



## Land Shaping Techniques to Alleviate Salinity and Waterlogging problems of Mono-Cropped Coastal Land for Multi-Crop Cultivation

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Land shaping techniques create different types of land situations like high land/ridges, medium land and normal low land apart from farm pond / furrows for fish cultivation and rain water harvesting in the farm. Waterlogging and salinity of soil reduced in the high lands providing scope for cultivation of diverse multi-crops other than rice during *kharif* and other seasons. The rainwater harvested in farm pond/furrows created a source of irrigation water which is highly scarce in the region. The different land shaping techniques viz. farm pond, deep furrow & high ridge per ha, and shallow furrow & medium ridge could harvest 4700, 2250 and 1125 cu. m. of rain water respectively in monsoon season. The land shaping techniques also provided a scope for more profitable integrated cultivation of crop-fish, paddy-cum-fish and crop and fish separately along with vegetable, fruits and other high value crops. A cropping schedule for multi-crop cultivation throughout the year for more farm income and productivity in mono-cropped salt affected low-lying coastal land has been suggested.

**(Key words:** *Land shaping technique, Integrated crop-fish cultivation, Salinity, Waterlogging, Rainwater harvesting, Coastal land*)

Indian coast line covers a length of about 8,129 km. The coastal agro-ecoregion is distributed over nine coastal states (Gujarat, Maharashtra, Karnataka, Kerala and Goa in the west, and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal in the east), besides Lakshadweep, Andaman Nicobar group of Islands, and Union Territories of Pondicherry and Daman & Diu, and occupies an area of 10.78 m ha (Velayutham *et al.*, 1999). There are wide variations among the coastal areas in terms of soil characteristics, land use pattern and agro-climatic conditions. Agriculture is the main occupation of the people of coastal regions. The lands are predominantly mono-cropped with long duration traditional variety of rice in *kharif* season. Most of the lands remain fallow during the rest of the period of year. The crop yield in the area is usually very poor due to a number of soil, water and climatic constraints. The major constraints are: salinity build up and lack of irrigation water during dry months (*rabi* and summer), deep waterlogging of fields (in *kharif*), drainage congestion, etc. The problem is also compounded by natural disasters like cyclone, sea water intrusion, drought, etc. that visit the coastal areas almost regularly. Many of the coastal areas have high monsoon rainfall which is much in excess of evapo-transpiration demand of

crops in the season (Bandyopadhyay *et al.*, 1988). The excess water goes waste to the seas as run-off. There is a good scope that the excess rain water can be harvested for irrigation in dry months. In *kharif* season the soil salinity remains low but most of the cultivated lands remain highly waterlogged due to high rainfall. The soil salinity starts increasing at the end of the *kharif* season on cessation of monsoon rains and reaches its maximum in the month of May-June before the on set of next monsoon rains (Bandyopadhyay *et al.*, 2003).

The reclamation of lands and creation of good irrigation facilities over large coastal areas is highly expensive and to be taken up by the Govt. / Govt. agencies, which has not yet been possible. Attempts have been made to alleviate the problems of salinity and waterlogging of coastal land along with creation of irrigation resource by rain water harvesting through some simple land shaping techniques adoptable at farmers level are discussed in this paper.

### MATERIALS AND METHODS

The study was conducted at the Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal. The soil was heavy texture with 40- 43 % clay, 10% sand and

47-50 % silt. The pH of surface soil in the experimental area varied from 5.8-7.1. The mean annual rainfall is 1763 mm of which about 90% occurs during June to October when the cultivated lands remain waterlogged as most of the lands are low-lying. The mean annual evapo-transpiration demand of crop is about 1303 mm and the percolation loss is negligible in the area. It is, thus, clear that about 460 mm of rain water is in excess annually which goes waste into the sea as run-off, which can otherwise be harvested for irrigation during dry periods. The three land shaping techniques taken for the study for alleviating soil salinity and waterlogging problems as well as for creation of irrigation resources at farmers' level are: (i) Farm pond (FP), ii) Deep furrow and high ridge (DF) and iii) Shallow furrow and medium ridge (SF). The techniques are briefly described below.

### I. Farm pond (FP)

About 20% of the farm area was converted into on-farm reservoir (FP) to harvest excess rainwater, the dug-out soil was used to raise the land to form high and medium land situations (Fig. 1) for growing multiple crops including vegetables. The pond was used for rainwater harvesting for irrigation and fish cultivation. The high land was free from waterlogging in *kharif* and could be used for multi-crop cultivation.

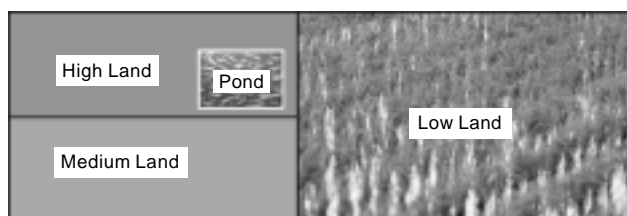


Fig. 1. Farm pond (FP) technique for rain-water harvesting for growing fish and multiple crops in different seasons (top view).

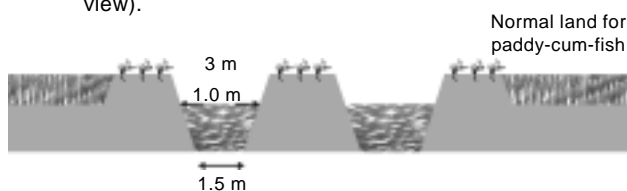


Fig. 2. Deep furrow and high ridge (DF) technique for growing fish and multiple crops in different seasons (side view).

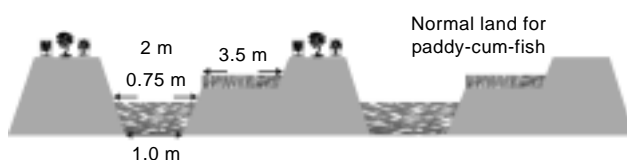


Fig. 3. Shallow furrow and medium ridge (SF) technique for growing fish and multiple crops in different seasons (side view).

### II. Deep furrow & high ridge (DF)

About 50 % of the farm land was shaped into alternate ridges (1.5 m top width  $\times$  1.0 m height  $\times$  3m bottom width) and furrows (3m top width  $\times$  1.5 m bottom width  $\times$  1.0 m depth) (Fig. 2). This resulted in creation of land free of waterlogging (ridges) during *kharif* and rain water harvesting (in furrows) for irrigation.

### III. Shallow furrow & medium ridge (SF)

About 75 % of the farm land was shaped into medium ridges (1.0 m top width  $\times$  0.75 m height  $\times$  2.0m bottom width) and furrows (2.0m top width  $\times$  1.0 m bottom width  $\times$  0.75 m depth) with a gap of 3.5m between two consecutive ridges and furrows (Fig. 3). The furrows were used for rainwater harvesting. The ridges were free from waterlogging in *kharif* and suitable for cultivation of crops other than rice throughout the year.

## RESULTS AND DISCUSSION

Each land shaping technique resulted in formation of 3 types of land situations viz. a) High land made over normal land with soil dugout for making pond/ furrows., b) Normal land (original low land existing in the farm and c) Furrows/ pond. In Farm pond (FP) technique, since the quantity of dug out soil was more, there was a scope for making another type of land viz. Medium land (less waterlogging in *kharif* for cultivation of HYV rice) with partial raising of a portion of the original farm land. The soil salinity build up in different types of land situations under different land shaping techniques at different period of year is presented in Table 1. The results indicated that in all the land situations under the 3 different techniques there was seasonal variation of soil salinity. The soil salinity was lowest in *kharif* (August). On drying up of standing water on field at the end of *kharif* season the soil salinity gradually increased to its highest value in the summer (May). In the present experimental field the soil salinity (ECe) of normal land in FP was  $1.7 \text{ dSm}^{-1}$  in August but it was  $16.5 \text{ dSm}^{-1}$  in May. In each technique the soil salinity in the high land / ridges was much less compared to the normal land. During the summer season (March-May) the soil salinity (ECe) in the normal land of the DF technique was 7.2 to  $12.2 \text{ dSm}^{-1}$  while, the same was 3.4 to  $5.4 \text{ dSm}^{-1}$  under high land condition. This indicated that even the marginally salt tolerant crops can be grown on ridges in *rabi*/ summer season, which could not be grown under normal land situation. The increase in soil salinity

**Table 1.** Effect of land shaping on soil salinity (Ece dS m<sup>-1</sup>)

I. Farm Pond (FP)							
High land	Feb	March	April	May	June	July	August
0-15 cm	2.70	5.10	5.25	5.58	4.50	1.86	0.78
15-30 cm	2.85	5.25	5.50	5.72	4.88	2.06	1.01
Medium land							
0-15 cm	3.08	5.38	5.63	7.00	6.25	1.94	0.62
15-30 cm	3.13	6.13	5.83	7.25	6.35	2.44	0.66
Normal land							
0-15 cm	7.28	7.85	8.50	16.50	11.25	2.36	1.66
15-30 cm	9.25	10.38	10.63	16.63	12.38	2.61	2.18
II. Deep furrow & high ridge (DF)							
High ridge							
0-15 cm	2.15	3.35	5.20	5.42	3.43	1.78	1.08
15-30 cm	2.90	4.88	5.00	3.95	2.85	1.81	1.11
30-45 cm	2.95	4.98	5.00	3.50	2.93	1.88	1.46
45-60 cm	2.75	3.63	3.88	3.98	2.73	1.95	1.48
60-75 cm	3.13	4.13	4.13	2.55	3.13	2.76	1.75
75-90 cm	3.53	4.55	4.80	5.13	3.50	2.90	2.80
90-105 cm	3.35	4.13	4.38	5.93	3.00	2.92	3.07
Normal land							
0-15 cm	6.23	7.15	8.50	12.21	10.06	2.19	1.72
15-30 cm	7.25	9.52	9.83	12.35	10.38	2.67	2.14
III. Shallow furrow & medium ridge (SF)							
Medium ridge							
0-15 cm	2.30	2.63	3.25	4.40	2.12	1.50	1.01
15-30 cm	2.38	3.13	3.70	5.55	2.21	1.55	1.12
30-45 cm	2.50	3.63	3.75	5.58	2.52	1.78	1.30
45-60 cm	3.50	3.75	3.93	6.00	2.66	2.12	2.42
60-75 cm	3.58	3.96	4.00	6.22	3.32	2.48	2.75
Normal land							
0-15 cm	6.87	7.18	8.87	13.18	12.11	4.56	2.21
15-30 cm	7.65	9.66	9.75	13.35	12.46	4.82	2.43

during *rabi*/ summer seasons was due to upward capillary rise of saline groundwater at shallow depth following evaporation from the soil surface, which resulted in gradual accumulation of salts in the surface soil. Lesser soil salinity in the raised soil (ridge, high land) might be due to : a) the distance between the saline groundwater table and the surface soil increased resulting in decreased accumulation of salt through upward capillary flow and/or b) due to the presence of fresh water (harvested rain water) in the furrows, the soil at the bottom region of ridges, remains almost saturated with fresh water in the initial months after

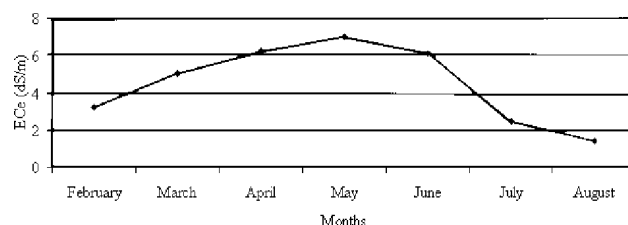
the *kharif* season (or as long as there was a stock of fresh water in the furrows) thereby decreasing the soil water potential at the bottom region of ridges, which resulted less upward capillary movement of saline groundwater. The salinity of groundwater increased with time after the cessation of monsoon rains till the onset of the next monsoon as evident from the salinity of water in the piezometers installed in the experimental area (Fig. 4).

The data on the depth of waterlogging of the land (Table 2) indicated that normal lands in the area are waterlogged during *kharif* season for which no crop other than rice (usually tall *indicas*) can be

**Table 2.** Depth of standing water on normal low land in kharif season

Month	Corresponding growth stage of rice crop	Average depth of standing water (cm)
July	Transplanting	10-15
August	Tillering	25-30
September	Maximum tillering	>30
October	Flowering	20-25
November	Grain filling	15-20
December	Maturity	0-2

grown during the *kharif* season. The studies conducted by Mahanta *et al.* (2004) in the Sunderban region of West Bengal also reported that about 46-50 % of normal cultivated land had higher



**Fig. 4.** Salinity of groundwater as observed in the piezometer standing water during initial growing period of rice which caused considerable reduction in yield and the higher waterlogging at initial stages of growth was more harmful. Under the present techniques the ridges/ high lands were free of waterlogging in *kharif*. Hence, crops like vegetable/ fruit crops, etc. other than rice can also be grown throughout the year on these lands instead of rice alone. The depth of standing water in furrows and pond was quite

**Table 3.** Proposed crop planning with different land shaping techniques

Land shaping techniques	Land situation created	Crops		Remarks
		<i>Kharif</i>	<i>Rabi</i>	
I. Farm Pond (FP)	(a) Farm Pond	Fish	Fish	The different land situations viz, high, medium and low land created can be used for multiple crop cultivation throughout the year. Harvested rainwater can be used for fish cultivation and irrigation purpose.
	(b) High-land created with excavated soil	Vegetables	Vegetables	
	(c) Medium-land created with excavated soil	HYV Rice	Vegetables, low-water requiring field crops	
	(d) Original low-land	Rice	Low-water requiring field crops, short duration rice	
II. Deep furrow & high ridge (DF)	(a) Furrows	Fish under paddy-cum-fish cultivation	Fish + Rain water harvesting	Furrows may be used for rain water harvesting & paddy-cum-fish cultivation. Ridges may be used for vegetable and fruit cultivation. Furrows also provide better drainage of field in dry months.
	(b) Ridges with excavated soil	Vegetables & fruit crops	Vegetables	
	(c) Original Low land	Rice under paddy-cum-fish cultivation	Low water requiring field crops	
III. Shallow furrow & medium ridge (SF)	(a) Furrows	Fish under paddy-cum-fish cultivation	Short duration rice	The furrow may be used for rain water harvesting & fish cultivation under paddy-cum-fish during <i>kharif</i> , ridges may be used for vegetable and/or fruit crop cultivation. The shallow furrows may be used for rice cultivation in <i>rabi</i> /summer as there will be less loss /wastage of water. Excess water of irrigation/rainwater during dry months will also be harvested in furrows.
	(b) Ridges with excavated soil	Fruit and vegetable crops	Vegetable and fruit crops	
	(c) Original Low land	Rice under paddy-cum-fish cultivation	Low water requiring field crops	

high during the *kharif* season which provided scope for more profitable double cropping of paddy-cum fish cultivation during the season. In farm pond technique fish could be cultivated in pond throughout the year while the harvested rain water can also be used for irrigation of low water requiring crops during dry months. In the SF technique the furrows can be used for paddy-cum-fish cultivation during *kharif*. Since, the depth of furrows was less (75 cm) in SF technique, the furrows can be used for paddy (being most preferred crop of the farmers) cultivation during *rabi* taking the advantages that water following rains/irrigation of other crops in the field will be accumulated in furrows and there will be less loss of water through vertical/horizontal movement of water from the furrows. In DF technique also profitable vegetable/fruit crop cultivation on ridges can be undertaken throughout the year and paddy cum- fish cultivation on field during *kharif* season. The quantity of rain water that could be harvested under deep furrow & high ridge and shallow furrow & medium ridge are 2250 and 1125 cu.m, per ha, respectively, which can be used for a few initial live saving irrigations of low water requiring *rabi* crops. In FP technique the volume of harvested rain water (4700 cu.m ha<sup>-1</sup>) was more which was sufficient to meet the irrigation requirement of low water requiring *rabi*/ summer crops besides, fish cultivation throughout the year. Besides rain water harvesting the different land shaping techniques also provide better drainage during dry months to the low-lying coastal lands. A possible schedule of crops under different techniques is given in Table 3, which shows that by adopting one of the land shaping techniques

multiple crops can be grown throughout the year on mono-cropped coastal saline soils. The choice for a particular model of land shaping technique will depend on farmers' preference and the situation of the farm land.

#### REFERENCES

- Bandyopadhyay, A.K., Bhargava, G.P., Rao, K.V.G.K., Sen, H.S., Sinha, T.S., Bandyopadhyay, B.K., Biswas, C.R., Bal, A.R., Dutt, S.K. and Mondal, R.C. (1988). *Coastal saline soils of India and their management*. Bulletin No. 13, Central Soil Salinity Research Institute, Regional Research Station, Canning Town, South 24 Parganas, W.B., India, 158 p.
- Bandyopadhyay, B.K., Maji, B., Sen, H.S. and Tyagi, N.K. (2003). *Coastal soils of West Bengal - Their nature, distribution and characteristics*. Bulletin No. 1/2003, Regional Research Station, Central Soil Salinity Research Institute, Canning Town, South 24 Parganas, W.B., India, 62 p.
- Mahanta, K.K., Burman, D. and Ambast, S.K. (2004). *Evaluation of basin characteristics for drainage improvement in the Sundarbans region*. Annual Report 2004-2005, Central Soil Salinity Research Institute, Karnal - 132 001, Haryana, India.
- Velayutham, M., Sarkar, D., Reddy, R. S., Natarajan, A., Krishan, P., Shiva Prasad, C. R., Challa, O., Harindranath, C. S., Shyampura, R. L., Sharma, J. P. and Bhattacharyya, T. (1999). Soil resource and their potentialities in coastal areas of India. *Journal of the Indian Society of Coastal Agricultural Research* 17: 29-47.