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Socio-economic Impacts of Agricultural Land Drainage — A Study from North-West India

K.K. Datta[1], C. de Jong[2], B.C. Roy[3] and S.B. Singh[4]

Abstract

At the global level, the annual losses of US $ 11.4 billion occur in agricultural production due to waterlogging. India is no exception to this menace and diverse statistics have shown that the problem is threatening agricultural production on 5.5 million to 13 million hectares. About one million hectare area is seriously affected, where agricultural production has been completely abandoned. To manage the problem in most fertile and irrigated areas, investment on drainage was initiated in the north-west region of India. This paper attempts to assess the benefits of installing sub-surface drainage for salinity control. The results have identified several farm-level benefits because of installing sub-surface drainage. These include (i) substantial increase in farm income, (ii) crop intensification and diversification towards high-value crops, and (iii) generation of employment opportunities. A proper management of this problem also helps in reducing income inequalities. Despite economic, social and environmental benefits, the adoption and acceptance of the subsurface drainage technology is always questioned, the specific reasons for which are: (i) indivisible nature of the technology, (ii) lack of collective action by the beneficiaries, (iii) conflicting objectives of the beneficiaries, and (iv) growing number of free riders. These could be controlled by appropriate institutional arrangements. The study has concluded that the technology dissemination without appropriate institutional arrangements might not yield the desired results.

Introduction

Agricultural land drainage has been in practice for millennia. Although it is recognized that drainage is important for sustainable agriculture, it

[1&4] ICAR Research Complex for NEH, Umroi Road, Umiam 793103, Meghalaya
[2] International Institute for Land Reclamation and Improvement/ ILRI, The Netherlands
[3] National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi-110 012

continues to remain a neglected factor. Due to long neglect, drainage needs felt an attention at least to the researchers and environmentalist. The reliable estimates on the effect of waterlogging and salinity on agricultural production at farm, regional, national or global level are not available. Since land degradation is location-specific and spatial in nature, the magnitude of losses varies from area to area. Worldwide, the extent of damage due to salinization ranges between 12 and 36 per cent. At the global level, the annual loss from 45.4 Mha salt-affected lands in the irrigated area has been estimated as US $ 11.4 billion (Ghassem *et al.*, 1995). Unfortunately, in India, the data on the occurrence and spread of waterlogging and salinity are varied and sketchy. The existing estimates range from 5.5 million hectares to 13 million hectares (Joshi *et al.*, 1992). It has been reported that an area of 0.7 to 1.0 million hectares is already seriously affected with waterlogging and salinity in the north-west India. Recent estimates point out that the damage due to waterlogging and soil salinity in this area is of the order of 10 to 15 per cent of the annual gross production per hectare. The potential annual loss in Haryana alone has been estimated as Rs 1669 million (about US $ 37 million) (Datta and De Jong, 2002).

There are three basic reasons for installing agricultural land drainage systems: (i) for trafficability so that seedbed preparation, planting, harvesting, and other field operations can be conducted in a timely manner, (ii) for protection of crops from excessive soil-water conditions, and (iii) for salinity control. This paper has assessed the impact of installing subsurface drainage for salinity control, with specific objectives as: (i) assessment of the economic benefits from sub-surface drainage on crop production, income level, efficiency, equity and the environments, (ii) quantification of the contribution of drainage compared with the undrained condition but under the identical production environment, and (iii) highlighting the factors, which affect its adoption.

Data and Analytical Tools

A socio-economic survey was conducted in the Gohana area, situated in the Gohana sub-division of Sonipat district in Haryana. The district was selected on the basis of the extent of the waterlogged saline area. In Haryana, about 207,000 hectares (54%) of the geographical area is affected by waterlogging and soil salinity. Five villages were selected purposely for the study. These villages covered an area of about 4,600 hectares, with about 2,150 households and had the population of 13,900.

The owners of the sample plots were identified with the help of revenue records and maps. In the selected plots, soil samples, crop cuttings, and water table measurements were obtained. In addition to this, socio-economic surveys of the owners and/or cultivators of the sample plots were also conducted. Since some of the farmers were found to possess two selected sample plots, the plot and farm surveys could be conducted for 225 farm families only.

The decomposition analysis following Bisaliah (1977) was undertaken to discern the absolute effects of drainage on gross crop income. The analysis disaggregated and quantified the difference in the observable output into its components. More simply, the technique provided a method to quantify the intervening factors of a difference such as 'with and without situation'.

Paddy and wheat being the main crops in the region, were chosen for the analysis. The approach assumed that in the undrained area, salinity build-up would directly influence the crop yields. To establish the relationship, the Cobb-Douglas production function was employed. Several explanatory variables, defined in different ways, were included in the function (1):

$$Y = a\, S^{b} F^{c} I^{d} K^{e} L^{f} e^{u} \qquad \ldots(1)$$

where, Y is the gross income from paddy and wheat (Rs/acre); S is cost of seeds (Rs/acre); F is cost of fertilizers (Rs/acre); I is cost of irrigation (Rs/acre); K is per acre cost of capital (includes costs of chemicals and machinery use); and L is the costs on labour (Rs/acre). Since fertilizer application has a direct effect on salinity, it was considered separately and not added into capital. The symbols a, b, c, d, e, and f are the regression coefficients of the respective variables and u is an error-term. The change in gross income between drained and undrained salinity-affected soils was decomposed into (i) changes due to drainage effect, and (ii) changes due to reallocation of inputs.

Drained Area

The drained area is given by Equation (2):

$$\log Y_d = \log A_d + b_d \log S_d + c_d \log F_d + d_d \log I_d + e_d \log K_d + f_d \log L_d \qquad \ldots(2)$$

Undrained Area

The undrained area is given by Equation (3):

$$\log Y_{ud} = \log A_{ud} + b_{ud} \log S_{ud} + c_{ud} \log F_{ud} + d_{ud} \log I_{ud}\; e_{ud} \log K_{ud} + f_{ud} \log L_{ud} \qquad \ldots(3)$$

Taking the difference of Equations (2) and (3), adding some terms, and subtracting the same terms yield Equation (4):

$$\log Y_d - \log Y_{ud} = (\log A_d - \log A_{ud}) + (b_d \log S_d - b_{ud} \log S_{ud} + b_d \log S_{ud} - b_d \log S_{ud}) + (c_d \log F_d - c_{ud} \log F_{ud} + c_d \log F_{ud} - c_d \log F_{ud}) + (d_d \log I_d - d_{ud} \log I_{ud} + d_d \log I_{ud} - d_d \log I_{ud}) + (e_d \log K_d - e_{ud} \log K_{ud} + g_d \log K_{ud} - g_d \log K_{ud}) (f_d \log L_d - f_{ud} \log L_{ud} + f_d \log L_{ud} - f_d \log L_{ud}) \quad ...(4)$$

Rearranging the terms in Equation (4) yields Equation (5):

$$\log (Y_d/Y_{ud}) = \log (A_d/A_{ud}) + [(b_d-b_{ud}) \log S_{ud}+(c_d-c_{ud}) \log F_{ud}+(d_d-d_{ud}) \log I_{ud} + (e_d-e_{ud}) \log K_{ud}+(fd-f_{ud}) \log L_{ud}] + [b_d \log (S_d/S_{ud}) + c_d \log (F_d/F_{ud}) + d_d \log (Id/I_{ud}) + e_d \log (K_d/K_{ud})+f_d \log (l_d/L_{ud})] \quad ...(5)$$

Equation (5) apportions approximately the differences in gross income per acre between drained (salinity-free) and undrained (salinity-affected) into two components. The sum of the first two bracketed components on the right hand side indicates the drainage effect. The third bracketed term measures the contribution of changes in input levels between the two situations.

Lorenz curve was used to depict the inequalities between drained and undrained situations and with and without drain area. Gini concentration ratios (GCR) were also computed with and without installing sub-surface drainage to measure the changes in equity issues. Finally, constraints and issues related to large-scale adoption of drainage were discussed on the basis of the experience gained from different drainage project areas.

Results and Discussion

Drainage Investment

Under a resource crunch situation, investment priorities are driven by the demand. Land augmentation or 'horizontal development' through reclamation will be needed for feeding the rural masses only when saturation on productivity in the normal lands has reached. At the stage of 'threshold levels', investment is needed to break the stagnant level of production. Returns to investment at the threshold levels constitute a big question because it is difficult to show its financial feasibility at farm, regional and national levels. Investment at 'threshold level' is guided by the potential for diversification, intensification and long-term sustainability in conserving the natural resources. The financing of such investments may be feasible for the developed countries where the scope of 'horizontal development' is limited and investments at all levels are justified only through 'vertical development'.

In India, it has been observed that investment on land reclamation takes place only when potential yields from the normal soils get exhausted (Datta and Joshi, 1990). Recently, Smedema (2002) has observed that 'The saturation point and the threshold level are useful concepts for the opportunity-driven drainage development of rainfed-land but less for drainage and salinity control of irrigated land. In the latter case, drainage is often not a choice but a dire necessity to salvage a valuable natural resource from degradation'.

Drainage Costs

To control the water table in areas underlain by groundwater of poor quality, subsurface field drainage systems are to be installed and connected with the main surface drainage system. Earlier studies in Haryana have shown that drainage is economically feasible if manually installed systems can be implemented at the cost of Rs 25, 000/ha (Datta *et al.*, 2000). Recently, mechanically installed drainage system in HOPP Gohana area was also justified with the same level of costs (Datta *et al.*, 2002). However, mechanised installations of SSD systems at the rate of Rs 43,000–45, 000 per ha are not yet feasible in Haryana at the current level of salinity. Agricultural development in Haryana has already reached the 'threshold level' at which drainage becomes a critical constraint for further advancement and an essential and viable investment. The investment on drainage is justified on the ground of 'protective measures'. It will help the state to break the threshold levels of agricultural production. It may be mentioned that though the process of salinization is very slow, its intervention in terms of drainage investment is required from the initial stage itself rather than letting the farmers suffer great losses over long periods when an unsustainable situation is reached.

Drainage Impacts

Direct Impact on Soil Salinity

Monitoring of soil and crop improvement in a drainage area provides a convenient way for impact assessment of subsurface drainage system in waterlogged saline lands. To assess the impact of subsurface drainage system on soil and crop, the samples of soil and crop were collected from several locations after the harvesting of *rabi* crops using the grid pattern and studied. These values were compared with the initial values of 1995-96 of drained and un-drained areas. The installation work of subsurface drainage system was started in 1997 and completed in June 1999. The average salinity levels in SSD project and control area during *rabi* of 1999-2000 were 4.6 and 9.2 dS/m, respectively whereas the average salinity of the (control) undrained area during *rabi* season of 1995-96 was 7.1 dS/m, indicating a decrease in salt content of 35 per cent after SSD. Block-wise drainage area also showed a similar picture. In some of the SSD blocks, the decrease in soil salinity ranged from 9.7 to 66.3 per cent. On the other hand, the salinity level in the undrained area increased from 9.0 (1995-96) to 9.2 (1999-00), indicating an increase of 2.2 per cent within two years.

Direct Impact on Water Table

For monitoring the depth to water table, 40 observation wells were installed within an area of 2000 hectares in Gohana block of Sonipat district. Twenty-seven observation wells were located within 1000 ha area where drainage was being installed and 13 points were located in undrained area. At 500-m grid point, depth to watertable was measured monthly and analysed. Overall, the depths were found fluctuating from the surface to a depth of 3.95 m in the study area. The water table was shallower in the undrained area than the drained area (Table 1). The average depth of water table in the area receded with time. The depth to water table in the drained area remained below 1.00 m during the growing season of *rab*i (winter) crops when pumping was operating properly. The watertable levels had been monitored during the previous three years also. After installations of SSD systems, the watertable levels went down.

Farmers reported crop losses of 20 to 50 per cent during the *kharif* mainly due to the heavy rainfall in combination with local storming winds, which cracked the stems of rice crop, causing the nearly matured grains to rot in the standing water. After installation of SSD, the impact was not only

Table 1. Water table in Gohana area before (1995-96) and after (1999-00) SSD (in m)

Area	March	June	September	December
		Before SSD		
Range	0.42-1.24	1.23-2.79	0.48-1.52	0.31-1.95
Average in drained area	0.79	1.91	0.83	1.00
Average in undrained area	0.63	1.24	0.48	0.59
		After SSD		
Range	0.12-1.47	1.31-2.65	0.64-1.22	0.34-1.30
Average in drained area	0.865	1.90	0.89	0.88
Average in undrained area	-	-	-	-

on the improvement of crop yield in the *kharif* season but also helped in timely or early sowing of the *rabi* crop. Another observation was that most of the saline waterlogged fallow lands could be reclaimed and brought back under crop production.

Indirect Impact on Cropping Pattern and Intensity

During the period 1986-90, the major *kharif* crops in the study area were paddy, jowar, and sorghum with respective percentages of 11, 7, and 7. But after the installation of drainage, their respective shares changed to 61, 14, and 3 per cent. The area under paddy increased tremendously due to increase in the number of shallow wells for irrigation. During *rabi*, wheat was the most important crop, covering 81 per cent of the area during the post-drainage period. It depicts an increase of about one-third in its area over the 60% during 1986-1990. A number of other crops are also grown in the area, but each of them occupies only a small percentage of the land. The perennial crop grown in the area is sugarcane, there was no change in its area of about 5 per cent of the cultivable land.

During the period 1986-90, the cropping intensity in the study area during the *kharif* was 35 per cent and during the *rabi* season, it was 82 per cent. Thus, annual cropping intensity was 117 per cent. during the post-drainage period (1999-2000), the cropping intensity was increased drastically; it was 83 per cent during *kharif* and 92 per cent during *rabi* season. Annual cropping intensity thus was 175 per cent, more than double of the pre-drainage value.

Impact on Crop Yield

The yield of wheat, the most important crop grown in the Gohana area, is about 2.6 tonne/ha. In 1994-95, wheat yield was as high as 3.7 tonne/ha, which was higher than the district (2.6 t/ha) and state (2.7 t/ha) averages for that year. The yields have been generally far below the potential yields and show a declining trend as is evident from the district level statistics. The most probable reason for this is the deterioration of the agricultural resource-base because of the aggravated problems of waterlogging and salinity. During 1995-96, paddy and wheat yields in Gohana area were about 1.8 and 3.1 tonne per hectare, respectively. The average wheat yield was 3.6 t/ha in drained and 2.4 t/ha in un-drained areas (Table 2), indicating a significant increase in wheat yield due to the installation of subsurface drainage system. The block-wise increase in wheat yield ranged from 9.7 to 54.0% as compared to its yield in *rabi* 1995-96. The net impact of yield enhancement due to SSD was about 49 per cent.

Table 2. Effect of sub-surface drainage system on crop yield

(tonne/ha)

Crops	Area	Before SSD (1995-96)	After SSD (1999-00)	Percentage of yield increase (+)/ decrease (-)
Wheat	Without drained	2.94	2.43	- 17.3
	With drained	3.07	3.61	+17.6
Paddy	Without drained	1.3	1.2	-7.69
	With drained	1.4	1.7	+21.43
Pearl Millet	Without drained	0.80	0.75	-6.25
	With drained	0.88	1.23	+39.77

It is clear from the above analysis that these were direct benefits of subsurface drainage on-farm due to controlling of the water table which also enhanced the process of desalinization through leaching of the salts. The combined impact of these changes was a substantial increase in farm incomes through (i) considerable increase in cropping intensity; (ii) shifting of the cropping patterns towards more remunerative crops; (iii) increase in crop yields; (iv) increase in gainful employment, and (v) conversion of moderate and marginal lands into agricultural usable land. In other words, SSD has helped in improving the farm income by creating proper conditions/ opportunities for crop intensification and crop diversification, overcoming of the crop-calendar constraints, allowing of the mechanization of farm operations, enhancing of the impact of fertilizers and other inputs, lowering of production costs, and mitigation of the adverse environmental impacts. In general, it could make the agricultural sector more competitive, efficient and sustainable.

Contribution of Drainage: Decomposition Analysis

To quantify the absolute contribution of drainage, a regression analysis was carried out. The estimated regression results [Equations (2) and (3)] for drained and undrained area in Gohana are presented in Tables 4 (a) and 4(b) for paddy and Tables 5(a) and 5(b) for wheat. Most of the selected variables, namely seeds, fertilizers, labour and capital are statistically significant, except labour, in both drained and undrained areas and irrigation for paddy undrained area. The value of R^2 was found to range from 33 to 68 per cent for wheat areas and about 57 per cent for the paddy area in both drained and undrained areas. The F-values were high in both the cases. Maybe, inclusion of different salinity levels as one of the variables in our production function improved the value of R^2 for wheat. The expected positive production elasticities of different factors indicated the response

Table 3(a). Average log values of the selected input-output parameters for paddy crop in Gohana during 2000

	Gross income	Seed costs	Fertilizer costs	Irrigation costs	Capital costs	Labour costs
Drained area	3.792947	2.041648	2.856421	2.816473	3.169412	3.014069
Undrained area	3.730641	2.060694	2.82138	2.803338	3.136155	3.006405

Table 3(b). Average log values of the selected input-output parameters for wheat crop in Gohana during 1999-00

	Gross income	Seed costs	Fertiliser costs	Irrigation costs	Capital costs	Labour costs
Drained area	2.7067	5.72008	6.44685	5.11053	7.31951	7.29875
Undrained area	2.55098	5.63450	6.43431	5.13869	7.30254	7.31686

Table 4(a). Production function of paddy crop (C-D) in the drained area of Gohana during 2000

Regression statistics	Coefficients	
Multiple R	0.753438	
R-squared	0.567668	
Adjusted R-squared	0.535405	
Standard error	0.164021	
F-value	17.59472	
Observations	73	
Factors		Standard Error
Intercept	-2.71976*	1.180255
Seeds	0.864683*	0.318242
Fertilizer	0.544942*	0.16262
Irrigation	0.365422**	0.226418
Capital costs	0.983354*	0.48664
Labour	-0.31688	0.347129

Table 4(b). Production function of paddy crop (C-D) in the undrained area of Gohana during 2000

Regression statistics	Coefficients	
Multiple R	0.755929	
R-square	0.571428	
Adjusted R-square	0.529411	
Standard error	0.161566	
F-value	13.59996	
Observations	57	
Factors		Standard error
Intercept	-2.82005**	1.46345
Seeds	0.164698	0.297916
Fertilizer	0.472837*	0.182007
Irrigation	-0.19751	0.209034
Capital costs	1.330303*	0.545551
Labour	0.418737***	0.368083

*, **, *** Significant at 1%; 5% and 10% probability level, respectively

on gross (paddy and wheat) income. For example, a one-percent increase in the fertilizer costs at mean level [6.4468 in Table 3(b)] increases wheat income in the drain area by 0.43 per cent and in the undrained area by 0.22 per cent. Similarly, in the case of paddy, the effect of increasing fertilizer costs by 1% [where the mean level is 2.8564 in Table 3(a)] fetched an additional 0.54 per cent income in the drain area, and 0.47 per cent income

Table 5(a). Production function of wheat crop (C-D) in the drained area of Gohana during 1999-00

Regression statistics	Coefficients	
Multiple R	0.825091	
R-square	0.680776	
Adjusted R-square	0.668007	
Standard error	0.193933	
F-value	53.31488	
Factors		Standard Error
Intercept	2.065399*	0.79695
Seeds	0.238736**	0.120019
Fertilizer	0.427158*	0.065751
Irrigation	0.072175**	0.035323
Variable costs	0.341752*	0.072924
Labour	0.10439	0.146858
Observations	131	

Table 5(b). Production function of wheat crop (C-D) in the undrained area of Gohana during 1999-00

Regression statistics	Coefficients	
Multiple R	0.576962	
R-square	0.332885	
Adjusted R-square	0.298139	
Standard error	0.195159	
Observations	102	
Factors		Standard Error
Intercept	4.579794*	0.806457
Seeds	0.098951*	0.046708
Fertilizer	0.220497**	0.145183
Irrigation	0.096959**	0.050555
Variable costs	0.322056*	0.090427
Labour	0.037118	0.091264

*, **, *** Significant at 1%; 5% and 10% probability level, respectively

in the undrained area. These observations suggest that drainage helps in using the fertilizers efficiently. It was an also indication that drainage helped reduce the costs of production.

The results of the decomposition exercise using the data from Tables 4 [(a) and (b)] and 5 [(a) and (b)] are reported in Table 6. The drainage technology accounted for about 40 per cent of the additional paddy income. The corresponding figure for wheat was 72 per cent. It was important to note that seeds, fertilizers, irrigation and capital costs were positively related

Table 6. Decomposition of income differences into drained and undrained area of Gohana area during 1999-00

Items	Percentage attributable	
	Paddy	Wheat
Sources of change		
Technological	39.49	71.51
Changes of input	60.51	18.33
(i) Seed	-3.90	13.12
(ii) Fertilisers	-26.43	3.44
(iii) Irrigation	30.65	-1.31
(iv) Capital	52.49	3.72
(v) Labour	7.70	-1.27

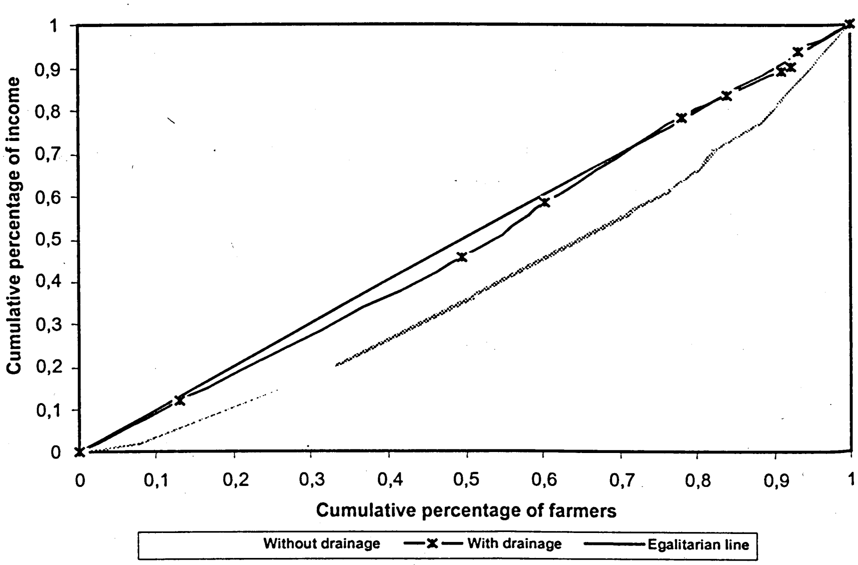

Figure 1. Income distribution with and without drainage installation at Gohana

and were statistically significant at different probability levels. This could be due to the fact that there was still a scope for enhancement of income through these inputs. However, field observations indicated that farmers were reluctant to use the best agronomical practices in the salt-affected areas.

Reducing Income Disparity

It is generally argued that in the canal irrigation system, there is a 'head' and 'tail' problem related to the distribution of irrigation water. Generally,

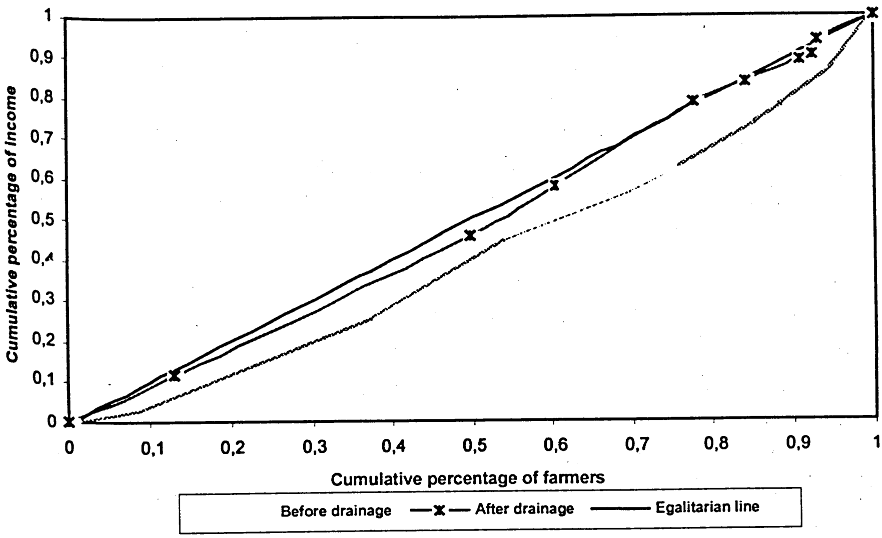

Figure 2. Income distribution before and after drainage installation at Gohana

the head farmers have an earlier and better access to water and achieve better development than the tail farmers. This situation is often reinforced over time as much of the progress and development bypass the poor or cannot be utilized beneficially due to the poor drainage conditions of the land. The poor drainage conditions, together with the inadequate and unreliable irrigation water supply, often result into severe waterlogging and salinization of the tail-end lands. Crop yields are often low from these lands and a part of the land becomes unproductive. Improved drainage, in combination with improved irrigation water management, under these conditions can be an effective instrument for combating poverty (Smedem, 2002).

To support that drainage technology helps in reducing the income disparities, Lorenz curve was derived (Figures 1 and 2) from HOPP area of Gohana. The Gini Concentration Ratio (GCR) was also calculated before and after drainage and without drainage. In the project area GCR before drainage was about 23 per cent but after drainage it was only 3 per cent. It clearly indicated that drainage technology can maximize the distribution of gains to the weaker sections of the society while conserving the land and water resources by reducing the income inequality by about 20 per cent. The Lorenz curves (Figures 1 and 2) also supported it by indicating the disparity between drained and undrained areas. The inequality curve was more prominent in the case of undrained area (Figure 2), whereas in the drained area, the disparity was less. Various means were identified for institutional support needed for the large-scale adoption of drainage.

In terms of employment generation, the drainage was found to help in creating additional employment during the installation stage and subsequently, during crop production stage. About 85 additional persondays per hectare were created. Apart from this, it helped in creating inter-sectoral linkages through demands for pipes and other drainage materials from the industrial sector. About 60 to 70 per cent share of the drainage technology goes to the industrial sector.

The improved drainage provides a number of social and environmental benefits like, better public healthcare, improved sanitation, safe water supply, better animal health, protection of rural infrastructure, enhanced rural well-being, etc. Recent research findings from Pakistan have indicated that these extra benefits can be quite substantial and can significantly contribute to the feasibility of investment in the improved drainage (IPTRID, 1999; Scheumann and Freisem, 2001). Agricultural drainage projects in Japan include the provision of improved village sanitation. The Drainage Boards in the Netherlands not only deal with the excess water control but also with water quality control. It is highly pertinent to recognize that much of early drainage developments were not for agricultural but for public health purposes — to reduce the prevalence of marshy conditions in the populated areas so as to combat malaria and other water-related diseases. Sub-surface drainage not only improves agricultural production but also helps control diseases carried by the mosquitoes and black flies infesting the wet area. It has been reported that the land drainage facilitated the settlement in North America (USDA, 1955).

Constraints to Adoption

Despite economic, social and environmental benefits, the adoption of sub-surface drainage is always questioned. Some of the reasons for it are as follows:

Constraints and the issues related to large-scale adoption of drainage were discussed from the experience gained from different drainage project areas in Haryana and Gujarat. Despite yielding high dividends, collective action is required to realise the potential benefits from SSD as the technology is indivisible. A study from small scale SSD area in Haryana and Gujarat has identified several constraints to its adoption (Datta and Joshi, 1992). These included: (i) indivisible nature of the SSD technology, (ii) no attempt by individual farm households on investment to prevent or cure the degraded lands, (iii) increased economic differentiation and socio-political factionalism, and (iv) internal heterogeneity and inequities. In order to overcome such problems, the drainage participatory approach is generally advocated. But there are several factors determining the success or failure of people's participation in effective implementation. These are (i) problem of free riders, (ii) degree of participation by beneficiaries, (iii) conflicting objectives, (iv) perception of the program objectives, (v) factionalism in the village, (vi) high dependence on government patronage, and (vii) completely eroded culture of group action and sharing systems (Datta and Joshi, 1992). Our analysis has concluded that the technology without institutional arrangement might not yield the desired results. A technology with high potential benefits may not make a difference and can be abandoned in the absence of required institutional arrangements (Datta, 2004).

Conclusions

Despite economic, social and environmental benefits, the adoption and acceptance of the sub-surface drainage technology has been always questioned. This study has shown several farm-level benefits of installing sub-surface drainage. The decomposition analysis has shown that drainage accounts for 40 to 70 per cent of the additional income generated. However, technology alone is not sufficient. A technology with high potential benefits may not make a difference and can be abandoned in the absence of required institutional arrangements. Investments on drainage can be justified on the ground of 'protective measures'. It will help the state in breaking the threshold levels of agricultural production. It may be mentioned that though the process of salinization is very slow but its intervention in terms of drainage investment is required from the initial stage itself rather than letting the farmers suffer great losses over long periods when an unsustainable situation is reached.

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