in the pilot area. ECe has been lowered two year after installation thus showing overall effect was positive. ECe of soils were reduced by 20.15 per cent in surface soil and 28.58- 41.24 per cent in sub surface soil. The depth wise reduction in soil salinity indicated that upper layers were reclaimed at faster rate (7.59 to 6.70 dS·m^{-1}, 11.70 %) than the deeper layers (9.62 to 8.77 dS·m^{-1}, 8.80 %) after one year of installation of SSD as salt encrustation at the top soils were leached out due to sub-surface drainage.

Financial viability

Economic viability of a closed surface drainage system is of major consideration for large-scale implementation of the project in the drainage sub basin and/or basin level. The techno-economic evaluation was carried out by A.P. Water Management Project [8]. The analysis showed that benefit cost ratio for the project worked out to be 3.32 with average annual return per rupee of investment to be 0.46. The SSD system at Kalipatnam had a capital investment of Rs. 0.479 million has the capacity to earn a rate of return of 27 per cent, which is higher than the opportunity cost of capital or market rate of interest and pay back period of 2.18 years proving that technological intervention is financially feasible, economically viable and cost effective.

Socio-economic impact of drainage interventions

The socio-economic including gender studies were conducted in the drainage pilot area. All the farmers including the women have participated in the surveys.

Farmers attitude to drainage

Post project evaluation to assess the farmer's view on drainage technology revealed that all the respondents were convinced and agreed that the drainage technology is an effective technology to solve the problems of water logging and soil salinity leading to increase in yield, increase in cropping intensity and switchover from fish culture to paddy cultivation. Farmers are aware that they had an increased access to credit. Farmers are able to take loans from banks and cooperative societies as they have got repayment capacity as they have assured crop for at least one season. This fact was confirmed from

the responses during interactions with the FAO Evaluation Team for evaluating project performance [1].

Knowledge on adoption of improved water management practices

The majority of the farmers have vast experience in irrigated agriculture. Farmers have gained hands on experience in water management aspects and awareness levels on various aspects like Crop management, Soil and water management, Identification of pests and diseases, Use of plant protection chemicals, Preparation of botanical extracts and Rodent control improved significantly during the tenure of the project with capacity building programs of APWAM Project in pilot areas like trainings and kalazathas.

Farmers input to implement and maintain drainage systems

- Farmers are willing to maintain the installed drainage systems on their own cost.
- Farmers are of the opinion that Government should support installation of sub-surface drainage systems in the form of subsidies. They are however, willing to actively participate in future drainage projects either by meeting a part of the cost by the way of providing labour for the installation.

Secondary benefits of drainage project interventions

The reclamation of water logged and salt affected lands besides resulting in direct benefits and sustainability of irrigated agriculture, also helps to achieve the following benefits.

Market value of land and social status

The land reclamation also leads to improvement in the social status of the farmers with improvement in land productivity. There was considerable improvement in asset value of the land after drainage intervention. Though, there has been general increase in land appreciation, still there is a gap in the market value of land in drainage pilot area and non pilot area to a tune of Rs.0.30 million$\cdot$ha^{-1}.

Employment generation

Reclamation program generates employment opportunities both during drainage execution and during post drainage period under crop production program. It generated as many as 32 man-days per ha during installation of drainage systems. Further, the intervention has also offered an annual employment of 107 man-days per ha during kharif and 125 man-days per ha during rabi on reclaimed land under crop production activities.

Gender issues

The following are the important observations made on this aspect:

- Although women are actively involved in farming activities, they are not so much involved in agriculture and agricultural water management.
- Women are aware of the thing that their increase annual incomes are due to drainage interventions in their fields.

- Women are also aware that their family expenditure had rose from pre-drainage period to post-drainage period owing to improved land productivity and increased annual cropping intensity.

Women are aware that part of their extra earnings were spent on improved diet for better health, better medical facilities, purchase of assets like oil engines, motor cycles, sprayers, etc, repair of existing houses, rearing of milk animals and chicks, education and marriage activities.

Table 3. Impact assessment of sub-surface drainage technology on soil salinity and productivity levels in Kalipatnam pilot areas

S.No.	Pre-drainage situation		End of 1st year	End of 2nd year	End of 3rd year	End of 4th year
1.	Soil salinity ($dS \cdot m^{-1}$) 0-15 cm	4.03-16.35 (7.59)	3.44-10.86 (6.49)	3.33-11.20 (6.06)	2.09-11.27 (5.08)	2.97-9.50 (5.51)
2.	Soil salinity ($dS \cdot m^{-1}$) 15-30 cm	6.06-27.50 (9.62)	4.06-13.75 (8.77)	2.93-12.15 (6.87)	2.93-9.48 (5.24)	2.90-13.0 (6.13)
3.	Kharif yield ($t \cdot ha^{-1}$)	3.8	4.4	5.0	5.5	5.3
4.	Rabi yield ($t \cdot ha^{-1}$)	5.3	8.0	7.4	7.9	7.1

Table 4. Comparison of market value of land in pilot and non-pilot areas

Pilot area	Pre-drainage (Rs. million·ha^{-1})	Post drainage (Rs.million·ha^{-1})	
	Pilot/Non pilot	Pilot	Non pilot
Kalipatnam pilot area	0.25	1.5	1.2

CONCLUSIONS

Based on the analysis of the study, the following conclusions were drawn:

1. Sub-surface drainage technology has been very instrumental in achieving sustainable agricultural productivity levels in the saline-sodic soils of Godavari Western Delta that were badly affected by salinity and waterlogged situations.
2. ECe of soils were reduced by 20.15 per cent in surface soil and 28.58- 41.24 per cent in sub surface soil indicating that desalinization of soil profile was taken place.
3. The productivity levels of paddy were increased by 46% in kharif season and 50% in rabi seasons.
4. Sub-surface drainage technology is financially feasible, economically viable and cost effective with pay back period of 2.18 years.
5. Better rural development through improved water and land management, enhanced efficiency of irrigation and drainage networks, increased attention to environmental protection and improved rural infrastructure was achieved.

BIBLIOGRAPHY

[1] Anonymous. 2008. *Report of FAO Evaluation Mission A.P. Water Management Project* (GCP/IND/176/NET).

[2] Anonymous. 2001. *A Technical report by National Bureau of Soil Survey and Land Use Pattern*, Nagpur.

[3] Azhar, A.H., Alam, M.M., Rafiq, M. 2005. Agricultural Impact assessment of sub-surface drainage projects in Pakistan – Crop Yield Analysis. *Pakistan Journal of Water Resources*, Vol 9(1), January-June, 2005/1.

[4] Christen, E.W., Ayar, J.E. 2001. *Sub-surface drainage system-Design and Management in Irrigated agriculture: Best Management Practices for reducing drainage volume and salt load.* Technical report 38/01, CSIRO, Land and Water, Griffith, NSW. P: 67-69

[5] Ritzema, H., Satyanarayana, T.V., Raman, S., Boonstra, J. 2008. Sub-surface drainage to combat water logging and salinity in irrigated lands in India: Lessons learned in farmer's fields. *Agricultural Water Management*, Vol 95(3), 179-189.

[6] Sreedevi, P, Ganesh Babu, R., Sreenivas, Ch. 2008. Evaluation of Design Characteristics to install Sub-surface drainage system at Kalipatnam Pilot area of Godavari Western Delta. *The Journal of Research ANGRAU*, Vol 36(1):1-5.

[7] Satyanarayana, T.V., Lakshmi, G.V., Srinivasulu, A., Hanumanthaiah, C.V., Ratnam,M., Hemakumar, H.V. 2002. *Drainage and Water Management for Salinity Control in Canal Commands.* A Comprehensive report of Research Achievements of Bapatla Network Center, Indo-Dutch Network Operational Research Project, Acharya N.G. Ranga Agricultural University, Bapatla.

[8] Vishnushankar Rao, D., Satyanarayana, T.V., Sridevi, P., Sreenivas, Ch., Sambasiva Rao, P. 2006. *Techno-Economic Evaluation of Sub-surface Drainage Technologies in Godavari Western Delta Saline-Alkali and Water logged Environment in Techno-Economic Evaluation of sub-Surface Drainage Technologies*, Acharya N.G. Ranga Agricultural University, A.P. Water Management Project, Bapatla. P: 25-52.

[9] Vishnu, Vardhan S, Sreenivas Ch, Venkata, Reddy, C., Muralikrishna, T. 2009. *Improving sub-surface Drainage System* – A case study. In Proc. Of 60th International Executive Council and 5th Asian Regiojnal Conference on " Improvement in Efficiency of Irrigated Projects through Technology Up gradation and Better Operations and maintenance" held during 6-11 December, 2009, New Delhi. P: 215

PROCENA UTICAJA UPRAVLJANJA ODVEDENOM VODOM NA SLANIM ZEMLJIŠTIMA NA OGLEDNOM POLJU DELTE ZAPADNOG GODAVARI U INDIJI

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Sažetak: A.P. projekat upravljanja vodom u Andhra Pradesh bio je planiran sa primenom različitih unapređenih postupaka navodnjavanja i drenaže vode i izveden je uz finansijsku pomoć FAO. Drenaža je efikasno sredstvo za borbu protiv negativnih efekata saliniteta i zadržavanja vode. Pet godina je operativno pilot istraživanje sprovođeno na parcelama farmera u oblasti Kalipatnam postavljanjem sistema pod-površinske drenaže sa koeficijentom drenaže od 1 mm na dan, radi kontrole rastućih vrednosti saliniteta zemljišta na oglednom polju u zapadnoj delti Godavari. Postignuto je značajno smanjenje saliniteta zemljišta od 33% na oglednom polju ispiranjem soli iz sistema sa 59 $t \cdot ha^{-1}$ tokom 2005 – 2009. Produktivnost je povećana za 15-25% u kharif sezoni i 25-40% u rabi sezoni. Ekonomska analiza je pokazala da je ovaj sistem drenaže i finansijski efikasan, a odnos prihoda i troškova je bio 3.3, sa periodom otplate od 2.18 godina i internom ratom od 27.19%. Značajan je bio i potencijalni uticaj na kvalitet zemljišta, osobine useva, unapređenje porodičnih prihoda i vrednost zemljišta.

Ključne reči*: Pod-površinski system drenaže, drenažni odliv, koeficijent drenaže, slain talog, interna rata, ispiranje, morska voda*

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