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# Increasing Small-holder Farmers' Income through Alternate Land-use Options in Coastal Salt-affected Areas of West Bengal

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**Abstract**

Tribal Sub-Plan (TSP) of Planning Commission, Govt. of India has one of the key focuses to develop agriculture and allied activities through promotion of integrated farming system having direct positive impact on livelihoods of the disadvantaged groups of people. Lack of good quality irrigation water and salinity in dry season; and waterlogged condition during wet season are the major impediments to enhance the agricultural productivities, hence low agricultural income in the region. Alternative land use options through better land and water management through integrated farming systems can provide fairly better income and livelihoods to the farmers in the region. The paper has analyzed effectiveness of some of these land management options coupled with better soil fertility management, particularly in the disadvantaged island ecosystem in coastal West Bengal. Such interventions have increased cropping intensity from 128 to 288% and per hectare return from ₹ 73623 to ₹ 158730 as compared to the prevailing practices. Besides, soil quality in terms of pH, ECe (salinity) and organic carbon content has improved significantly after the interventions. Investment on the alternative land use options have been encouraging with positive internal rate of return (34%), net present value (₹ 100343), benefit cost ratio (1.17) and pay-back period (1.26 years). Finally, key constraints for large-scale out-scaling of these interventions in other areas have also been highlighted.

***Key words:*** Agricultural income, Marginal farmer, Coastal agriculture, Alternate land use options, Acid sulphate soils

## Introduction

*Sundarbans*, a fragile coastal ecosystem under the Ganga-Brahmaputra delta system formed by the geo-dynamic forces resulting in an uneven thickness and width of the surface horizon; but the morphological nature of entire Sundarbans delta is more or less uniform. The tract is of recent alluvial plain of lower deltaic Bengal basin, raised on an average of 2-3 meter above the mean sea level (msl). Salinity is the major cause of plant mortality, rises to the maximum in the middle of the May and decreases during the monsoon. Drainage congestion, water logging during *kharif* and water scarcity in the winter season (*rabi*) are the other problems. Natural adversities like, cyclones, *tsunami*, gales, heavy rains, floods, etc. which cause colossal loss to the crops and properties are almost annual features of the coastal region. Presence of acid sulfate soil layer at varying depth further aggravated the problems of cropping system intensification. Poor-quality of ground water is another constraint, restricting the expansion of irrigated agriculture in the region. The risk of coastal environment is further accentuated due to poverty, lack of education and of the agrarian population mostly belonging to the low-income group. High unemployment and extremely poor livelihoods conditions is the characteristic feature of the rural life of the fragile ecosystem. The farming community is dominated by very poor, marginal and landless farmers, majority of whom belong to backward communities. Agriculture under such looming marginal environment of the vulnerable ecosystem threatened with salinity and occurrence of acid sulfate layers, resulted into low crop productivity and income.

Land management technologies (land shaping) like farm pond, deep furrow & high ridge, shallow furrow & medium ridge, broad bed & furrow system and paddy-cum-fish cultivation have been developed for managing such fragile ecosystem (CSSRI, 2014; Mandal *et al.,* 2017; NAIP, 2015). Farm pond technique is very popular in the region for water harvesting during *kharif* season and their subsequent utilization in the *rabi* season. However, the application of land management technologies is linked with the depth of occurrence of acid sulfate layer. Its application and use in *Sundarbans* island ecosystem is little complicated due to the presence of such acid sulfate layer at shallower depth at different places. Digging pond to an economical depth and exposition of acid sulfate layer may cause severe acidity which is detrimental to bio-diversity and environmental sustainability in the island an also causes high fish mortality and poor crop productivity. In such situation one single technology and blanket recommendation may not be enough to solve the multifaceted problems. A system based approach considering the problems of salinity, acidity and occurrence of acid sulfate layer is needed for the management of soil and water resources for overall agricultural productivity and ensuring livelihood security of the people living in the Island.

Keeping in view of the above challenges of land use management, an inter-institutional (ICAR-NBSS&LUP, RC-Kolkata as lead centre in collaboration with ICAR-CSSRI-RRS Canning Town and ICAR-CIFA, Kalyani Center) project, titled '*Land use options for enhancing productivity and improving livelihood in Bali Island of Sundarbans*', was implemented during 2014-15 to 2017-18 through financial support from Tribal Sub-plan (TSP) fund of Govt. of India to develop agriculture through promotion of integrated farming system (crop-fish integration) that have direct positive impact on livelihoods of the disadvantaged group of people. Unfortunately, Tribal sub-plan mechanism involving area specific development and special schemes for numerically small and economically and socially more marginalized vulnerable groups, has not made much headway (Institute of Social Sciences, 2003). Key objectives of the interventions were to augmenting farm productivity through sustainable management of land and water resources and integrated farming system under coastal salt-affected areas in *Sundarbans*; and enhancing farm income and better livelihoods for disadvantaged farming communities in coastal areas. Currently, the interventions are being implemented on land shaping techniques and improving homestead production system (HPS) in the Bali Island under Gosaba block of South 24 Parganas. Major interventions undertaken were (1) Land shaping techniques (land modification through farm pond, deep furrow & high ridge, shallow furrow and medium ridge and paddy-cum-fish cultivation); (2) Improved and salt tolerant paddy varieties; (3) Multiple cropping/crop diversification (low water requiring crops, vegetables etc); (4) Improving homestead production system; and (5) promotion of vermi-composting for reducing input cost (chemical fertilizer). The research paper quantified the success of the land management options for the small-holder farmers towards increasing not only the agricultural income but also sustainable enhancing of livelihoods.

## Materials and Methods

**Layout of farm pond (FP):** About 20% of the farm area is converted into on-farm pond of about 3m 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* season (Fig. 1 a,b). The pond is used for rainwater harvesting for irrigation and pisciculture. Poultry/livestock farming can also be practiced in the farm

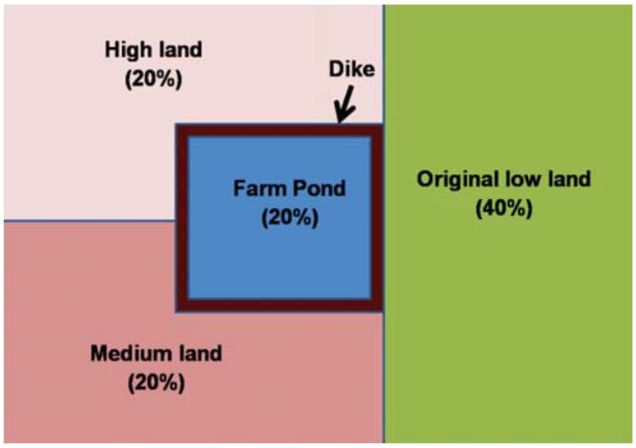


**Fig. 1a** Layout of farm pond technology

**Fig. 1b** Farm pond technology at farmers' field

along with crops and fishes with the use of pond water. The integrated crop-fish-livestock/poultry-duckery farming is environmental friendly and efficient for integrated nutrient management in the farm. The high land is free from water logging in *Kharif* and with less salinity build up in dry seasons and thus, can be used for multiple and diversified crop cultivation throughout the year.

## Shallow furrow and medium ridge (SF)

About 75% of the farm land is shaped into medium ridges (1.0 m top width × 0.75 m height × 2.0 m bottom width) and furrows (2.0 m top width × 1.0 m bottom width × 0.75 m depth) with a gap of 3.5 m between two consecutive ridges and furrows (Fig. 2a & b). As in DF above the furrows are used for rainwater harvesting and paddy + fish cultivation during *Kharif*. These ridges remain relatively free of waterlogging

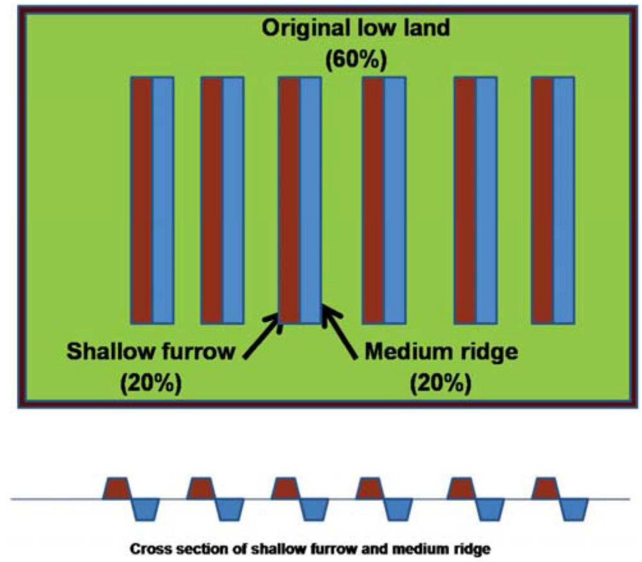


**Fig. 2a** Layout of Shallow furrow and medium ridge technology

**Fig. 2b** Shallow furrow and medium ridge technology at farmers field

during *Kharif* with less soil salinity build up in dry seasons (due to higher elevation and presence of fresh rain water in furrows). Remaining portion of the farmland including the furrows is used for growing more profitable paddy + fish cultivation in *Kharif*. The rainwater harvested in furrows is used for irrigation. The remaining portion of farm land (non- furrow and non- ridge area) are used for low water requiring crops (like cotton, groundnut, etc.) during dry (*Rabi*/ summer) seasons. The rain water stored in furrows is used for initial irrigations during *Rabi*. The water stored in furrows is also used for fish cultivation and supplementary irrigation in *Kharif*. The ridges are used for cultivation of vegetables and other horticultural crops round the year instead of mono-cropping with rice in *Kharif*. The rain water stored in furrows keeps the root zone soil relatively saturated with fresh water during the initial dry months after *Kharif,* thus reduces upward capillary flow of brackish water from shallow subsurface layer and thereby reduces the salinity build up in soil. The furrows provide better drainage and protect the crops from damages congestion following occasional heavy rains in *Rabi/* summer due to climatic disturbances. Water harvested in furrows from such rains also provides additional source of irrigation. This technology is very effective for increasing the productivity of poorly drained coastal saline lands. The effect of soil salinity is minimized thereby increasing the income, livelihood security and employment opportunities of poor coastal farmers.

**Paddy-cum-fish (PCF):** Trenches (3m top width × 1.5 m bottom width × 1.5 m depth) are dug around the periphery of the farm land leaving about 3.5m wide outer from boundary and the dugout soil is used for making dikes (about 1.5 m top width ×1.5 m height × 3m bottom width) to protect free flow of water from the field and harvesting more rain water in the field and trench (Fig. 3a,b). A small ditch is dug out at one corner of the field as shelter for fish when water will dry out in trenches. The dikes are used for vegetable cultivation throughout the year. Remaining portion of the farm land including the trenches is used for more profitable paddy + fish cultivation in K*harif.* The land (non-trench and non-ridge area) is used for low water requiring crops during dry (*Rabi/* summer) seasons with the rain water harvested in trenches. Presence of deep trenches in the field provides better drainage condition in the field during the non-monsoon months. During the dry seasons the land can also be used for remunerative brackish water fish cultivation with the plenty of brackish water (ground/river water) available in the area. The land can again be used for paddy-cum-fresh water fish cultivation in *Kharif* if the brackish water is pumped out (required for harvesting of fishes) and the land is allowed to wash out the salts with a few initial pre-monsoon heavy showers common in the area.

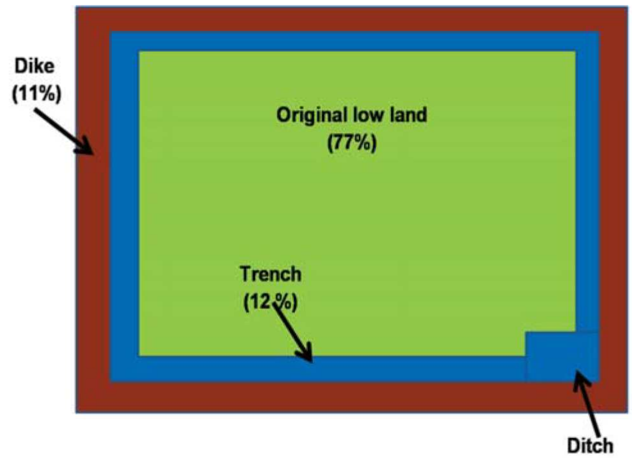


**Fig. 3a** Layout of paddy-cum-fish cultivation technology

**Fig. 3b** Paddy-cum-fish cultivation technology at farmers' field

## Data sources

ICAR-NBSS & LUP in collaboration with ICAR-CSSRI, RRS Canning Town and ICAR-CIFA, Kalyani Center, initiated the project on *Land use options for enhancing productivity and improving livelihood in Bali Island of Sundarbans* with 7 collaborative farmers in 2014-15, increased to 32 farmers in 2015-16 and further covered 23 tribal farm families during 2016-17. Currently (2017-18) project activities have been extended to over 83 farm households in *Bali* and *Amlamethi* villages under Gosaba block of South 24 Parganas district during 2017-18. Present study is based on the primary information collected from these collaborative farmers. Detailed information pertaining to the baseline socio-economic conditions such as land holdings, land use pattern, occupation and family particulars have been collected. Primary data on each intervention have been collected from the farmers before (2014-15) and after (2017-18) implementations of the activities. Cost and return of cultivation of each crop have been calculated following farm budgeting analysis. Besides, baseline information has also been collected from 40 non-collaborative farmers to analyze the determinants and constraints of adoption of the land management intervention options in the study area.

Financial feasibility analysis has been carried out for investment on these land management interventions based on incremental cost-return through undiscounted cash flow measures, payback period as well as discounted cash flow measures such as Internal Rate of Return (IRR), Net Present Value (NPV) and Benefit Cost Ratio (BCR). The total budget of the project was ₹ 74.18 lakh (1 lakh=100 thousand) planned to be incurred on all these land use options during 2014-15 to 2018-19 and almost entire amount (99%) has been spent so far (March 2018). Return to investment (planned budget in the project) has been assessed by taking into consideration of the total incremental benefits realized by all farmers during this period of time.

## Results and Discussions

### Socio-economic status of the farmers

The project on land use options was implemented in two villages, *Bali* and *Amlamethi* under Gosaba block of South 24 Parganas. As per Census 2011, the area under *Bali* village was 944 ha with 1478 households and 6234 population. Similarly, the area of *Amlamethi* was 1039 ha with 2378 households and total population of 9298. Overall, the share of backward population, scheduled caste (SC) and scheduled tribe (ST) was 64 and 6% in these villages and the primary focus of this project was to improve the livelihoods conditions of the tribal farmers in these villages. All the farmers were marginal farmers, operating less than a hectare of land with an average operational holding size of the 0.35 ha and 6% farmers were landless (Table 1). Average age of the respondent farmers was 41 years and the family size was 4.8 members per family. The cropping system was dominated by *kharif* paddy (average area of 0.22 ha) followed by *rabi* paddy (0.11 ha), homestead production land (0.08 ha)

**Table1.** Socio-economic status of the farmers in the study villages

| S. N. | Particulars | Average | Max | Min | Standard deviation |
|---|---|---|---|---|---|
| 1. | Operational area (ha) | 0.35 | 2.18 | 0 | ± 2.1776 |
| 2. | Family size (no) | 4.8 | 10 | 1 | ± 1.5831 |
| 3. | Age of respondents (years) | 41 | 55 | 28 | ± 7.4757 |
| 4. | Area undercrops | | | | |
| (a) | *Kharif* paddy (ha) | 0.22 | 0.60 | 0 | ± 1.4167 |
| (b) | *Rabi* paddy (ha) | 0.11 | 0.53 | 0 | ± 1.3467 |
| (c) | Homestead land (ha) | 0.08 | 0.20 | 0.03 | ± 5.2054 |
| (d) | Mixed vegetables and others (ha) | 0.06 | 0.16 | 0.01 | ± 4.9590 |
| 5. | Production of crops | | | | |
| (a) | *Kharif* paddy (kg per household) | 1013 | 2940 | 0 | ± 15.7822 |
| (b) | *Rabi* paddy (kg per household) | 680 | 2240 | 0 | ±17.6888 |
| (c) | Homestead land (vegetables kg per household) | 101 | 280 | 70 | ± 34.6107 |
| (d) | Mixed-vegetables(vegetables kg per household) | 1062 | 3805 | 260 | ±801.8890 |
| 6. | Area under pond (ha) | 0.09 | 0.20 | 0.02 | ± 0.4248 |
| 7. | Income from agriculture (Rs/household/year) | 25768 | 90277 | 2747 | ± 28037.18 |
| 8. | Off-farm income(Rs/household/year) | 20084 | 25500 | 12300 | ± 3551.72 |
| 9. | Landless (%) | 6 | | | |
| 10. | Primary occupation – agriculture (%) | 69 | | | |
| 11. | Primary occupation – labourers (%) | 31 | | | |
| 12. | Total net cropped area (ha) | 22.77 | | | |
| 13. | Gross cropped area (ha) | 29.15 | | | |
| 14. | Cropping intensity (%) | 128 | | | |

and mixed vegetables plot (0.06 ha). Average production of *kharif* paddy (grown by all except landless farmers) was 1013 kg per family per year and 680 kg for *rabi* paddy (grown by 24% of the farmers). Almost all the farmers in the study area possessed some kind of homestead production system (Mandal *et al.,* 2016) along with a pond. Average production of vegetables (mainly) from homestead land was estimated to be 101 kg and the average size of pond was 0.09 ha. Besides, the farmers also grow vegetables in their mixed-crop plot and the average production was 1062 kg per household per year. Average income from agriculture (estimated from the quantity of produce sold by the farmers) was ₹ 25768 per households per year and the off-farm income (mainly from daily wage or migrant labourers) was ₹ 20084 per households per family. Agriculture was the primary occupation for 69% of the sample farmers and rest were working either as daily paid wage labourers or working in the distant places as seasonal migrant labourers. The cropping intensity of the production system was estimated to be 128%. Key objective of the project was to increase this baseline cropping intensity through higher cropping system intensification by better land use management options and thereby increasing agricultural income of the farmers. Further insights from the villages, socio-economic status of the tribal farmers of *Amlamethi* village indicated that they were extremely resource poor, 83 of them were having tiny operational holdings (0.18 ha) and 17 percent were landless. Around 40% were illiterate and over half of the farm families were not having food self-sufficiency from their own production system. Primary occupation of these tribal farmers was acting as daily paid labourers (engaged in neighbour's agricultural field or government schemes like MGNREGA), seasonal migration to other states (3-6 months) or daily wage labourers in cities (such as Kolkata) and their livelihoods were not secure.

### Investment and interventions types

During the project period 2014-15 to 2017-18 a number of land use options and soil nutrient management practices have been demonstrated at the fields of collaborative farmers. Various interventions have been covered over 95 farmers in the study area (Table 2). Special attention has been given to the landless (6%) farmers also through interventions in improving their homestead land. Key interventions made, were land shaping techniques (farm pond, renovation

**Table 2**. Investment and types of interventions made for alternative land use

| Sl. no. | Name of interventions | No of farmers | Area of interventions (ha) | Investment (₹ lakh#) |
|---|---|---|---|---|
| 1. | Land shaping | | | |
| (a) | Farm pond | 56 | 9.2 | 55.26 |
| (b) | Renovation and de-siltation of pond | 16 | 4.1 | |
| (c) | Paddy-cum-fish | 5 | 1.8 | |
| (d) | Medium ridge and furrow | 6 | 2.1 | |
| | ***Sub-total (land shaping)*** | ***83*** | ***17.2*** | ***55.26*** |
| 2. | Improving homestead production system and crop diversification | 56 | 5.7 | 4.77 |
| 3. | Soil reclamation and fertility management | 123 | 13.7 | 2.48 |
| 4. | Development of fish culture | 72 | 8.0 | 6.42 |
| 5. | Green manuring | 126 | 14.0 | 0.45 |
| | ***Sub-total (non-land shaping)*** | * | ***41.4*** | ***14.12*** |
| 6. | Vermicompost unit | 43 | - | 1.35 |
| 7. | Farm implements | 43 | - | 1.90 |
| 8. | Others (survey, farmers training etc) | 123 | - | 1.55 |
| | Total | * | **58.6** | **74.18** |

Note: Per hectare cost of land shaping ₹ 3.2 lakh per ha including soil excavation and input support during the project period (2014-15 to 2017-18), Cost of vermi-compost unit ₹ 3000 per unit and cost of farm implements (sprayer) is ₹ 440 per unit. *Total number of farmers under non-land shaping interventions will not tally with column total as multiple interventions have been made for many farmers. Figures in parentheses indicated investment per hectare. # ₹ 1 lakh= ₹ 100 thousand

and de-siltation of existing pond, paddy-cum-fish and medium ridge and furrow system), improving homestead production system, crop diversification, soil reclamation and fertility management, development of fish culture, vermi-compost unit, green manuring (*Sesbania* spp.) and distribution of small farm implements (e.g., hand sprayer, water pump set & vermi-beds). Together with all these interventions an amount of ₹ 74.18 lakh was spent for improving the land use pattern towards higher income of the farmers. Out of this total investment ₹ 55.26 lakh was utilized for land shaping interventions and ₹ 14.12 lakh for improving homestead productions system, soil reclamation and fertility management, developing fish culture, green manuring; and rest amount (₹ 0.80 lakh) was incurred on preparation of vermi-composting units, buying farm-implements, conducting survey and farmers training during the period 2014-15 to 2017-18. Land shaping technologies were implemented on 17.2 hectares of land covering 83 farmers. Overall the project activities have covered over 95 farmers and some of the farmers have been benefited with multiple interventions.

### Change in cropping pattern and economic impact of the land use options

Economic impact of these alternative land management options has been analyzed by comparing the return, before and after the interventions. Detailed cost-return has been calculated both per hectare as well as on total area under interventions from 60 numbers of collaborative farmers during 2017-18. After land shaping interventions the land becomes suitable for growing multiple crops (mainly vegetables) particularly in *rabi* season. The cropping intensity has increased to 288% which is significantly higher than estimated baseline level of intensification (128%) (Table 3). Overall the crop-fish integration increased the farmers income to ₹ 158730 per ha, comprising of income from vegetables cultivation (₹ 189266 per ha), paddy (₹ 39897 per ha) and pond fisheries ₹ 17.68 lakh per ha). Per hectare return from agriculture after interventions (₹ 158730 per ha) was substantially higher than the prevailing farm income (₹ 73623 per ha or ₹ 25768 per average area of 0.35) as estimated from baseline survey.

### Return to investment on alternative land use and management options

Return to investment on alternative land use options has been examined through investment analysis criteria, IRR, NPV, BCR and Payback period. Based on earlier experiences (Mandal *et al.,* 2013, 2015) the economic life of the land shaping interventions has been assumed to be 10 years. Although such interventions can be productive for many more years beyond this economic life period (10 years), however after this economic life there is a need of large amount of additional investment for repairing of embankments and de-silting of pond or furrows. Also, in view of the changing socio-economic conditions and broader policy environment, assuming longer economic life for carrying out investment analysis on such natural resource management technology interventions may not reflect the actual grassroots scenarios. The discount rate has been applied @14% and this rate was sufficient to cover the time value of money due to inflation and risks. It is also assumed that the cost and return of inputs and output under interventions would change at same magnitude throughout the economic life of the project.

Investment analysis on these alternative land use options has been carried out by estimating incremental cost-return of interventions on per hectare basis at 2017-18 prices. For calculating the per hectare cost-return of these land use options, detailed information was collected from 60 collaborating farmers in this project during 2017-18. Under this TSP funded project an amount of ₹ 55.26 lakh has been invested on different land shaping interventions on 17.2 ha of land. The land shaping interventions are modification of land configuration of 20% land area, converting to on-farm reservoir (OFR) for water harvesting structures (pond or furrow). Therefore, for a hectare of targeted land under interventions, there is a need of creating OFR of 0.20 ha only. Thus, actual area under interventions for all land shaping techniques under the project was 86 hectare (17.2 ha multiplied by 5) and per hectare investment cost has been estimated to be ₹ 4256 (2017-18 prices) (Table 4). This amount has been assumed to be the initial investment (₹ per ha) considering all land shaping interventions. Besides, the project

**Table 3.** Impact on cash return of cropping system and alternative land use options (2017-18 prices)

| Sl.no | Crops | Area (ha)* | Production (kg)* | Farm-gate price (₹ kg$^{-1}$) | Return (₹ per actual area) | Return (₹ ha$^{-1}$) |
|---|---|---|---|---|---|---|
| **A** | **Vegetables** | | | | | |
| (a) | Ridge gourd | 0.35 | 1025 | 10 | 10250 | 29567 |
| (b) | Cowpea | 0.35 | 572 | 15 | 8580 | 24750 |
| (c ) | Bitter gourd (*rabi*) | 0.23 | 2117 | 20 | 42340 | 186794 |
| (d) | Bitter gourd (*kharif*) | 0.11 | 575 | 20 | 11500 | 107813 |
| (e) | Lady's finger | 0.33 | 5373 | 15 | 80595 | 246719 |
| (f) | Cabbage | 0.32 | 2755 | 10 | 27545 | 86078 |
| (g) | Cauliflower | 0.31 | 6080 | 10 | 60800 | 198261 |
| (h) | Pumpkin | 0.12 | 1768 | 5 | 8840 | 73667 |
| (i) | Knol-khol | 0.23 | 2065 | 15 | 30975 | 132750 |
| (j) | Amaranthus (red) | 0.31 | 3172 | 10 | 31720 | 101234 |
| (k) | Spinach | 0.30 | 3491 | 10 | 34910 | 116367 |
| (l) | Green chlli | 0.13 | 1860 | 20 | 37200 | 293684 |
| (m) | Red chilli | 0.13 | 619 | 60 | 37140 | 293211 |
| (n) | Coriander leaf | 0.31 | 2959 | 40 | 118360 | 377745 |
| (o) | Radish | 0.32 | 2695 | 12 | 32340 | 101063 |
| (p) | Brinjal | 0.33 | 8570 | 25 | 214250 | 655867 |
| | Total | 4.16 | 45696 | - | 787345 | 189266 |
| **B** | **Paddy (variety wise)** | | | | | |
| (a) | Masuri | 4.93 | 12930 | 14 | 181020 | 36693 |
| (b) | CR 1017/CR1018/R1009 | 1.67 | 7500 | 12 | 90000 | 54000 |
| (c ) | Dudheswar | 3.73 | 7847 | 18 | 141246 | 37834 |
| | Total | 10.33 | 28277 | | 412266 | 39897 |
| **C** | **Fish (pond)** | 0.68 | 10079 | 120 | 1209480 | 1768246 |
| D | Overall (vegetables+paddy+fish) | 15.18 | 84052 | | 2409091 | 158730 |
| E | Overall (vegetables+paddy) | 14.49 | 73973 | | 1199611 | 82770 |
| F | Net cropped area* (vegetable +paddy) | 5.04 | | | | |
| G | Cropping intensity (excluding fisheries) | 288 | | | | |

Note: *Area and production represented total of 60 farmers.

**Table 4.** Return to investment on alternative land use and management options

| Sl. No. | Parameter | Cost/Return over economic life | |
|---|---|---|---|
| | | 1st year | 2nd - 10th Year |
| 1 | Initial investment (₹ ha$^{-1}$) | 64256 | 0 |
| 2 | Annual investment (₹ ha$^{-1}$) | 0 | 34106 |
| 3 | Opportunity cost* (₹ ha$^{-1}$) | 73623 | 73623 |
| 4 | Total cost (₹ ha$^{-1}$) | 137879 | 107729 |
| 5 | Gross return (₹ ha$^{-1}$) | 0 | 158730 |
| 6 | Incremental net return (₹ ha$^{-1}$) | -137879 | 51001 |
| 7 | Investment criteria | | |
| (a) | Internal Rate of Return (%) | 34 | |
| (b) | Net Present Value (NPV in ₹) | 100343 | |
| (c) | Benefit Cost Ratio (BCR) | 1.17 | |
| (d) | Payback (years) | 1.26 | |

Note: *Opportunity cost is the per hectare return before interventions calculated from baseline

**Table 5.** Impact of land shaping technologies on soil quality

| Sl. No. | Land shaping technologies | pH | | ECe (dS $m^{-1}$) | | Organic Carbon (%) | |
|---|---|---|---|---|---|---|---|
| | | Before | After | Before | After | Before | After |
| 1. | Farm pond technology | 5.5 | 5.9 | 6.8 | 5.7 | 0.62 | 0.67 |
| 2. | Shallow furrow & medium ridge | 4.4 | 4.7 | 7.8 | 6.7 | 0.43 | 0.47 |
| 3. | Paddy-cum-fish cultivation | 4.2 | 4.5 | 12.5 | 10.3 | 0.40 | 0.43 |

has also extended support to input supply for crop cultivation (vegetables and paddy seeds, fish fingerlings, feed etc) as well as better land management through inputs (lime, dolomite etc particularly for acid sulfate soil management). Total expenditure on all these inputs supply and land management was ₹ 14.12 lakh for an area of 41.40 ha or ₹ 34016 per ha. This amount (₹ 34106 per ha) is considered as the incremental cost required by the farmers. Opportunity cost was calculated by deducting prevailing per hectare return (₹ 73623 per ha) of the farmers as estimated from baseline information (₹ 25768 for an average area of 0.35 ha), before interventions of these land use options (Table 3). Total cost was calculated by addition of investment on land shaping (for 1st year), annual investment (subsequent years) and opportunity cost (throughout the economic life) for the first year. Return for the first year was assumed to be nil as it was the time period required for planning, arranging finance and execution of the land shaping. Return per hectare (₹ 158730 per ha) has been calculated based on detailed input-output data collected from 60 collaborating farmers at 2017-18 prices. Per hectare incremental return (₹ 51001 per ha) has been calculated by deducting opportunity cost (₹ 73623 per ha) from return after interventions (₹ 158730 per ha). All investment criteria, IRR (34%), NPV (₹ 100343) and BCR (1.15) indicated such investment was quite effective and also recovered the initial investment quickly (payback period was 1.26 year). Overall the return to investment on all alternative land use options indicated the positive impact by increasing farmers' income and such proposition was quite effective for these small-holder farmers.

## Impact of land use options on soil quality

Besides positive impact on farm economy in terms of increase in cropping intensity and enhancing income, the land shaping technologies also have benefits to improve the soil quality. The impact of land shaping technologies on soil quality such as pH, salinity (ECe) and organic carbon has been analyzed before and after the interventions at farmers' fields. All these soil quality parameters under different land shaping technologies indicated improvement over the initial level, thus facilitated the land suitable for growing multiple crops and have increased cropping intensity (Table 5). Crop choices by the farmers in the coastal salt-affected areas are highly restricted due high salinity particularly during *rabi* season. Lowering the salinity level, primarily due to presence of harvested of freshwater in the land shaping plots has created opportunities for growing more number of crops (also diversification) after the interventions.

## Constraints for adoption alternative land management options

Constraints of large scale adoption of these successfully evolved alternative land use options have been analyzed through ranking analysis, based on the response from the respondent farmers. Through Focused Group Discussion (FGD), the constraints have been ranked by percentage of respondents. Marginal land holdings (average operational holdings of 0.35 ha) that too fragmented over several plots was the key constraints (95%) of out-scaling of these alternative land use options (land shaping technologies in particular), followed by high initial investment on soil excavation (90%); input availability in time, quantity and quality (due to remoteness of the place) (84%); uncertainty in market prices (80%); scarcity of labour in time (76%); backwardness and poor road connectivity (75%) that often makes the transportation of commodities very difficult and instability of production and risk (70 percent) due to soil and

**Table 6.** Constraints in out-scaling of alternative land use options

| Sl. No. | Constraints | % of respondent | Rank |
|---|---|---|---|
| 1. | Marginal land holdings with multiple sub-plots | 95 | 1 |
| 2. | High initial investment | 90 | 2 |
| 3. | Input availability in time, quantity and quality | 84 | 3 |
| 4. | Uncertain market prices | 80 | 4 |
| 5. | Scarcity of labour in time | 76 | 5 |
| 6. | Backwardness and poor road connectivity | 75 | 6 |
| 7. | Instability in production and risk | 70 | 7 |
| 8. | Presence of acid sulfate layer at shallow depth | 68 | 8 |

water salinity in patches often increased mortality of plants. Presence of acid sulfate soil (68%) at a very low depth was one the key technical constraints for promotion of land shaping as this soil is neither suitable for crop cultivation nor fisheries. Once exposed through excavation, it may require several years for soil management to make suitable for cultivation. Therefore, utmost care needs to be taken while excavation of soil affected by acid sulfate.

## Conclusions

Coastal salt-affected soils are typically constrained with low productivity, low cropping system intensification (dominated by *kharif* paddy) and hence low income of farmers (Humphreys *et al.*, 2015). Alternative land management options such as land shaping technologies (farm pond, paddy-cum-fish cultivation or furrow & ridge methods) coupled with suitable natural resources management (soil amendment by lime, applying vermi-compost or green manuring) increased the land productivity and farmers income substantially. Investment on such alternative land management options have been quite successful in terms of improving soil quality, increasing cropping system intensification through multiple cropping and in turn increasing the farmers income significantly. However, large scale out-scaling of such interventions are constrained with several factors like fragmented (sub-plot) land holdings, high initial investment, quality input availability at time, uncertain market prices, high instability of crop output & agricultural risk and presence of acid sulfate soil layer at shallow depth. Overall such land use interventions favoured the investment in large scale in the disadvantaged coastal salt-affected areas for better livelihoods of the farming communities.

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