MODEL SCHEME ON RECLAMATION OF SALINE-ALKALI SOILS USING UNDERGROUND DRAINAGE SYSTEM

Introduction

Soil salinity has caused heavy loss of national wealth in India. Out of 329 million hectares of land in the country, about 175 million ha. (53 %) is suffering from degradation in some form or the other. There are 7.61 M ha of salt affected soils in India as per the Ministry of Agriculture, GOI. The extent of this problem area as given by different sources varys from 8.56 M ha to 10.9 M ha. Water logging affects another 8.52 M ha mainly in the irrigation commands, which includes some of the saline-alkali soils also. In Haryana, parts of Punjab, Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu, substantial areas of good irrigated lands are affected by saline - alkali and water-logging problems. There are several reasons for development of salinity in the soils, such as:

- Excessive and uncontrolled irrigation
- Accumulation of salts in the top layer due to evapo-transpiration in arid conditions
- Water logging conditions in perennial river basins/ irrigation sources due to seepage
- Excessive use of chemical fertilizers containing chlorides, sulfates etc.
- Poor drainage conditions.

The problem of salinity, alkalinity and water logging deserve special treatments based on the local conditions and soil texture, structure and topography. When water is used for agricultural purposes, in most cases more than 50 percent goes waste. It seeps out of unlined channels, pipes, ditches, runoff fields or percolates in to the soil and accumulate in uneven depressions. Water dissolves naturally occurring salts in the rocks and soils and carries them to the surface of the soil, where the water molecules evaporate, leaving the salts to accumulate near the surface. Excess salts, eventually will lead to alkali problem.

The growing problem of salinity-alkalinity should be minimised or eliminated as early as possible since it is growing at the rate of 10% every year. Soil salinity has become an acute problem rendering crop productivity to decline or making the soil unfit for cultivation. Irrigation has both sides of bane and boon. Unscientific irrigation has endangered many favorable environmental conditions and human health. The Government / people have now realised the seriousness of the problem. In the absence of adequate drainage provisions, with the introduction of new irrigation projects and also the faulty water management practices on the farms, additional area will turn salty each year.

Saline soils contain soluble salts which impair the soil productivity. Such soils can normally be identified by the presence of white crusts of salts on the surface of the land area and poor crop growth. Internal drainage of such soils will not be bad. By opening adequate drains, such soils can be improved.

Drainage becomes a problem when the soil is water logged. In such soils, the aeration will be a limiting factor and microbial activities will be hindered and hence the removal of excess water from such water logged areas becomes very essential.

On the other hand, sodic soils containing excess sodium become extremely water-logged as the soil porosity is lost and water do not percolate down easily / quickly. In case of excess Sodium contents of the soil, it has to be treated with soil amendments such as gypsum, sulfur etc., and then the salts have to be drained. In summary, the basic requirement is provision of adequate and appropriate drainage system. Black soils are worst affected as they have poor drainage due to high clay content.

2. Visual Effects of Saline - Alkali soil

The Harmful effects of saline water irrigation are mainly associated with accumulation of salts in the soil and are manifested through reduced availability of water to plants, delayed germination and slow growth rate.

- Excessive salts in the soil can induce early wilting and the effects are almost similar to those of drought.
- Some of the visual symptoms are that the plants look stunted; leaves are smaller but thicker and have often dark green colour as compared to plants growing in a salt free area irrigated with good quality water.
- Alkali soils become extremely hard on drying and slushy on wetting. Black incrustation is seen on the surface.
- All useful microbial activity is completely lost making the soil unhealthy for crops.

3. Management of Saline soils

The farmers are aware of soil salinity and its bad effects. The yields of various crops have drastically reduced due to salinity. The problem is more pronounced in recent years. The farmers are shifting to other activities like dairying and there is growing tendency towards crop rotation. The farmers are following measures like green manuring, crop rotation, sub-soiling, open drainages, mulching etc. to a limited extent. The practice of application of amendments like Gypsum is not popular in many parts of the country due to non availability in the local markets.

The problem of saline soils was studied from various angles and concluded that unless corrective measures are adopted at appropriate time, vast tracts of so called fertile soils will become barren leading to unproductivity and under production. It is the ultimate responsibility of every one involved in rural development to save the soil from the bad effects to sustain the growing population. The importance of soil management will have to be given top most priority in the years to come. Otherwise, viability of crop production will be eroded.

4. Provision of subsurface drainage

In the areas of high salinity, it is essential to bring down the salinity by leaching the salts. It is also necessary to lower the water table if it is shallow and saline and maintain it below the critical depth to prevent resalinisation. Drainage of agricultural lands can be achieved through a package of the following measures :

- Intercept the flood and seepage water from above by opening sufficiently large drain (called interceptor drain) and divert the same from affecting the holding.
- Construct a good feeder drain (called vertical disposal drain) in the field, along the slope and connect it with the common drain or natural drains such as nallas.
- Construct adequate drains in the plots and crop fields and connect them to the vertical disposal drain.
- Provide drop pits and stone pitching in erodable spots.
- If the soils are alkali in nature, apply sufficient quantities of chemical and organic amendments, based on soil test results.

Traditionally drainage is provided by means of open ditches, dug out either by human labour or by earth moving equipment. The width and depth depends on the quantity of water to be removed and root system of the crop. Though, they can be opened without much skills, they have several limitations such as :

- The sides collapse and silt up fast.
- Weeds and grasses grow up and clog the drain and also spread weed seed.
- Harbor pests like rats.
- Become water-logging and breed mosquitoes.
- Occupy 15-20 % of land area.
- Obstruct cultivation and movement of machinery.
- All lateral drains have to be ploughed up and re-laid after each cropping.

Out of the various methods of drainage systems and reclamation of saline soils, subsurface drainage system will be most effective and long lasting particularly in heavy soils. This system includes laying of perforated PVC pipes under ground and draining the accumulated salts along with water to a common outlets/well. The drained water will be tested for its quality and if found suitable, the same water will be recycled to the crop. There are different dimensions of perforated and unperforated pipes (blind pipes) available with reputed plastic manufacturing companies , with BIS specification. It is an excellent system for all irrigated agriculture crops like sugarcane, yielding orchards, plantations and sensitive crops like turmeric.

The steps involved in laying a successful sub-surface drainage system :

- Investigation and diagnosis of the water-logging problem, soil physical and chemical properties, availability of natural outlet and fall etc.
- Drawing a perfect design, which include decisions on dia of the pipe, distance between laterals, depth and manholes for maintenance.
- Sellection of proper materials - pipes, fittings, filter material, outlets etc.
- Proper laying of the system to ensure smooth flow.

5. Benefits of drainage Flooding and loss of seeds and fertilizers are largely eliminated Dries up the fields quickly soon after rains and thus making the land ready for cultivation. It avoids permanently ponded areas and swamps etc. It removes excess water, salinity and alkalinity from the soils It keeps the soil pores open and thus increase both infiltration and permeability rates of the soil Where underground drainage is practiced, there will be a better physical condition of the soil that permits vigorous and deeper root growth and as a result drought tolerance. Improves earthworms, soil microbes etc. and thus better health of soil. Reduces certain crop diseases.

6. <u>Difficulties in financing for soil reclamation</u>

Besides ignorance of bad effects of soil salinity and subsequentreduction in crop yields, the bankers are reluctant to finance for reclamation of saline soils. In certain case, the local bankers are not aware that NABARD provides refinance assistance for reclamation of saline soils under land development activity. There are certain difficulties in financing for reclamation activities as discussed below :

- Desalinisation is a long term process; and simultaneously protection to safeguard land area is also essential.
- Desalinisation is not limited to the individual efforts. It should be scientifically managed on the basis of land slope and command areas. Individual farmer's efforts goes futile if other neighboring farmers do not follow the amelioration programmes. Collective efforts are essential for more effectiveness.
- Desalinisation is a scientific process. On the contrary, farmers do not know scientific processes and their results. Farmers ignorance in this respect results in waste of time and money. Lack of demonstration farms is a serious limitation.
- UGP drainage system is a skill oriented one and needs proper guidance.
- Schemes for amelioration of salinity are not being submitted by the farmers. Similarly farmers are not aware of the scheme of financing for desalinisation. Lack of knowledge among farmers and many officials is a serious limitation. Farmers are restless due to the growing problem of salinity, but helpless due to lack of knowledge and lethargy of the farmers institutions in solving the problem of soil salinity. Sugar factories and NGOs should take initiative in this regard and work out for repayment through tie-up and extension support.
- Government initiation plays a significant role in the scheme of desalinisation. In fact the problem of salinity is an out come of hurried efforts of irrigation development. Government is not having any well-drawn out scheme for this problem.
- Cooperative credit structure is much worried of the salinity, because of its high exposure to cooperative sugar factories. Other financial agencies are not so worried of the problem.

- Construction of drainage systems to channelise the saline water to flow towards slopes is the major effort required to be implemented. The use of excavators is essential. Similarly drainage should be constructed as per the slopes, which covers farm units owned by many farmers. So group action needs to be promoted. Simultaneously proper maintenance of the drainages is also essential. All these activities can only be made through collective efforts. Banking agencies consider that it would be difficult to coordinate.

In order to adopt permanent and cost effective saline soil treatment methods, it has been suggested to take up the subsoil drainage system rather than following temporary cultural practices like green manuring, open drains, crop rotation, mulching etc. A simple model of laying underground drainage system with PVC pipes to drain out excess water in waterlogged areas and soluble salts in salt affected areas is explained below.

7. Potential Benefiits and high Returns:

The subsurface drainage system is perceived as costly. The initial cost varys from Rs. 60,000 to Rs.75,000 per ha. However, considering the huge loss to yield and income, the investment is highly viable and prudential. It has been observed in many sugarcane growing areas of Maharashtra that there has been a drastic reduction of cane yields, from as high as 120 to135 tons per ha to as low as 50 to 60 tons per ha now. For example the average cane productivity in many sugar factory command areas in Ahmed Nagar District has come down to 60 to 75 tons per ha. The value of this loss is substantial to take such high investment to restore the soil productivity. It amounts to a loss of income of over Rs. 50,000 per ha per year. One of the innovative farmers who had installed such an under ground system near Rahuri of Maharashtra started getting an yield level of about 150 tons of cane per ha. From this it is evident that even if Rs. 25,000/- has to be spent per acre, the entire investment can be recovered with 2-3 years. Similarly, those of the farmers who have laid under ground tile drains in coastal Karnataka in Areca gardens have started realizing very high yields of areca nut, as also inter crops of pepper. Since such areas have assured irrigation, this item should be taken up on high priority. The investment is highly viable. However, the high initial cost warrants credit support to many farmers. The sugar factories which will be highly benefited from the increased availability of cane with in their command area, should help the farmers in arranging the credit, pipes, earth moving machinery etc. to the farmers. The command area banks should come forward to formulate suitable location specific schemes. To provide guidance in this regard a model scheme is given below.

8. Model Scheme:

The model is prepared for a land holding of 1 ha (2.5 acres) taking into account the average land holding of a marginal farmer. It would be technically more feasible and economical if larger holdings go for the investment, as the same disposal drain will serve more number of collecting drains. In this connection it may be suggested that two to three small farmers can plan a combined system by aligning common collector pipe in the middle of two farms to which the laterals from each farmer's land can be connected. It will reduce the average cost. Small farmers, thus can take up the system collectively for successful reclamation.

The unit cost for laying a subsurface drainage system in one ha is worked out and depicted in the annexure-I. The procedure of laying the underground drainage system is discussed below.

i. Soil Survey/land levelling

Survey of the land is to be done to assess the slope. If the land is uneven, barren/uncultivated for some years, land levelling may be necessary to avoid further water logging and ensure efficient irrigation. Contour map of the area may be sourced from the Department of Agriculture or Irrigation.Based on the general slope, the lateral lines have to be alligned across the slope and the main drain along the slope. The out let of the main drain should have some extra pipe to take the water up to the natural nalla/drainage system. The out let should be above the nall for the water to flow. If necessary contour survey may be got done by employing a qualified overseer.

ii. Soil Sampling

Successful reclamation and management of salt affected soils requires proper diagnosis of the nature and intensity of the problem and suitable measures adopted for its control under given resource conditions. Accordingly, representative soil and water samples must be adequately characterised in the laboratory and in the field. Collection of representative soil and water samples is therefore the basis for the correct diagnosis whether the soil is saline or alkali or saline-alkali, etc. and make sound management decissions.

Number of samples :

It depends on the size of the plot/ farm area and the spatial variability in the field. Field plots which are more or less uniform may make a single unit for the purpose of sampling. Normally, 8-10 samples are collected from this uniform field unit to make one composite sample. However, salt affected soils have lot of spatial variability. Therefore, when it is intended to bring large acreage of barren lands under reclamation, it is appropriate to level and bund the fields and then take samples for surface layer (0-15 cm) and subsurface (15-30 cm) for laboratory analysis. Thus for one acre plot two composite samples of each layer may be needed. The samples taken at 8-10 localities should cover the whole area, the soil has to be mixed well and sub-sampling procedures followed to obtain about 1 kg soil, which should be shade dried, labelled and packed in clean bag.

iii. Preparation of trenches :

The depth of the system depends on the crop and the natural out let level. The thumb rule is that the drain pipes should be laid below the root zone. For annual crops the pipes can be laid in about 1 m bgl. Excavation of trenches should always be started from the outlet end so that the trench can be kept free from accumulated water. Work should be done as far as possible in the drier season. It would be convenient if an excavator / JCB is deployed for digging the trenches.

Assuming a square shape plot of 1 ha, the lenth of the trench would be around 400m lateral at a spacing of 25m and 100m main line including out side lead length.The width and depth of trench would be 0.75m and 1.25m respectively.

The gradient of the lateral is kept usually about 0.2% and for the main trench about 0.4%. As mentioned earlier, the lateral lines are dug across the slope and the main along the slope. The rate for engaging excavator is assumed at Rs. 500/- per hour irrespective of the depth of the trench. The time required for digging the trenches depends on the nature of soil and season. On an average 30 hours is required for preparing trench at the required measurement. The cost for the purpose comes to Rs. 15,000/-.The cost for pipes is worked out assuming 400m length of laterals and 100m length of main line.In case of uneven shape plots, more length may be needed.However,in case of sandy soils,spacing between laterals can be increased.

iv. Laying PVC pipes :

The PVC pipes are to be cut according to the size and laid down in the trenches. Care should be taken that perforated pipes are laid in lateral trenches and blind pipes in mainline. On an average 80 mm pipes are used for laterals and 100 mm pipes are used for the main line or 100 mm pipes may be used for both laterals and mains if the discharge expected is more. The end of the lateral is properly fixed in the sockets of the couplings of other lateral or mainline. Filter materials like coconut fiber, gravel, Agave etc. have to be used to cover the sockets so as to avoid clogging of perforations.

V. Sand filling around pipes

To prevent clogging of the perforations by fine soil and silt and clog the pipes eventually, sand casting is done along the lateral pipes. For the purpose, coarse sand should be placed around the pipes up to 2" to 3". The size of the sand particles should be more than the size of perforations. Sand should be placed in bottom of the trenches, before the pipes are lowered and then placed all round.

The quantity needed would be about 5 truck loads per ha and the cost of sand for the purpose is taken at Rs. 8,000 @ Rs/ 1600 per truck including royality and transportation. In areas where coconut coir is available in plenty, it can be used instead of sand.

Vi. Refilling of trenches

The trenches are to be refilled with labour or machinery. Labour requirement for sand casting, refilling of trenches and other works would be about 50 male and 100 female labourers. This would cost about Rs. 7,000 @ Rs. 60/- for male labour and Rs. 40/- for female labour. The soil is put back in such a way that the top layer should come again at the top.

Vii. Observation wells

These are necessary to inspect the lines for clogging and take up cleaning when ever necessary. They are constructed along the main drain where two or more laterals meet. The bottom of the silt box should be atleast 1 foot below the flow of the outlet pipe and the incoming pipe should enter at a higher elevation than the outlet pipe. The depth of the observation well depends on the corresponding depth of the main line. The cost incurred for collection of stone and construction of observation wells would be around Rs. 2800/-. Two observation wells are considered per ha.

Viii. Construction of sump/well

If well maintained open drains are available, the main line can be connected to the open drain. But recycling of the drained water will not be possible in this case. If the drain water is suitable for reirrigation, the main line is to be connected to a sump/ storage tank. It is observed that farmers would like to have such arrangement. The water can be reirrigated through drip or by traditional method of furrow-irrigation. The depth of weir depends on the nature of soil, extent of water logging etc. On an average 4 to 5 m deep 2 m dia sump can be constructed to store the drained water before it is being recycled. Since the main drain pipe enters at a depth of 1 to 1.5 m below ground level, there is no possibility of drained water flowing out of the well. Revetment at the mouth of the well is required to avoid slipping of soil and siltation. The average cost for construction of such well is worked out to be Rs. 8500. The drain water, however, is to be tested for its quality and suitability for reuse. It may be possible to use this kind of water conjunctively along with good quality canal water.

ix. Recurring expenditure/maintenance cost

A well laid out underground drainage system doesn't require any maintenance cost. If any deposit of silt is observed, it can be easily removed with the help of the observation wells. Since the drained water is free of silt, no desiltation of the well/ weir is required if revetment is done.

X. Cost of the Investment/System:

The average cost as per the above components comes to as follows:

Component	Cost in Rupees
Soil survey/ land levelling	1,000
Soil testing	200
Digging of trenches	15,000
Cost of PVC pipes	27,500
Sand for filling	8,000
Observation wells	2,800
Storage tank/Sump	8,500

Labour cost	7,000
Total	**70,000**

Xi. <u>Cost of cultivation</u>

The cost of cultivation varies based on whether it is planted crop, ratoon crop, short duration crop or long duration crop like Adsali etc. Farmers in some parts of Maharashtra state and Telengana area of Andhra Pradesh traditionally prefer to grow Adsali crop which comes to harvesting after 18 months from the date of planting. In such cases farmers will not get income in the first year for raising Adsali crop. The farmer gets his income from sugar factory in the second year only. Farmers generally adopt ratooning which comes to harvesting within 12 months after cutting of plantation crop. There are variations in the cost of cultivation, yield and maturity period between planted crop and ratoon crop and varities. Based on the method of cultivation, the scale of finance adopted in a few states is given below.

Name of the state	Season/method		Scale of finance per ha.(Rs)	Remarks
Andhra Pradesh	Ratoon	Adsali	17500-36000	Ref. year 2004-05
	Plantation		25000-41000	
	E K Sali		27500-30000	
Uttar Pradesh	Average		20000-40000	Ref. year 2003-04
Maharashtra	Average		22000-25000	Ref. Year 2004-05

In practice, farmers keep half of the area under planted crop and half under ratoon so as to even out the costs and returns over all the years. Accordingly, in the model, uniform cost of cultivation and yields over the years based on the average of planted and ratoon crops have been assumed for working out economics.

Xii. <u>Pre and Post-development yield / income</u>

Based on the above data and field observations, yield and costs under pre development and post development conditions are given in Annexure - II as per the following assumptions :

<u>Pre-development situation</u>:

<u>Yield</u>

40 t/ha planted crop and 30 t/ha for ratoon crop. Average 35 t/ha

Cost of cultivation : Rs.25000/ha for plantation and Rs.15000/ha for ratoon crop with average cost of Rs.20000/ha., owing to prevailing salinity and drainage problem, farmers do not like to put more inputs on crop production.

Post Development :

After the land is fully reclaimed it is assumed that it will reach an average yield of 100 t/ha for planted crop and 80 t/ha under ratoon crop over a period of 3 years. When the land is reclaimed gradually with the drainage provision, optimum inputs can be used for getting maximum benefit. Hence, the average cost of cultivation is assumed at Rs.30,000/- per ha.which is the prevailing rates for normal soils.

Cane Price:

Assumed at Rs.850 per tonne on average basis, though each state fixes the SAP based on recovery and incentives the government decides. This inturn is based on the MSP fixed by GOI which is currently Rs.76/ quintal for recovery of 8.5%.

9. Economics of the Model

Economic analysis of the model are given in Annexures I to IV. The summary of the same is as follows :

Unit Cost	Rs.70,000
Margin @15%	Rs.10,500
Bank Loan	Rs.59,500
BCR	1:1.6
IRR	66%
Repayment	6 years with 1st year holiday for the principal amount

Annexure-I

Cost analysis of subsurface drains with PVC pipes

Unit : One ha.

Amt. in rupees

1. Soil survey/ land levelling Rs. 1000.00
2. Soil testing Rs. 200.00
3. Digging of trenches Rs. 15000.00
4. Cost of PVC pipes Rs. 27500.00
5. Sand for filling Rs. 8000.00
6. Observation wells Rs. 2800.00
7. Storage tank/weir Rs. 8500.00
8. Labour cost Rs. 7000.00

Total Rs. 70000.00

Annexure - II

Pre treatment - post treatment yield income analysis

Without project

(Amt. Rs./ha)

Years	1	2	3	4	5	6
Cost of cultivation	20,000	20,000	20,000	20,000	20,000	20,000
Yield (t/ha.)	35	35	35	35	35	35
Gross income	29,750	29,750	29,750	29,750	29,750	29,750
Net Income	9,750	9,750	9,750	9,750	9,750	9,750

With project

Years	1	2	3	4	5	6
Cost of cultivation	30,000	30,000	30,000	30,000	30,000	30,000
Yield (t/ha.)	50	75	90	90	90	90
Gross income	42,500	63,750	76,500	76,500	76,500	76,500
Net Income	12,500	33,750	46,500	46,500	46,500	46,500
Net Incremental Income	2,750	24,000	36,750	36,750	36,750	36,750

Annexure-III Financial analysis - BCR,NPW and IRR

Initial Investment Rs. 70,000
Bank Loan @ 85 % =Rs. 59500
Interest Rate 12 %
Margin Money 15 % =Rs. 10500

Sr.No.	Particular	Years					
		1	2	3	4	5	6
1)	Cost	100000	30000	30000	30000	30000	30000
2)	Income	42500	63750	76500	76500	76500	76500
3)	Net income	-57500	33750	46500	46500	46500	46500
A)	Discount Rate	15%					

B)	NPV COST	174,404.05					
C)	NPV Total Benefit	412,250.00					
D)	NPV Net Benefit	75,902.83					
E)	BCR	0.423054084	01:01.4				
F)	Average DSCR	2.62					
G)	IRR	66%					

Annexure IV Repayment Schedule

										(Amt in Rs)
Year	Bank Loan O/S at the beginning of the years	Gross Retunes	Cost of Cult.	Surplus available for repayment	Repayment			Bank Loan O/S at the end of the year	Net surplus	DSCR
					Principal	Interest	Total			
1	59500	42500	30000	12500	0	7140	7140	59500	5360	1.7507
2	59500	63750	30000	33750	12000	7140	19140	47500	14610	1.763323
3	47500	76500	30000	46500	12000	5700	17700	35500	28800	2.627119
4	35500	76500	30000	46500	12000	4260	16260	23500	30240	2.859779
5	23500	76500	30000	46500	12000	2820	14820	11500	31680	3.137652
6	11500	76500	30000	46500	11500	1380	12880	0	33620	3.610248
					59500			Average DSCR-		2.624803