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Land shaping to enhance productivity and economic benefit in coastal region of West Bengal

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Abstract
Field experiment was conducted in low-lying coastal region of West Bengal to evaluate the impacts of the farm-pond land shaping technology on crop productivity and economic returns. A land shaping model for small holding of 0.30 ha was developed with excavated pond area 0.06 ha, raised land 0.20 ha, land embankment 0.01ha and pond embankment 0.017 ha. The pond size of 72 ft × 60 ft × 9 ft was capable of harvesting 10 acre-inches of rainwater, using for irrigation to *rabi* vegetables and banana grown on embankments, and also for fisheries and duckery. Results showed that the land shaping programme has converted the mono-cropping situation into multiple cropping with a value crop diversification index 0.81. Besides the creation of additional 410 man-days per annum, the net return from land shaping of 0.3 ha was Rs. 17986 with multiple cropping as against Rs. 2652 from mono-cropped with *kharif* paddy before land shaping. The net present value of benefit was Rs. 1,17,387 and benefit-cost ratio was 1.97, which was quite encouraging for the farmers to adopt this eco-friendly technology in fragile coastal ecosystem.

Keywords: Land shaping, crop productivity, economic return, eco-friendly

Introduction
Primary source of livelihood in coastal region of West Bengal is agriculture (Bandyopadhyay *et al*., 2003) [2]. Large scale mono-cropping with *kharif* rice followed by land fallowing during dry period results in low cropping intensity (146%) compared to that of the state. Crop productivity of the area is very low due to number of abiotic stresses. The major bottlenecks are soil salinity, lack of irrigation facility, water logging and poor drainage of fields in monsoon (Mandal *et al.*, 2011) [5]. The area is also prone to climatic disasters like storm and flood with intrusion of sea water. The submergence of crop land due to heavy rain and thereafter non-availability of irrigation water during post-monsoon period is the most common feature of this region.

Land shaping technology may be a viable proposition for low-lying situation as it provides ample scope for rainwater harvesting, increases cropping intensity and creates income and employment opportunities (Bandyopadhyay *et al*., 2009) [1]. The mean annual rainfall of this region is about 2000 mm of which 90% occurs during June to September, resulting in water-logging of most of the low-lying lands. A substantial amount of rain water is lost as runoff to sea which can otherwise be harvested for irrigation during dry periods. However, the land shaping is an improved engineering solution for productive use of low land in costal ecosystem by introduction of double cropping or micro situation based diversified cropping. It creates opportunity of work throughout the year. Moreover, this technique conserves groundwater by effective land and water use. Therefore, an attempt has been made to adopt the land shaping technique in mono-cropped area of coastal West Bengal to enhance agricultural productivity and farm income of small farmers.

Materials and Methods
Field study was conducted during 2015-2018 at Lalpur and Prasadpur villages of Dhablat Gram Panchayet, South 24 Parganas situated under the coastal saline zone of West Bengal. The soil was clay-loam with pH 7.9. The mean annual rainfall is 1783 mm. In this study, the farm pond land shaping technology had been adopted to harvest excess rain water by digging out farm pond. The dug-out soil was used for raising the land to form well drained upland

situation for growing multiple crops including vegetables. In this method, the farmer's field of 0.30 ha with length of 180 ft and breadth of 120 ft was selected (Fig. 1). About 20 % of the farm area (0.06 ha) was excavated up to 9 ft to form a farm pond for rain water harvesting. The length and breadth of the pond were 72 and 60 ft respectively. The excavated soil was used to raise the adjoining low land area up to 1 to 1.5 ft to form a high land condition. Around the periphery of the pond, an embankment was made of 4 ft width and 5 ft height, constituting an area of 0.017 ha for vegetable cultivation. The total land area was also provided with an embankment having an area of 0.01 ha. This high land was free from water logging during monsoon and suitable for multi-cropped cultivation. The pond water was used for aquaculture and irrigation in rabi/summer period. Different crops were grown on land, and land and pond embankments throughout the year with recommended practices. To judge the sustainability of land shaping, the Simpson index of crop diversification was calculated by the following formula-

Simpson Index of Diversification $(SID) = \frac{n}{1 - \Sigma(X_i / \Sigma X_i)^2}$, where X_i = area under i^{th} crop & index scale = 0 to 1

Economics of the land shaping was calculated based on net present value (NPV) and benefit-cost ratio.

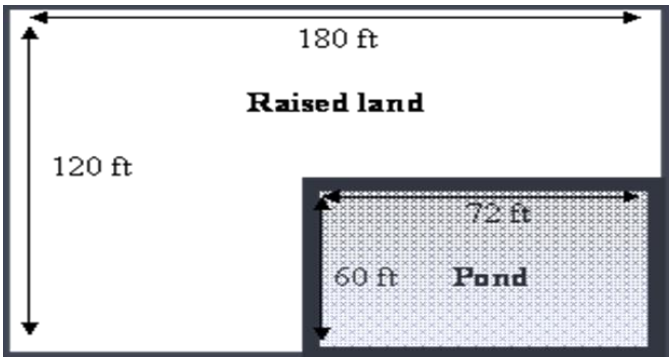

Fig 1: A land shaping model for small holding (0.30 ha)

Results and discussion

Agricultural productivity

Land shaping is a simple technique, mainly based on local inputs. The main investment is labour, which is ample in this area of high population and high unemployment. But the net impact of land shaping is high. Farmers can grow crop throughout the year. Our study also showed the same result. Before implementation of land shaping program, mono-cropping of paddy was practised there only in *kharif* season. This *kharif* paddy also used to produce lesser yield due to deep water-logging. After implementation of land shaping technology on those areas, several land conditions were created resulting in crop diversification as well as crop intensification. In our research field, a sustainable farming system was developed by integrating agriculture, horticulture and fisheries components. Out of total 0.30 ha, the raised land of 0.20 ha was utilised for growing high yielding paddy in *kharif* (Table 1). At the land embankment area of 0.01 ha, dolichos bean was profitably grown due to devoid of water-logging. The dug-out farm pond of 0.06 ha was capable of storing 10 acre-inches of water, which was utilised for fisheries and duck rearing throughout the year. The pond embankment of 0.017 ha was used for growing vegetable okra and aerial cultivation of bottle gourd over the bamboo structure constructed along the inner side slope of the pond. With the help of harvested water, farmers had grown *rabi* vegetables like hybrid tomato on 0.2 ha raised land, french bean on 0.01 ha land embankment and bitter gourd on 0.017 ha pond embankment. The harvested rain water was used for irrigating those *rabi* vegetables. On the pond embankment, the year round cultivation of banana was done for higher profit. The number of crops in a year was gone up and farmers were planting a varied range of crops, which provided nutritional security to farm families. The value of the Simpson index of crop diversification was estimated 0.81, indicating highly diversified cropping pattern. The diversity generated through this technology became asset of those marginal farmers and also strengthened the ecosystem. The agricultural production of the land-shaped area had increased by 40–50%. Even they had a surplus to sell. The above results were in conformity with CSSRI (2008) [4].

Economic feasibility

Land shaping program allows the farmers to grow different types of profitable crops throughout the year, resulting in higher income and better socio-economic conditions of farmers. Before implementation of land-shaping program, farmers used to grow only *kharif* paddy and the net return was Rs. 2652 from the research area of 0.30 ha (Table 1). After implementing this technology, the farmers were able to grow diversified crops in different seasons and so, the net returns from the same area also increased many-folds. The total enhancement of net return due to multiple cropping was Rs. 17986, of which *kharif* crops contributed Rs. 2978, from *rabi* vegetables Rs.12030, and also from fisheries/duckery and banana Rs. 2978. The maximum income came from *rabi* vegetables, specially from hybrid tomato grown on the upland condition, produced satisfactory yield as those were periodically irrigated by the pond water as and when required. This higher return from *rabi* crops provided surplus income to the farm families, which was not available to them before implementing the program. Therefore, this technology gave 6.78 times more return over mono-cropping which was practiced before land shaping. The higher farm income was reported by Pandey *et al*. (2005) [6].

The economic benefits in terms of the net present value and benefit-cost ratio from land shaping of 0.30 ha farmland was calculated considering the economic life for 15 years (Table 2).The initial expenditure compared to the benefits was little bit higher due to the labour cost involved for land shaping. But as the time progresses, the cost was cut down as only maintenance of the land was needed. Therefore, the income of the farmers increased over time due to the productive use of the land throughout the year. The excavated pond also started to produce surplus income to the farmers through fish production and duckery. Not only that, the farmers could get periodical income either from paddy or winter vegetables or fishery/duckery or banana year-round. The monetary gain was converted to present value of rupees at 10% discounting factor (D.F.). Thus, the present value of gross benefits was recorded Rs. 2,38,292 and that of gross cost Rs.1,20,355. So, the net present value of benefit was Rs. 1,17,387 and benefit-cost ratio was 1.97, which was quite satisfactory and encouraging for the farmers to adopt the land shaping technology.

Besides the economic viability of land-shaping programme, it had generated a large number of man-days in different activities (Table 3). It is a labour-intensive technology, therefore, the employment generation for excavation of pond was 200 man-days and that of for multiple cropping and allied activities were 160 and 50 man-days respectively. Hence, a

total creation of 410 additional man-days through year-round activities became an employment source for rural youth and women, who were otherwise compelled to migrate to other jobs in the lean periods and shift from the parental occupation of agriculture. The benefit of employment generation was also reported by Burman *et al*. (2007b) [3].

Table 1: Crop diversification and net returns from land shaping (0.30 ha)

Before land shaping	**Mono cropping**	**Rs. 2652**
After land shaping	Multiple cropping	Rs. 17986
Kharif		1768
HYV paddy	0.20 ha land	380
Dolichos bean	0.01 ha land embankment	400
Bottle gourd	Aerial cultivation	430
Ladies finger	0.017 ha pond embankment	Net return (A)-Rs. 2978
Rabi		10353
Hybrid Tomato	0.20 ha land	650
French bean	0.01 ha land embankment	1027
Bitter gourd	0.017 ha pond embankment	Net return (B)-Rs.12030.0
Year round		954
Banana	0.017 ha pond embankment	2024
Fish/prawn and duck	0.06 ha pond	Net return (C)-Rs. 2978
Total net return (A + B + C) = Rs. 17986		

Table 2: Economic analysis of land shaping programme

Year	**Gross Costs (Rs.)**	**Present Value at 10% D.F. (Rs.)**	**Gross Benefits (Rs.)**	**Present Value at 10% D.F. (Rs.)**	**NPV of Benefits at 10% D.F. (Rs.)**
1	32000	29088	29468	26786	-2302
2	13181	10887	31167	25743	14856
3	13265	9962	31251	23469	13507
4	13322	9098	31308	21383	12285
5	13464	8361	31450	19530	11169
6	13582	7660	31568	17804	10144
7	13657	7006	31643	16232	9226
8	13729	6411	31715	14810	8399
9	13813	5856	31799	13482	7626
10	13906	5367	31892	12310	6943
11	14010	4903	31996	11198	6295
12	14096	4496	31996	10206	5710
13	14158	4105	31996	9278	5173
14	14220	3739	31996	8414	4675
15	14297	3416	31996	7647	4231
		1,20,355		2,38,292	1,17,937

BCR=1.97

Table 3: Employment generation in land shaping programme

Activities	**Man-days created**
1. Excavation of pond	200
2. Multiple cropping and integration	160
3. Allied services	50

Conclusion

The study clearly indicates that land shaping is an effective technology for conserving rainwater, augmenting land productivity and enhancing income and employment of the farm families without any detrimental effect to the fragile coastal ecosystem. Therefore, a policy measure is utmost necessary for promoting this technology in a large scale towards livelihood security of small holders.

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