Agricultural Economics Research Review
Vol. 22 (Conference Number) 2009 pp 423-430

Crop Productivity Losses, Activity Diversification and Livelihood Security – A Study in Resource Degraded Areas of Southern Tamil Nadu

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Abstract

The present study has examined land degradation and its impact on livelihood security of farm households. Specifically, it has estimated the impact of sodic soils at farm level in terms of resource use, productivity and profitability of crop production and has examined income, employment and household consumption behaviour for ensuring better livelihood. The study conducted in the Ramanathapuram and Tuticorin districts of Southern Tamil Nadu, is based on data collected from 160 affected and 80 non-affected sample households. Sources of productivity differences between affected and non-affected farming situations have been identified by decomposing the productivity changes. To find the relationship between income, household expenditure and activity diversification, the simultaneous equation model (3 SLS estimation) has been estimated. The study has indicated that output from agriculture is substantially lower in the degraded farms. The contribution of sodic salts is higher in the yield differences. The occurrence of pebbles ($CaCO_3$) at higher rate, poor maintenance of canal and higher application of fertilizers are the significant factors for the yield damage in crops. The estimated parameters of simultaneous equation model have revealed that consumption expenditure is largely influenced by the magnitude of income and income-generating activities. The activity diversification and land quality variables have depicted a larger influence on the household income. Land quality being one of the variables with a negative, but significant coefficient of considerable magnitude, warrants immediate attention. The study has suggested that in the resource-degraded areas, activity diversification while reducing uncertainty, would increase opportunities to earn more income for the better livelihood opportunities in the rural areas.

Introduction

Land and water are the two important natural resources which are under tremendous stress due to ever-increasing biotic pressure (Gwande *et al.*, 2000). It has resulted in problems like salinity, alkalinity and waterlogging all of which have adverse effects on these resources. It ultimately leads to productivity decline in short- and medium-terms and land abandonment in the long-run. At farm level, the negative effects have been reported as reduction in farm income, restricted choice of crops and land abandonment (Chopra and Gulati, 1998, Mani, 2001). The degradation of land and water adds to uncertainties in agriculture in terms of employment, environment and economic development. In the rural areas of developing economies, the agriculture is the fundamental source of livelihood.

In the resource-degraded areas of developing economies, the shift in employment from farm to non-form activities has occurred because the share of crop income in total household income has declined over time (Singh *et al*., 2003). Shylendra and Thomas (1995) have opined that non-farm migratory activity would remain as one of the major sources of employment and livelihood for rural households. Thus, the maintenance and continuous adaptation to a diverse portfolio of activities by the rural households has been a distinguishing feature of survival strategies adopted, in particular, by the poorer households in the developing countries (Ellis, 1998; 2000; Barrett *et al*., 2000;

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Reardon *et al*., 2001; Lanjow and Lanjow, 2001; Ferrington *et al*., 2006). Some scholars view diversification in employment as a deliberate household strategy, others consider it an involuntary response to crisis. As the rural household's employment and income are subject to seasonality, there is always a likelihood of mismatch between uneven income streams and continuous consumption requirements which lead to labour smoothening and consumption smoothening problems. Diversification helps to mitigate the adverse effect.

Problem Focus

In India, on an average, about 170 million hectares of land has been affected through different forms of land degradation, of which salinization has occurred in about 10 million hectares (Saxena and Pofali, 1999). In Tamil Nadu various forms of land degradations have affected 3.82 million hectares of land, of which 0.29 million hectares is considered as salt-affected. Among these, more than 45 per cent of problem soils (0.11 Mha) are concentrated in the southern districts of Tamil Nadu. The predominantly prevailing vertisols in these districts are most vulnarerable to salts because of their poor structural stability.

The relationship between crop yield and soil salinity has been quantified for many crops under typical growing conditions, which has revealed that sodicity typically reduces crop yields (Quirk, 2004). The natural resource degradation has resulted is not only reducing dependency on agriculture but also has caused changes in income and employment pattern of the rural households. Hence, to make an assessment of the effect of problem soils on farm productivity and in turn its effect on livelihood of farm households, the present study was taken up in southern Tamil Nadu with the following objectives,

- To estimate the impact of sodic soils at farm level in terms of resource use, productivity and profitability of crop production, and
- To examine the income, employment and household consumption behaviour towards ensuring better livelihood at the micro level.

Data and Methodology

Information about farm households which included the agro-socio-economic details like cropping pattern, irrigation sources, severity level of problem soils, cost of cultivation, farm income, employment, consumption and migration particulars were collected from 160 affected and 80 non-affected sample farm households in the Tuticorin and Ramanathapuram districts of Tamil Nadu. The basic set of criteria like cropping area under vertisols, area under problem soils, soils with high soil pH (> 8.5) was used for the classification of affected and non-affected regions before selection of the sample households.

Differences in productivity, income and employment across affected and non-affected farming situations were worked out from the cross-sectional data. Sources of productivity differences between the affected and non-affected farming situations were identified by decomposing the productivity changes, following Bisaliah (1977). Cobb-Douglas production functions for the affected and non-affected farms were specified as follows:

$$\ln Y_{SL} = \ln A_{SL} + a_{SL} \ln ML_{SL} + b_{SL} \ln SD_{SL} + c_{SL} \ln MU_{SL} + d_{SL} \ln FR_{SL} + e_{SL} \ln HL_{SL} + f_{SL} \ln PS_{SL} + U_{SL} \quad \ldots(1)$$

$$\ln Y_{No} = \ln A_{No} + a_{No} \ln ML_{No} + b_{No} \ln SD_{No} + c_{No} \ln MU_{No} + d_{No} \ln FR_{No} + e_{No} \ln HL_{No} + f_{No} \ln PS_{No} + U_{No} \quad \ldots(2)$$

where,

Y = Yield per hectare (subscripts SL = Salt-affected farms; No = Non-affected farms)

A = Intercept

ML = Machine power (Rs/ha)

SD = Cost of seed used (Rs/ha)

MU = Cost of manures (Rs/ ha)

FR = Cost of fertilizers (Rs/ha)

PS = Cost of pesticides (Rs/ha)

HL = Human labour (humandays/ha)

a to f = Coefficients to be estimated, and

U = Random error-term.

Taking differences between Equations (1) and (2) and adding and subtracting some terms and on rearranging, one gets Equation (3):

$$\ln (Yd_{SL}/Yd_{No}) = \{\ln (A_{SL} / A_{No})\} + \{(a_{SL} - a_{No}) \ln ML_{No} + (b_{SL} - b_{No}) \ln SD_{No} + (c_{SL} - c_{No}) \ln MU_{No} + (d_{SL} - d_{No}) \ln FR_{No} + (e_{SL} - e_{No}) \ln HL_{No} + (f_{SL} - f_{No}) \ln PS_{No}\} + \{ a_{SL} \ln (ML_{SL} / ML_{No}) + b_{SL} \ln(SD_{SL} / SD_{No}) + c_{SL} \ln(\ln MU_{SL} / \ln MU_{No}) + d_{SL} \ln(FR_{SL} / FR_{No}) + e_{SL} \ln (\ln HL_{SL} / \ln HL_{No}) + f_{SL} \ln (PS_{SL} / PS_{No}) + g_{SL} \ln (OC_{SL} / OC_{No})\} + [(U2 - U1)] \quad \ldots(3)$$

The LHS of Equation (3) denotes the difference in per hectare productivity of salt-affected and non-affected farms, while the RHS decomposes the difference in productivity into the changes due to sodicity in soils as well as use of various inputs. Equation (3) particularly apportions the differences in gross income per hectare between non–affected and salt-affected lands into three components. The first term on the right hand side indicates the percentage change in yield per hectare due to a shift in the scale parameter A. The next term measures the effect of change in slope parameters. These two terms sum up to the total degradation effect. The third term measures the contribution of changes in input levels to changes in output.

The yield damage function in the linear model was worked out for assessment of crop loss in terms of value for the affected farms. Also, the factors responsible for land-quality deterioration were identified and ranked by using Garrett's scoring technique as per Equation (4):

$$\text{Per cent position} = \frac{100\left(R_{ij} - 0.50\right)}{N} \quad \ldots(4)$$

where,

R_{ij} = Rank assigned for the i[th] category by the j[th] respondent, and

N = Number of reasons assigned by the j[th] individual.

Using the table developed by Garrett, mean of the score was arrived. Highest mean score was ranked first. Thus, according to the mean score, reasons were ranked.

In most of rural farm households, under the problem situation (reduction in income from agriculture) family members have been diverted to other activities to earn for meeting consumption expenditure. The simultaneous equation model (3 SLS estimation) was taken up following Palanisamy and Flinn (1989) to identify the relationship between income, household expenditure and activity diversification due to the existence of endogenous relationship among household income, consumption expenditure and activity diversification, which was proven by Hausman specification test. The household income (HI), consumption expenditure (CE) and activity diversification (AD) are greatly influenced by variables, such as land size (FZ), land quality (LQ), durable assets (DA), area under commercial crops (CP), number of educated members (EM) in family, number of dependents (FD) in family, family size (FU) in adult consumption units (obtained by using the Lusk coefficient), education level (EN) of head, and wage differentials (WD) between activities. These were included as independent variables to capture the simultaneous / structural relationship between them. A dummy variable (1, if affected and 0, if non-affected) was also included to capture the effect of problem soil (resource degradation) in farm households. Due to the existence of structural relationship between the variables included in the model, three structural equations were specified as follows:

$$HI = \alpha_0 \, FZ^{\alpha 1} \, DA^{\alpha 2} \, CP^{\alpha 3} \, LQ^{\alpha 4} \, EM^{\alpha 5} \, SD^{\alpha 6} \, \hat{AD}^{\alpha 7} \, e_1 \quad \ldots(5)$$

$$CE = \beta_0 \, \hat{HI}^{\beta 1} \, EN^{\beta 2} \, FD^{\beta 3} \, FU^{\beta 4} \, DA^{\beta 5} \, \hat{AD}^{\beta 6} \, SD^{\beta 7} e_2 \quad \ldots(6)$$

$$AD = \hat{HI}^{\gamma 1} \, \hat{EP}^{\gamma 2} \, EM^{\gamma 3} \, ER^{\gamma 4} \, WD^{\gamma 5} \, SD^{\gamma 6} \quad \ldots(7)$$

where,

α_i , β_i, γ_i are the elasticities to be estimated,

α_0, and β_0 are intercepts, and

e_i (i = 1 and 2) are the error-terms.

The activity diversification index (AD) was worked out based on Herfindhal's diversification index. The index (the ratio of number of activities taken up by the individual household members to the total number of activities taken up by members of all sample households) was worked out as per Equation (8):

Table 1. Area under crops, net returns and value difference from crops in sample households

(Rs/ha)

Particulars	Area under crops (ha)			Net returns			Value difference	
	Affected farms	Non-affected farms	All farms	Affected farms	Non-affected farms	All farms	Rs	Per cent
Paddy	0.30	0.26	0.28	5087	10558	6648	5471	52
Sorghum	0.21	0.11	0.16	2034	4607	3320	2573	59
Cumbu	0.14	0.13	0.13	2897	5158	4028	2261	28
Greengram	0.15	0.17	0.16	4672	12484	8578	7812	63
Blackgram	0.05	0.05	0.05	2091	6996	4543	4905	70
Chilly	0.28	0.25	0.27	6341	13602	9972	7261	36
Cotton	0.10	0.10	0.10	5343	14125	9734	8782	31
Other crops	0.22	0.013	0.117					
Average cropped area, ha	1.45	1.083	1.267					
Cropping intensity, per cent	115	113	114					

$$ADI = \Sigma Pi^2 * PNFIW \quad \ldots(8)$$

where,

$$Pi = \frac{\text{Number of activities taken up by members in a family}}{\text{Total number of activities taken up by members in all sample households}}$$

i = 1, 2, 3, ….., n, and

PNFIW = Proportion of non-farm income (weight).

The three-stage least squares (3 SLS) is a system which can be applied to all equations specified at the same time. All the parameters can be estimated simultaneously. Least squares method was applied in three successive stages. In the 3 SLS method, more information can be utilized compared to the single equation method. In the above equations, household income, expenditure and activity diversification were the endogenous variables and all the independent variables were exogenous to the system.

Results and Discussion

Area under Crops and Value of Crop Output

Details provided in Table 1 reveal that in both affected and non-affected sample households, paddy (22.90 per cent and 24.07 per cent), followed by chillies (21.37 per cent and 23.15 per cent) occupied the major area of irrigated lands, followed by sorghum, cumbu and pulses under the rainfed situation. Among the other crops, cotton, followed by paddy were grown in wetlands.

The yield damage (in value terms) has been found very high in sorghum (59 per cent), followed by paddy (52 per cent) in the sample farms. Next to cereals, the yield loss was very high in pulses crops, it was 63 per cent in green gram and 70 per cent in black gram due to sodicity problems in soils. But, the yield damage was comparatively lower at 36 per cent in chilly and 31 per cent in cotton. Since paddy and chilly occupied the major area under cultivation, the economics were worked out for these crops. The productivity differences between affected and non-affected farms were also worked out for these two crops. The major reasons for land quality deterioration in the affected sample farms were also identified through Garrett's scoring technique (Table 2). It was found that occurrence of pebbles ($CaCO_3$) in the soil due to rock de-solidification (mean score value 67.70) and poor

Table 2. Reasons identified for soil quality deterioration in salt-affected farms

Reasons	Mean score value	Rank
Rock de-solidification	67.70	I
Irrigation with saline water	64.79	II
Poor irrigation canal maintenance	58.66	III
Higher doses of fertilizer application	47.76	IV
Intensive and mono-cropping	37.23	V
Arid climate	34.77	VI
Low level of organic amendments	29.79	VII

Table 3. Economics of cultivation of paddy and chillies in sample households

(Rs/ha)

Particulars	Paddy		Chillies	
	Affected farms	Non-affected farms	Affected farms	Non-affected farms
Labour				
a. Human labour	2712	2591	4342	4430
	(20.21)	(18.95)	(35.56)	(36.74)
b. Machine power	5015	5015	2338	2072
	(36.67)	(36.67)	(19.16)	(17.18)
Sub-total	7464	7606	6681	6502
	(55.62)	(55.61)	(54.72)	(53.92)
Factor inputs				
a. Seed (kg)	1788	1750	791	774
	(13.32)	(12.80)	(6.48)	(6.42)
b. Manure (Rs)	850	1135	1074	1256
	(6.33)	(8.30)	(8.80)	(10.42)
c. Fertilizers (kg)	1820	1707	1613	1596
	(13.56)	(12.49)	(13.22)	(13.24)
d. Pesticides (Rs)	400	368	580	531
	(2.98)	(2.69)	(4.76)	(4.41)
e. Other costs (Rs)	1098	1109	1467	1397
	(8.18)	(8.11)	(12.02)	(11.59)
Total cost	13420	13677	12208	12058
	(100.00)	(100.00)	(100.00)	(100.00)
Yield, kg/ha	2606	3908	773	1128
Total returns (Rs)	18507	26753	18549	25660
Net returns (Rs)	5087	13076	6341	13602

Note: Figures within the parentheses indicate percentages to total variable cost

quality of irrigation water (mean score value of 64.79), were the major reasons for the deterioration of land quality, followed by poor canal maintenance and application of higher doses of fertilizer.

Input-use, Yield, Cost and Returns and Impact of Sodicity

Economics of production of paddy and chilly crops in the affected and non-affected farms have been presented in Table 3. The share in total variable cost of human labour, including machine power, was highest in paddy in both affected (55.62 per cent) and non-affected (55.61 per cent) farms, followed by fertilizer. Although cost of cultivation for paddy in both affected and non-affected farms (Rs 13420 and Rs 13677) was more or less same, the yield variation was significant. This largely influenced the net return, which was as low as Rs 5087/ha in the affected and high as Rs 13076 per ha in non-affected paddy farms.

A similar pattern was noticed in chilly also. Labour cost accounted for the major share in both affected and non-affected farms, followed by the fertilizers and plant protection chemicals. The cost of chilly cultivation was higher in the affected than non-affected farms and the net return was also lower (Rs 6341 in affected (Rs 6341/ha) than non-affected (Rs 13602/ha) farms from chilly cultivation. Hence, the productivity difference between affected and non-affected farms was decomposed into its constituent sources and the results have been presented in Table 4.

Impact of Sodicity on Farm Productivity

A perusal of Table 4 revealed that total productivity difference between affected and non-affected farms

Table 4. Decomposition of sources of differences in productivity of affected and non-affected farms

Sources of difference in productivity of affected and non-affected farms	Percentage	
	Paddy	Chillies
Total observed change in productivity	33.28	31.47
Total estimated difference in productivity	30.37	29.27
Due to sodic salts	27.70	25.84
Due to differences in input-use level	2.67	3.43
Human labour	0.82	0.63
Machine labour	0.55	0.40
Seeds	0.33	0.64
Manures	0.48	0.63
Fertilizer	0.44	0.54
Pesticides	0.05	0.59

was 30.3 per cent for paddy and 29.27 per cent for chillies. Among different sources responsible for total productivity variation, the effect of sodicity was maximum in both paddy (27.70 per cent) and chillies (25.84 per cent). The contribution of differences in input-use level was only marginal, 2.67 per cent in paddy and 3.43 per cent in chillies. Among various inputs, those contributing positively to the productivity difference between affected and non-affected paddy and chilly farms were: human labour, machine labour, seeds, manures, fertilizers, and pesticides (Table 4).

Consequences of Sodic Soils on Livelihood Security of Farm Households

For the resource-poor farm households under resource-degraded conditions, employment opportunities in agriculture were limited in the study area. They had to seek alternative employment opportunities in off-farm and non-farm activities to supplement their income. Non-farm sources of employment contributed predominantly in the affected category of farms (52.58 per cent), whereas, in non-affected sample farms, it accounted for only 36.86 per cent, whereas on-farm employment contributed 54.10 per cent to the total employment. Off-farm activities constituted only 7.58 and 9.04 per cent of the total employment in these categories of farms (Table 5).

It could be noted that contribution of crop production was lower by the affected (24.60 per cent) than non-affected (36.18 per cent) farm households. But, the proportion of non-farm income to total household income was higher in affected (58.72 per cent) than non-affected (45.63 per cent) farm categories. The average income of farms was higher in the affected than non-affected category, where non-farm income constituted a major part of total income. This means that non-farm occupation paid more to all the categories of farms. The consumption expenditure was practically the same in both in affected and non-affected sample farm families. However, the share of food consumption expenditure was higher for non-affected (62.44 per

Table 5. Source-wise employment, income and consumption pattern in sample households

Particulars	Affected farms	Non-affected farms
Employment (human-days)		
On - farm		
Crop production	139 (22.15)	216 (36.86)
Livestock	111 (17.69)	101 (17.24)
Total	250 (39.84)	317 (54.10)
Off - farm	47 (7.58)	53 (9.04)
Non - farm	330 (52.58)	216 (36.86)
Casual Jobs	231 (70.00)	139 (64.35)
Permanent jobs	99 (30.00)	77 (35.65)
Total employment per household	628	586
Average earners	3.17	3.25
Per earner employment days	198	180
Earnings (thousand Rs)		
On - farm	23.94 (35.23)	29.14 (47.61)
Crop production	16.70 (24.58)	22.54 (36.82)
Livestock	7.24 (10.65)	6.60 (10.79)
Off - farm income	3.11 (4.58)	3.45 (6.76)
Non - farm	39.90 (58.72)	27.49 (45.63)
Casual jobs	27.09 (39.87)	15.61 (25.91)
Permanent jobs	12.81 (18.85)	11.88 (19.72)
Total family income	66.95 (100.00)	60.08 (100.00)
Consumption (Rs)		
Total food expenditure	19908 (55.19)	21991 (62.44)
Total non-food expenditure	16166 (44.81)	13228 (37.56)
Total food and non-food expenditure	36074 (100.00)	35219 (100.00)

Note: Numbers within the parentheses indicate percentages to total

Table 6. Determinants of household income, expenditure and activity diversification

Variables	Co-efficient	't' statistics
Dependent variable		
Household income (Rs)		
Constant	10.423***	50.95 (0.00)
Total educated members (No.)	0.089***	3.61 (0.00)
Farm size (ha)	0.178***	5.76 (0.00)
Land quality (Scores)	-0.127***	-2.74 (0.01)
Durable asset value (Rs)	0.037*	1.74 (0.08)
Area under commercial crop (ha)	0.026***	3.91 (0.00)
Estimated value of activity diversification index	0.608***	11.46 (0.00)
Sample dummy (1, if affected, 0, if non-affected)	-0.0019**	-1.89 (0.04)
R^2	0.61	
log L	-261.64	
Family consumption expenditure (Rs)		
Constant	7.238***	9.49 (0.00)
Education level of head (years)	0.047***	2.61 (0.01)
Dependents (No.)	0.096***	2.46 (0.01)
Family consumption units (converted units)	0.161**	1.89 (0.04)
Sample dummy (1, if affected, 0, if non-affected)	-0.0091**	-1.92 (0.03)
Estimated value of household income (Rs)	0.262***	3.61 (0.00)
Estimated value of activity diversification index	0.364***	3.95 (0.00)
R^2	0.63	
log L	-203.01	
Activity diversification index		
Constant	-3.741	-0.917
Total educated members (No.)	0.243*	1.72 (0.08)
Earners (No.)	2.26***	5.14 (0.00)
Wage differences (Rs)	0.096***	4.55 (0.00)
Estimated value of household income (Rs)	-1.99***	-2.89 (0.004)
Estimated value of consumption expenditure (Rs)	1.81***	2.53 (0.01)
Sample dummy (1, if affected, 0, if non-affected)	0.084***	2.455 (0.01)
R^2	0.55	
log L	-154.02	

*Notes:****, **, * indicate significance at one per cent, 5 per cent and 10 per cent levels, respectively

cent) than affected (55.19 per cent), families while it was reverse for the non-food expenditure.

Determinants of Household Income, Expenditure and Activity Diversification

The results of the simultaneous equation (3SLS) model have revealed that the activity diversification had greater influence on household income (coefficient: 0.608), followed by farm size and land quality with 0.178 and –0.127 values, respectively (Table 6).

The land quality index with a significant but negative co-efficient warrants attention to tackle this problem earnestly to enhance income of farm household in the light of the fact that in non-affected farms, agriculture happenes to contribute a considerable share to the total income as well as employment which has wider implications for food security of these household. The significant and relatively larger influence of activity diversification (0.364), household income (0.262) and family consumption units (0.161) on household consumption expenditure was, as expected, a factor that warrents attention, signifying the need for provision of diverse source of income-generating activities in the rural areas. Also, the number of earners (coefficient, 2.26), and difference in wage rates between different activities in trade and service sector have acted as pull factors (coefficient, 0.096) for members of farm households to diversity their activities. It could be concluded that activity diversification, while reducing uncertainty, would increase opportunities to earn more income for the better livelihood opportunities in rural areas.

Summary and Conclusions

The study has revealed that yield damage (in value terms) has been high in all crops grown in the soil-affected households. The contribution of sodic salts has been higher to the yield differences, viz., 27.70 per cent in paddy and 25.84 per cent in chilly crops. The occurrence of pebbles ($CaCO_3$) in large quantities, poor maintenance of canal and higher application of fertilizers and manures and irrigation with insufficient water have been found to be the significant factors for the yield damage in crops. The livelihood dependence (both for income, employment and consumption expenditure) of sample farms is found high on non-farm activities, followed by livestock maintenance. The estimated parameters of simultaneous equation model have revealed that the consumption expenditure is largely influenced by the magnitude of income and income-generating activities rather than the demand side variables such as number of dependents or family consumption units. This would in a way imply a healthy trend in decision-making by the households in planning consumption expenditure. The activity diversification and land quality variables have a relatively greater influence on the household income. Land quality being one of the variables with a negative, but significant coefficient of considerable magnitude, warrants attention to tackle this problem earnestly on a sustained basis to enhance farm family income. It may be concluded that the activity diversification while reducing uncertainty, would increase opportunities to earn more income for the better livelihood opportunities in the rural areas.

References

Bisaliah, S. (1997) Decomposition analysis of output change under new production technology in wheat farming, *Indian Journal of Agricultural Economics*, **23**(3): 193-201.

Chopra, Kancahan and Gulati, S.C. (1998) Environmental degradation, property rights and population movements: Hypothesis and evidence from Rajasthan (India), *Environment and Development Economics*, **3**(1): 35-37.

Elisabeth, Sadoulet and de Janvry, Alan (1995) *Quantitative Development Policy Analysis*, The Johns Hopkins University Press, Maryland, pp. 20-22.

Gawande, S.P. (2000) Land reform and social equity for sustainable production systems, Advances in Land Resource Management for 21st Century, *International Conference on Land Resource Management for Food, Employment and Environmental Security*, 9-13 November, Delhi. pp. 88-95.

Joshi, P.K. (1994) Socio-economic impacts of managing salt-affected Soils. In: *Salinity Management for Sustainable Agriculture*, Eds: D.L.N. Rao, N.T. Singh, Raj K. Gupta, and N.K. Tyagi. Central Soil Salinity Research Institute, Karnal. pp. 282-293.

Mani, K., Chandran, K. and Sivanathan, M. (2001) *Problem Soil Management — Prospects and Issues*, Vol. 2. A special publication released at 22nd Convocation, Tamil Nadu Agricultural University, Coimbatore.

Palanisami, K. and Flinn, J.C. (1989) Impact of varying water supply on input use and yield of tank irrigated rice, *Agricultural Water Management*, **15**: 347-59.

Pindyk, R.S. and Rubinfield, Danial L. (1991) *Econometric Models and Forecasting.* McGraw Hill Book Company, New York.

Quirk, J.P. (2004) *Sodic Soils.* Australian Academy of Science, www/Google search.com.

Saxena, R.K. and Pofali, R.M. (1999) *Physiographic Regions of India and their Land Degradation Status: Landform Processes and Environment Management*.

Singh, R.K., Babu, Govind and Singh, Babu (2003) Changing pattern in rural non-farm economy in Uttar Pradesh, *Agricultural Economics Research Review,* (Conference No.): 150.

Shylendra, H.S. and Thomas, P. (1995) Non\-farm employment: Nature, magnitude and determinants in a semi-arid village of western India, *Indian Journal of Agricultural Economics*, **50**(3): 410-416.