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Research Note

An Economic Analysis of Land Reclamation Technologies for Amelioration of Irrigation-induced Soil Degradation

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Abstract

The economic feasibility of land reclamation technologies adopted by the farmers of Tungbhadra Command Area in Karnatka for amelioraion of irrigation-induced soil degradation has been studied. The data have been analysed using tabular method and partial budgeting method. It has been found that the available technologies are not being spread effectively among the affected farm households. Amongst different technologies followed by the farmers, adoption of leaching has been found least costly and could result in an incremental output of 14 quintals per hectare on saline soils of both head- and mid-regions. Green manuring has been observed to be another effective technology and could enhance crop yields on saline as well as waterlogged soils. Partial budgeting analysis has suggested that the technologies are viable irrespective of the farm size. Biological measures such as adoption of salt-resistant crop varieties can be profitable for small and marginal farmers. Instead of leaving their lands fallow due to their inability to adopt capital-intensive technologies, they should adopt them for land reclamation and higher returns.

Introduction

The problem of land degradation has been acute in certain areas, especially in the arid and semi-arid regions. Vast stretches of land resources are threatened with degradation at a fast pace. The degradation process of soils is posing a great threat jeopardizing food security not only for the present generation but for the future generations also. Degradation of the ecosystem, particularly the land component and the consequential loss of

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productivity of this precious resource would severely affect the survival of a majority of human and livestock populations. The resultant effects of the problem could be massive unemployment, migration of labour, regional disparity, loss of natural resource-base, ecological imbalances, etc. These problems though develop at a slower pace initially, assume alarming proportions later to affect the agrarian economy rather seriously. The problem of soil degradation is likely to aggravate further as new areas are being brought under irrigation without adopting proper water management and drainage measures. Such soil degradation processes have already transformed large fertile irrigated areas into unproductive barren lands. In the long-run, these problems drive the land out of cultivation permanently.

The production potential of crops on saline and waterlogged soils is severely impaired leading to reduction in crop yields. For increasing agricultural production at both the farm and national levels, it is imperative to treat the problematic soils to increase their productive capacity. The main reason for the low output of crops cultivated on these soils is their low fertility status and presence of toxic substances. The remedial measures should address the elimination of these toxic substances and thereby increase the fertility status of soil to recoup the soil health to its original status.

In the recent past, many major and medium irrigation projects in the Karnataka state have witnessed serious soil salinity and waterlogging problems. There are five command areas in the state, namely Cauvery Command Area, Malaprabha and Ghataprabha Command Area, Bhadra Command Area, Tungabhadra Command Area and Upper Krishna Project Area.

Tungabhadra Command Area, considered to be the rice bowl of the state, is worst affected by irrigation-induced soil degradation in terms of soil salinity and waterlogging (4,7221 ha), accounting for over 55 per cent of the state's degraded land due to irrigation-induced soil degradation. The problem is more alarming due to vertisols. The problem of soil degradation is likely to aggravate further leading to permanent abandonment of land and posing of serious threat to the sustainability of soil and water resources. The productivity on degraded soils declined sharply by 36 per cent on saline and 43 per cent on waterlogged soils. The loss in employment was to the tune of 32 per cent (Chinnappa, 2002).

The feasibility of reclamation technologies is crucial in decision-making relating to the scale of investments for those who have sizeable landholdings in problematic soils. The saline and waterlogged soils are deteriorating and possess characteristics that are undesirable for plant growth. Therefore, for the successful establishment of crops, proper agronomic management practices should be adopted to suit the socio-economic condition of the farming community. Farmers have been practising some of the ameliorative/ reclamation measures mainly to bring about improvement in the land productivity.

The ameliorative measures adopted by the farmers to cope with the problem of soil degradation include both agronomical and biological methods. The agronomical method of soil reclamation plays an important role in the amelioration of saline and waterlogged soils. The essence of this method is land leveling, leaching, and surface drainage, which produce an ameliorative effect on the soil. The biological methods of soil reclamation include green manuring, addition of organic amendments and growing of resistant varieties. The present study attempts to evaluate such technologies economically to provide a feedback to the farming community.

Methodology

The study was conducted in the Tungabhadra Project area of the Karnataka state. This Command has the largest concentration of area under salinity and waterlogging compared to other irrigated commands of the state. Hence, it was purposively selected for the present study. There are four canals emerging from the dam site. Among them, the Tungabhadra left bank canal had the highest area under saline and waterlogged soils. Hence, this was selected for the study. Distributory No. 76 was selected at the third stage based on the area under degraded soils. Two villages, namely Byagwat and Hirekotnakal, listed under head- and mid-regions of the distributory, respectively were selected at the fourth stage. A sample consisting 50 respondents from the saline land and 50 from waterlogged land were selected from Byagwat village, representing head region of the distributory. Similarly, another sample comprising 50 saline and 20 waterlogged farms were chosen from Hirekotnakal village. Thus, 170 respondents constituted the sample for the soil degradation study. Primary data were collected from the respondents for the year 1999-2000 with the help of pre-tested schedules. The data comprised general information, landholdings, cropping pattern, assets, cost of cultivation, input-use pattern, reclamation methods, costs and returns, and factors affecting adoption of reclamation technology. Data were analysed by using tabular framework for computing cost and returns of reclamation technologies. Partial budgeting was employed to study the economic feasibility of various technologies adopted for reclamation.

Results and Discussion

(i) Farmer's Ameliorative / Reclamation Measures

The distribution of farm households according to different methods of ameliorative/reclamation measures is given in Table 1. It was observed that farmers adopted various methods to reclaim their problematic soils, namely (i) green manuring, (ii) surface drainage, (iii) organic amendments, (iv) land levelling, (v) leaching, and (v) growing of tolerant crop varieties. It was observed that 102 farmers had taken up these measures of reclamation of which, majority of the farmers (42 %) had adopted growing tolerant crop varieties, followed by organic amendments, (22%), and surface drainage (17%). However, the least number of farmers had adopted green manuring (4 %) and leaching (5 %) for reclamation. Intensive land levelling was another method adopted by 11 per cent of the farmers. Out of the total sample size (170) of problematic soils, around 32 per cent of the farmers in the head-region and 28 per cent in the mid-region reclaimed their lands by using these measures. The details of area reclaimed, reclamation expenditure, incremental output and results of partial budgeting pertaining to various reclamation technologies are provided in Tables 2-6.

(a) Green Manuring

Green manuring was found to be popular among some migrant Andhra farmers. Four farmers in the mid-region attempted this measure for reclamation of their saline and waterlogged soils. For green manuring, *Dhaincha* was grown immediately after *rabi* crop and incorporated into the soil before *kharif* planting. *Dhaincha* is a leguminous crop and is tolerant to high saline and waterlogged conditions. Green manuring with *Dhaincha* is particularly valuable in saline soils since it hastens the process of reclamation by hydraulic conductivity and leaching-out salts.

The cost of growing green manure crops, availability of irrigation water and other economic considerations would affect the decision of a farmer. The cost of growing green manures was minimal (Rs 460). Green manuring resulted in additional output of 13 quintals and 12 quintals of paddy on saline soils and waterlogged soils of the mid-region, respectively. The area reclaimed through this method was only 9 ha, accounting for only 6 per cent of the total reclaimed land. The practice of growing green manuring crops is yet to spread in the study area. At present, only a few progressive and innovative farmers with scientific outlook are practising this measure. It is worth emulating by other farmers too in the region, as this is a low cost technology. *Dhaincha* is the most appropriate crop for green manuring

Table 1. Distribution of sample farmers according to ameliorative /reclamation measures

(Number of farmers)

Reclamation measures	Head-region		Mid-region		Total	Percentage
	Saline soils (n = 50)	Waterlogged soils (n = 50)	Saline soils (n = 50)	Waterlogged soils (n = 20)	(n = 170)	
Green manuring	-	-	2	2	4	4
Surface drains	3	9	1	4	17	17
Application of organic amendments	5	4	9	4	22	21
land levelling	2	4	4	1	11	11
Leaching	1	-	4	-	5	5
Growing of tolerant crop varieties	17	11	10	5	43	42
Total	28 (16)	28 (16)	30 (18)	16 (10)	102 (60)	100.00

Figures within the parentheses indicate percentage to total number of respondents (170)

Table 2. Ameliorative / reclamation expenditure

(Rs/ha)

Ameliorative technologies	Head-region		Mid-region	
	Saline soils	Waterlogged soils	Saline soils	Waterlogged soils
Green manuring	-	-	460	460
Surface drainage	4250	3875	2083	2400
Organic amendments	1167	1094	2125	-
Land levelling	12812	8979	7487	2347
Leaching	-	-	-	-
Growing of tolerant crop varieties	-	-	-	-

because of its tolerance to salinity and waterlogging, besides generating an additional income of Rs 8,920 and Rs 8,320, respectively on saline and waterlogged soils of the mid-region.

(b) Surface Drainage

Surface drainage was adopted by 17 farmers, accounting for 17 per cent and reclaiming 23 hectares of land at the estimated ameliorative expenditure ranging from Rs 2,083 to Rs 4,250. Providing surface drainage involved opening of trenches of one metre depth with a spacing of seven metres between them around the field. It appeared that this measure was fairly suitable to saline and waterlogged soils to ensure leaching of salts and draining-out of water from time to time. Thus, less salty environment could be maintained around the root zone of crop plants. Surface drainage helped in removing excessive water which could adversely affect the crop. During the rainy season, the rain water that enters the field will also find its way through the surface drainage as runoff. Such a drainage provision had resulted in additional output of 13 quintals/ha on saline soils and 9 quintals/ ha on waterlogged soils of the head-region. The financial feasibility of technologies under farmers resource endowments has been well documented by Singh (1978) and Joshi (1983).

(c) Addition of Organic Amendments

Although the reclamation work could be carried out by following other methods, use of farmyard manure is beneficial in reclamation of degraded soils. It not only enhances the process of reclamation, but also provides essential plant nutrients and improves the physical conditions of the soil. Application of FYM also aids in the uptake of other native and applied nutrients by plants. A total of 22 farmers constituting 21 per cent had

Table 3. Area reclaimed by different ameliorative / reclamation measurers

(ha)

Ameliorative technologies	Head-Region		Mid-Region		Total		Total reclaimed land	Percentage
	Saline soils	Waterlogged soils	Saline soils	Waterlogged soils	Saline soils	Waterlogged soils		
Green manuring	-	-	7	2	7	2	9	6
Surface drainage	5	9	5	4	10	13	23	16
Organic amendments	7	2	12	5	19	7	26	19
Land levelling	4	3	3	3	7	7	15	9
Leaching	3	-	9	-	12	-	12	8
Growing of tolerant crop varieties	14	17	24	6	38	23	61	42
Total	33	31	60	2	93	52	145	100

Table 4. Incremental productivity on reclaimed land with different ameliorative /reclamation measures

(q/ha)

Ameliorative technologies	Head-region						Mid-region					
	Saline soil			Waterlogged soil			Saline soil			Waterlogged soil		
	Before	After	Incremental	Before	After	Incremental	Before	After	Incremental	Before	After	Incremental
Green manuring							11	24	13	10	22	12
Surface drainage	52	65	13	35	43	9	9	15	6	23	33	10
Organic amendments	48	52	4	46	49	3	23	31	8	22	28	6
Land levelling	15	19	4	33	39	6	33	46	13	19	26	7
Leaching	29	43	14	-	-	-	31	45	14	-	-	-
Growing of tolerant crop varieties	22	31	9	38	45	8	39	50	11	30	38	8

Table 5. Economic evaluation of ameliorative /reclamation technologies using partial budgeting — Head-region

(Rs/ha)

Technologies	Increase in cost		Decrease in returns		Total		Decrease in cost		Increase in returns		Total		Net change	
	S	WL	S	WL	S	WL	S	WL	S	WL	S	WL	S	WL
Green manuring	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface drainage	1057	840	-	-	1057	840	-	-	9388	6184	9388	6184	8331	5344
Amendments	1467	1306	-	-	1467	1306	-	-	2681	2252	2681	2252	1214	946
Land levelling	990	694	-	-	990	694	-	-	2681	4561	2681	4561	1690	3867
Leaching	-	-	-	-	-	-	-	-	9831	-	9831	-	9831	-
Growing of tolerant crop varieties	-	-	-	-	-	-	-	-	6342	5362	6342	5362	6342	5362

S = Saline soils
WL = Waterlogged soils

Table 6. Economic evaluation of ameliorative /reclamation technologies using partial budgeting — Mid-region

(Rs/ha)

Technologies	Increase in cost		Decrease in returns		Total		Decrease in cost		Increase in returns		Total		Net change	
	S	WL	S	WL	S	WL	S	WL	S	WL	S	WL	S	WL
Green manuring	460	460	-	-	460	460	-	-	9380	8780	9380	8780	8920	8320
Surface drinage	635	683	-	-	635	683	-	-	4468	6971	4468	6971	3833	6288
Ammendments	2412	913	-	-	2412	913	-	-	6306	4025	6306	4025	3894	3112
Land levelling	579	181	-	-	579	181	-	-	9601	4912	9601	4912	9022	4730
Leaching	-	-	-	-	-	-	-	-	9924	-	9924	-	9924	-
Resistant plant varieties	-	-	-	-	-	-	-	-	7593	5970	7593	5970	7593	5970

S = Saline soils
WL = Waterlogged soils

practised this method to reclaim their lands. An area of 26 ha was put to reclamation by this method. The farmers who practised addition of organic amendments like FYM were able to obtain an additional output of 4 quintals/ha and 3 quintals/ha, respectively on saline and waterlogged soils of the head region. This indicated that even practising of such indigenous and inexpensive method could have some ameliorative effect on the degraded soils, resulting in modest increase in output. With a judicious application of both organic manures and chemical fertilizers, building-up of soil fertility became possible. Thus, considerable improvement could be brought about gradually to enhance the output levels on saline and waterlogged soils.

(d) Land Levelling

Reclamation of saline and waterlogged soils can be accomplished by proper levelling and bunding. Land levelling was adopted as an ameliorative measure by 11 farmers, accounting for 11 per cent to reclaim 13 ha of land at the estimated cost ranging from Rs 8,979 to Rs 12,812 in the head-region and Rs 2,347 to Rs 7,487 in the mid-region. The fields were levelled to almost zero slope and smoothed with the help of tractors and strong bunds were put around the fields so that outside water did not enter into the field under reclamation. Preventing the entry of outside water was crucial because if such water came through the adjoining fields, the water could get contaminated on the way and could bring harmful substances. Hence, levelling of land played a key role in the reclamation of saline and waterlogged soils by boosting the productive capacity of land. The additional output obtained was substantial on saline soils of the mid-region (13 quintals).

(e) Leaching

Leaching of saline soils was practised by 5 farmers. About 12 ha land was reclaimed through leaching. Leaching of saline soils with canal water for long periods results in leaching-out of the soluble salts below the root zone. With repetition of this process for a few years, farmers were able to reclaim their lands to some extent and could grow a few crops like rice. Leaching is done by impounding the water in the field, making to it stand for a period of over one week and then draining out. It was done continuously by applying 10 cm of water every week before planting. Leaching did not involve additional expenditure. It was an easy and low cost technology promising higher benefits. It could produce incremental yield of 14 quintals/ha of grains on saline soils in the head and mid regions. The method was not being followed by many farmers mainly due to non-availability of good quality water in the region. Though canal water was being provided for cultivation of crops, the water flowed through and got contaminated on its way. Intermittent impounding with good quality water could enhance the leaching efficacy. For obtaining optimum results, continuous submergence should be avoided. The intermittent flooding and draining of fields decreased the effect of harmful salts for the successful cultivation of crops. The results indicated that leaching was the best method with higher benefits at the least cost. In areas, where good quality water was not available, farmers may be advised to use groundwater or rainwater during the monsoon season.

(f) Growing Resistant and Tolerant Plant Varieties

Growing crop varieties, which are tolerant to saline and waterlogged situations is quite promising for effective utilization of degraded soils. It was found that 43 farmers (42%) practised this method and could put 61 ha of land to productive use. As the cost of this technology is quite low, it is worth emulating by other farmers. Tolerant genotypes can be successfully grown on the degraded soils. The additional benefit obtained by this method was of 9 quintals/ha and 7.5 quintals/ha, respectively on saline and waterlogged soils of the head-region. Thus, the management practices such as choice of crop varieties that are tolerant to soil degradation can aid in obtaining relatively higher yields.

(ii) Economic Evaluation of Different Ameliorative/ Reclamation Measures

Partial budgeting method was employed to appraise the economic feasibility of various ameliorative /reclamation measures adopted by respondents for the amelioration of their degraded lands. The additional costs due to above ameliorative /reclamation measures were estimated and compared to additional returns. The partial budgets for each of the ameliorative/ reclamation measures were constructed and the summaries are presented in Tables 5 and 6. The results indicated that all the technologies provided higher returns with varying degrees.

Green manuring generated higher marginal returns as revealed by the partial budgeting analysis, indicating its cost-effectiveness. This is presumably due to the lower cost incurred on this practice. Economic evaluation of ameliorative expenditure on organic amendments for restoring fertility of saline and waterlogged soils by partial budgeting technique indicated that marginal increase in returns over the costs in the head-region was of the order of Rs 1,215 and Rs 946, respectively. The gain was higher in the mid-region with Rs 3,894 and Rs 3,112 for these soils, respectively, indicating that the technology was promising and economically sound.

Ameliorative/reclamation expenditure incurred on the biological amelioration of saline and waterlogged soils through adoption of salt-tolerant crop varieties showed that the additional returns over the additional costs were higher than other ameliorative measures. This indicated that the technology was economically feasible for producing foodgrains in different degraded soils and it will be more cost-effective and suitable for resource poor farmers.

Land levelling needed fairly high ameliorative /reclamation expenditure, ranging from Rs 2,347 to Rs 12,812. The ameliorative expenditure on this method was highly capital-intensive in nature. It was difficult to afford by small and marginal farmers. In order to induce the farmers to undertake such high cost ameliorative /reclamation measures at a faster rate, subsidies ranging from 25 to 50 per cent may be given. This will not only reduce the farmer's ameliorative/reclamation expenditure but will also help in boosting the productivity of degraded soils.

Surface drainage is yet another method of amelioration /reclamation which yielded additional returns of Rs 8,331, Rs 5,344, Rs 3,833 and Rs 6,288, respectively on saline and waterlogged soils of the head and mid regions. This indicated that ameliorative expenditure on surface drainage was an economically sound proposition. Unwanted environmental degradation like soil salinity and waterlogging could be avoided by practising leaching as ameliorative method. The resultant benefits from such an expenditure were found to be greater than costs. The results of partial budgeting indicated that leaching was the best amelioration/ reclamation measure with the minimum expenditure. The technologies adopted as coping methods to overcome the problem of soil degradation were found to be economical and profitable, as revealed by the partial budgeting analysis. Hence the hypothesis that ameliorative expenditure is cost-effective and the reclamation measures enhance productivity levels were testified.

Summary and Conclusions

Available reclamation technologies have been adopted on a limited scale by the farmers to reclaim their lands. The study has indicated that farmers adopt a score of strategies to treat the problem. These include (i) green manuring, (ii) surface drainage, (iii) addition of organic amendments, (iv) land levelling, (vi) leaching, and (vi) growing of tolerant crop varieties. These technologies are not spread effectively among the affected farm households, and there is a big gap. It has to be bridged by the effective dissemination of technologies through demonstrations at the farm level.

Adoption of leaching could result in an incremental output of 14 quintals per hectare on saline soils of the head and mid regions. Growing of tolerant paddy varieties could yield additional output of 9 quintals and 11 quintals per hectare on saline soils of the head and mid regions, respectively. Adoption of green manuring could enhance the crop yields by 13 quintals and 12 quintals on saline and waterlogged soils of the mid region, respectively. Datta (1997) has observed that biological amelioration technology by adopting salt-resistant crop varieties of paddy and wheat is economically feasible.

Partial budgeting analysis has suggested that the technologies are feasible irrespective of the farm size. Biological measures in terms of use of tolerant varieties by small and marginal farmers can be adopted to a greater extent instead of leaving their available land assets fallow due to their inability to adopt capital-intensive technologies. The tolerant crop varieties could generate better returns and are economically feasible. Therefore, instead of investing more on reclamation programme, the small and marginal farmers could opt for low-cost technologies. The input delivery should be restructured and strengthened. All the inputs which are necessary for reclamation should be made available at one place at subsidized rates in order to promote the use of such inputs for land reclamation. There is a greater need for crop options that are tolerant to salts.

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