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# Doubling farmers' income

## through land-shaping technologies in coastal-salt affected areas

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*Agriculture is the major occupation of people living in the rural areas of coastal regions in the country but it is highly complex, risk prone and entirely dependent on the vagaries of nature. The most practical and environmentally non-destructive way of creating irrigation resources in the area is through harvesting of excess rainwater that goes waste as runoff into the sea. The harvesting of excess rainwater can be done effectively through suitable land-shaping of the farm land, which involves in modifying the surface of the farm-land for harvesting of excess rain-water as well as making the land surface suitably shaped for adoption of improved cultivation of diversified crops and integrated farming. The major purpose of these land shaping are for - creating irrigation resources through harvesting excess rainwater, improving drainage congestion of land, reducing influence of brackish groundwater-table at shallow depth for soil salinity build up in during dry months, diversification and multiple crop cultivation round the year on mono-cropped coastal land and agriculture-aquaculture-livestock integrated farming system for higher productivity and livelihood security of poor farming communities.*

**Key words:** Coastal areas, Farmers' income, Land-shaping, Salt affected areas, Technologies

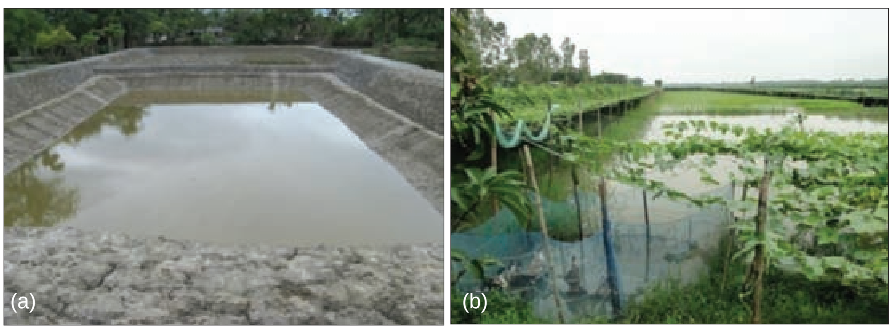

Fig 1 a.b. Farm-pond land-shaping technique - without and with crops

THE coastal zone of India, a broad transitional zone between land and sea, is traditionally backward in agricultural productivity and socio-economic status of farming communities. The coastal agro-ecosystem of the country occupies an area of about 10.8 million ha and are spread over the 7,517 km long coastline along the Bay of Bengal in the East coast and Arabian sea in the West coast. The coastline of the country in its journey covers West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat, Goa, Puducherry and Daman & Diu; and 2 group of islands namely Andaman & Nicobar group in the Bay of Bengal and Lakshadeep & Minicoy group in the Arabian sea in the country. People living in the rural areas of coastal regions of the country are farmers and their profession is full of risk and based on the vagaries of nature.

### Land and water management technologies

Strategies for increasing farmers' income through above mentioned technologies are discussed here.

*Crop-fish integration through land-shaping models:* The management of agricultural land to improve farm income in coastal saline environment is quite challenging and most of the agricultural area is characterized by mono-cropping with low-yielding rice varieties during *kharif*. Under such fragile environment sustaining the livelihoods of this resource poor farmers become a real challenge both for technology developers as well as policy makers. To increase the farm income under the coastal saline environment, strategies have been taken up to increase the adoption of the salt resistant crop varieties and

Fig. 2 a,b. Deep-furrow-and-high-ridge land shaping technique - without and with crops

more important harvesting, storing and appropriate management through different kind of land-shaping technologies. In coastal area the land-shaping techniques are unique in addressing the key challenges such as land degradation (salinity), drainage congestion and scarcity of fresh water for irrigation and in turn have the potential to enhancing production, productivity, income and employment. The success of improved agro-technologies is dependent on sustainable management of soil and water resources. Land-shaping techniques are changing the configuration of land through soil excavation and making it suitable for water harvesting that creates option for multiple-cropping, fisheries and also reduces the soil and water salinity. Farmers in coastal region view their farming operation as a system where crop and fisheries are integral part of their farming system. These land-shaping interventions were implemented through crop-fish integration for achieving high impact and adoptability among the farmers.

## LAND-SHAPING MODELS

Land-shaping models (5) made the land suitable for growing multiple crops and rearing fish.

### Grassroots experiences of technology innovations and impact

Different types of land-shaping technologies demonstrated extensively at farmers' fields during implementation of National Agricultural Innovations Project (GEF funded) by Central Soil Salinity Research Institute; Regional Research Station, Canning Town, in collaboration with Central Island Agricultural Research Institute, Port Blair; Central Institute of Brackishwater Aquaculture , KRC, Kakdwip, Ramakrishna Ashram; Krishi Vigyan Kendra, Nimpith; and Bidhan Chandra Krishi Viswavidyalaya, Mohanpur. Some of the high impact technologies were Farm Pond, Deep Furrow and High Ridge, Paddy-cum-Fish, and Broad Bed and Furrow System.

**(i)** ***Farm pond system*** **(*FP*)**: About 20% of the farm area is converted into on-farm pond of about 3 m depth to harvest excess rainwater. The dug-out soil is used to raise the land to form high land/dike and medium land situations besides the original low land situation in the farm for growing multiple and diversified crops throughout the year instead of mono-cropping with rice in *kharif* (Figs 1 a,b).

*Impact:* Over 215 ha (1,345 households) of land converted as Farm Pond in Sundarbans and A&N Island, between 2010 and 2014. The adoption is continuing and various state governments have included the models in their implementing programme.

Key impacts: These are cropping system increased from 114 % to 193-200%; employment generation increased from 87 man-days to 227 man-days/households/year; Output-input ratio realized 2.95; household level farm income increased from ₹ 7,700 to ₹ 48,768 households (0.35 ha)/year; and salinity level reduced significantly.

***(ii) Deep furrow and high ridge (DFR) system :*** About 50 % of the farm land is shaped into alternate ridges (1.5 m top width ×1.0 m height × 3 m bottom width) and furrows (3 m top width × 1.5 m bottom width × 1.0 m depth). Dug-out soil from furrows is used for making ridges (Figs 2. a,b).

*Impact*: Demonstration was completed around 15 ha (65 households). The adoption is continuing converging with different government schemes and programmes.

Key impacts: These are cropping intensity increased from 114 % to 186 %; employment generation increased from 87 man-days to 218 man-days per households per year; output-input ratio realized 2.31; household level farm income increased from ₹ 7,700 to ₹ 35,812 per households (0.35 ha) per year; and salinity level reduced significantly.

**(iii)** ***Paddy-cum-fish (PCF) system:*** Trenches (3 m top width × 1.5 m bottom width × 1.5 m depth) are dug around the periphery of the farm-land leaving about 3.5 m wide outer from boundary and the dugout soil is used for making dikes (about 1.5 m top width × 1.5 m height × 3 m bottom width) to protect free flow of water from the field and harvesting more rainwater in the field and trench. A small ditch is dug out at one corner of the field as shelter for fishes when water will dry out in trenches (Figs 3 a,b).

*Impact*: Demonstration was

Fig. 3 a,b. Paddy-cum-fish land shaping technique - without and with crops completed involving over 84 ha (348 households) of land has been converted into this system during 2010-2014 and adoption is continuing converging with different government schemes and programmes.

Key impacts: These are cropping intensity increased from 114% to 166%; employment generation increased from 87 man-days to 223 man-days per households per year; output-input ratio realized 2.13; household level farm income increased from ₹ 7,700 to ₹ 44,295 per households (0.35 ha) per year; and salinity level reduced significantly.

**(iv) *Broad bed and furrow system (BBF):*** This system was implemented in coastal region of Andaman and Nicobar Islands. This involves shaping of land for broad beds and furrows alternatively in low-lying lands. This technique was implemented in *Tsunami* affected areas in Andaman and Nicobar Islands. In BBF technique beds of 4-5 $m^3$ width and 1 m height, and furrow of 5-6 m width and 1m deep with a provision of (2 m × 4 m × 1 m) fish shelter at the end of the furrow has been made (Figs 4 a,b). Raised beds are used for cultivation of vegetables round the year and fish was cultivated in the furrows. This system provided the scope for *in-situ* rainwater harvesting of about 3,800 $m^3$ $ha^{-1}$ and which was used to cultivate second crop during dry seasons.

*Impact:* Demonstration covering over 9 ha (51 households) of land has been converted into this system between 2010 and 2014 and adoption is continuing converging with different government schemes and programmes.

Key impacts: These are cropping intensity increased from 100% to 240%; employment generation incresed from 9 man-days to 48 man-days per households per year; output-input ratio realized 1.95; household level farm income increased from ₹ 4,800 to ₹ 4,3350/households (0.20 ha)/year; and salinity level reduced significantly.

## Overall impact of land-shaping technologies

The participatory demonstration at farmers' field about 370 ha of land in *Sundarbans* and Andaman and Nicobar Islands has been converted from mono-cropped to multi-cropped with integrated crop and fish cultivation through implementation of different land shaping techniques like farm pond, deep furrow and high ridge, paddy-cum-fish, broad bed and furrow, three-tire system, paired bed system and drainage improvement network. About 13,04,500 $m^3$ rainwater was harvested under various land-shaping techniques adopted which has been brought under multiple cultivation of crops and fishes with harvested rainwater. The cropping intensity increased up to 240% from a base level value of 100% due to implementing the land shaping techniques in the study area, as an additional benefit it contributed to harvesting of atmospheric $CO_2$. Compared to base-line value the income of the farmers has increased by many-folds (upto 9 times). Raising of land and creating water harvesting facilities reduced the problem of drainage congestion and salinity build up in soil during dry months thus, improved soil environment. Reduction of salinity and drainage congestion and increase in availability of fresh water for irrigation helped the farmers to grow multiple and diversified crops round the year instead of mono-cropping with rice in monsoon season (*kharif*). About 5,11,600 man-days were created per year from the farming activities after 4 years of implementation of land-shaping techniques in the study area. As the farmers get employment in their own farm land throughout the year, this has checked the seasonal migration rate of the farm family. About 21 ha area was brought under brackishwater aquaculture through shaping of land into shallow depth pond in the coastal areas particularly near the brackishwater rivers or sea coast which remain highly saline throughout the year and not suitable for crop cultivation.

Fig. 4. (a) Broad bed and (b) Furrow system land-shaping technique - without and with crops

## Financial viability of the land-shaping technologies

On-farm demonstration showed the success of these land-shaping models in Sundarbans and Andaman and Nicobar Islands in increasing farm income and providing gainful employment to the farmers. However, these land-shaping models involved high initial investment, particularly on soil excavation (Table 1). For analyzing the viability of investment, financial analysis of these land-shaping models, farm pond, paddy-cum-fish, deep-furrow and high ridge and broad bed and furrow system, was carried. The financial analysis has revealed a direct relationship between investment on a land-shaping model and value of IRR, NPV, B-C ratio (Table 1). The payback period was calculated to be 1.41, 1.78, 2.13 and 1.67 years, respectively under FP, PCF, DFR and BBF type of land-shaping models. Financial analysis of all land-shaping models under study indicated that investment on such interventions were financially viable and attractive proposition for the coastal region of Sundarbans (West Bengal) and Andaman and Nicobar Islands. For out-scaling of these technologies to a greater scale there is a need to address some socio-economic constraints and policy support. Such proposition of crop-fish integration in agriculture

**Table 1.** Financial feasibility of land-shaping models in the coastal areas of West Bengal, and Andaman & Nicobar Islands (2014-15 prices)

| Criteria | Farm pond | Paddy-cum-fish farming | Deep furrow and high ridge | Broad bed and furrow system | Remarks |
|---|---|---|---|---|---|
| Initial investment (₹/ha) | 1,45,770 | 1,35,800 | 87,850 | 1,92,350 | Cost of Soil excavation |
| Internal rate of return (%) | 46 | 42 | 36 | 48 | >Discount rate (14%) so feasible |
| Net present value (₹) | 2,85,059 | 2,32,450 | 96,817 | 3,66,501 | Positive return, feasible |
| Benefit: cost ratio | 1.58 | 1.55 | 1.20 | 1.62 | > 1, hence feasible |
| Payback period (years) | 1.41 | 1.78 | 2.13 | 1.67 | Recovers initial investment quickly |

*Note:* The broad bed and furrow system was implemented in Andaman & Nicobar Islands.

through these land-shaping models was highly suitable for pulling the income of intra-agricultural sector in coastal region of India.

## Challenges for out-scaling of technologies

*Agricultural risk and adoption behaviour of farmers:* Farmers' have to operate their farming operation under diverse socio-economic conditions that affect their decisions to adopt new technologies. Socio-economic factors like input prices, market environment, fragmented and small-and marginal-land holdings, availability of own or hired human labour, labour wage rates, financial and credit needs, availability and capacity to absorption of credit, risk preferences etc., all these factors affect the adoption behaviour towards new technologies. Resource poor farmers were naturally risk averters and they tend to prefer a lower outcome that is relatively certain to the prospect of a higher return with a greater degree of uncertainty was attached. Farmers preferred stability of output even with a lower return rather than the high-cost high-return technologies where the instability of output was higher.

The sources of agricultural risk are many bio-physical (poor quality soil or water, pest and disease attack etc), climatic (variability and frequency of events), socio-economic, markets and also government policies. The markets for agricultural inputs and outputs have a direct incidence on farming risk, particularly through prices. Scientists have reported that there is an inverse relationship between high growth of agriculture and agrarian distress. Farmers were always in the receiving end with uncertainty in price, was it less production due to pest and diseases attack or over production due to favourable weather condition. Escalating input prices coupled with high degree of instability in market prices; farmers sometimes failed to recover the cost of cultivation and therefore aggravated the distress situation. In general, the farmers across coastal region were in distress due to their low income and there was a need of concerted efforts to enhance the farmers' income significantly. The research experiments at farmers' field often indicated encouraging results towards higher cropping system intensification and profitability. However, availability of good quality and quantity of irrigation water and accessibility will determine the extent of adoption of such cropping systems. The evolved options might be technologically sound and profitable in output-input ratio. But due to limited water availability farmers might compel to grow multiple crops in small plots (fragmented land) that have primary objectives of meeting households level food security with less commercial/business motives.

For achieving and continuing with higher cropping system intensification from the existing cropping system, farmers need continuous support like more capital investment, additional knowledge on crop management and assurance of remunerative price. Also, socio-economic factors: risk preference, risk bearing abilities, risk mitigation strategies and adequacy of capital often determined the level of adoption of new cropping systems.

*Farm size and operational holdings :* Major constraints identified for adoption of land-shaping models were marginal-land holdings and shape of lands, high initial investment, presence of acid sulphate soil layer after certain depth, distance from residential areas, scarcity of labour availability in time, low marketable surplus, hence high marketing cost or lack remunerative price, high input prices, poor input supply and output delivery, difficult to reverse the land-shaping to original land, availability of quality crop and fish seed and lack of supervision by family members. It was noticed that as the farm size, percentage of low land area, aggregate family income, family size and educational level increases the probability of adoption of these technologies.

## SUMMARY

Land-shaping technologies are the suitable and economically viable options for sustainable land and water management in coastal salt affected areas in India. The goal of doubling farmers' income can be realized through implementation of such technologies. However, major constraints for adoption of land-shaping techniques are marginal-land holdings that too divided into several parcels, high initial investment, and presence of acid sulphate soils near surface or at shallow depth at places. There is a need to converge on-going schemes to mobilize financial resources towards large-scale implementation of these technologies to farmers' field for socially inclusive agricultural growth in the marginal areas.

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