International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 50, 2017, pp.-4857-4860.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

BEST OPTIMAL PLAN FOR SEWAGE AFFECTED FARMS IN MADURAI DISTRICT, TAMIL NADU

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Received: October 13, 2017; Revised: October 22, 2017; Accepted: October 23, 2017; Published: October 30, 2017

Abstract- The study was conducted in Madurai district of Tamil Nadu to study the best optimal plan for sewage affected farms.In seriously affected farms of Avaniyapuram and Sakkimangalam study area, optimal plan I revealed that by optimization of available resources, an increase of net income of 6.95 per cent and 7.18 per cent respectively as compared to the existing plan could be attained. The optimal plan II revealed that an increased net income of 49.87 per cent and 51.25 per cent respectively could be attained as compared to the optimal plan I by inclusion of diary and poultry enterprises. In low affected farms of Avaniyapuram and Sakkimangalam study area, optimal plan I achieved an increased net income of 10.69 and 8.66 per cent respectively as compared to the existing plan. Optimal plan II revealed still higher net income of 30.51 per cent and 31.91 per cent respectively as compared to the optimal plan I could be attained with inclusion of diary enterprise alone. Hence by optimization of available resources and by practicing subsidiary enterprises of dairy and poultry, farmers can manage sewage pollution.

Keywords- Best management practices, averting inputs, dairy and poultry.

Citation: Amarnath J.S. and Sridevi U. (2017) Best Optimal Plan for Sewage Affected Farms in Madurai District, Tamil Nadu. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 50, pp.-4857-4860.

Academic Editor / Reviewer: A. Daniel Viswasam Samuel

Introduction

In Madurai district, sewage treatment plants are located at two regions of Avaniyapuram and Sakkimangalam. In these regions, sewage pollution affected the water resources, land, human and livestock. The negative externalities included contamination of ground water, reduction in soil fertility, reduction in cropped area, socio-economic consequences and health problems for both human beings and animals. In this juncture, no prior in depth scientific study has been taken up in the study area to suggest best optimal plans to counteract these externalities. Hence this was attempted and presented in this article [1].

Methodology

Choice of the Study Area

Madurai district was selected purposively for the study since it faces sewage problem due to location of Sewage Treatment Plants. Among the thirteen blocks of the district, Thiruparangudaram block and Madurai East block are affected by sewage pollution due to location of sewage treatment plants in these blocks. Based on the intensity of the pollution as evinced from the electrical conductivity of irrigation water, the villages were classified into two categories namely seriously affected and low affected [Table-1] [2].

In Thiruparangudaram block, Avaniyapuram village was selected for seriously affected category purposively whereas another village namely kaluvangulam was selected for low affected and Paraipatty village was selected for non-affected area. Then from each category, 35 farmers were selected at random. In Madurai East block, Sakkimangalam village was selected for seriously affected category whereas another village namely Elamanur was selected for low affected and Nedungkulam village was selected for non-affected category. Then from each category 35 farmers were selected at random. Thus the sample size constituted 210 farmers [3].

Table-1 *Electrical conductivity of irrigation water of study area*

Class	Villages		Criteria	Classification
	Unit 1	Unit 2	EC (ds/m)	
I	Avaniyapuram	Sakkimangalam	7.50	Seriously affected
II	Kaluvangulam	Elamanur	2.00	Low affected
III	Paraipatty	Nedungkulam	0.60	Non affected

Source: Department of Agriculture- Avaniyapuram & Sakkimangalam- Madurai district 2015.

Identification of Best Management Practices for minimizing losses due to sewage Pollution

The best management practices for minimizing sewage pollution problem are identified by an extension of linear programming optimization model employed in farm economics [4,5].

The extensions included the environmental component of averting expenditure for crops and allied activities. The representative farm was selected based on the averting expenditure incurred in each category. The objective function of the model is to maximize the net returns over variable cost per hectare firstly in crop enterprises subjected to the resource constraints and averting expenditure specified in the model. The resultant plan is optimal plan I. Then the allied activities of dairy and poultry is introduced in the model and optimal plan II is generated. The optimal plans were identified by Tora optimization package [6].

Result and Discussion

Best management practices for seriously affected farms of Avaniyapuram study area

Details of the existing plan in the representative farm of Avaniyapuram study area under seriously affected category (0.71 ha) are given in [Table-2]. The existing plan included crops paddy, maize, vegetables and fodder grass. The averting

expenditure incurred for the existing plan was Rs.13881 per hectare. The net income from the existing plan was worked out to Rs. 62780 per hectare. The optimal plan I maximizes the net income with the constraints specified in the model and the results are given in [Table-3]. The minimum land constraints included for paddy, maize and fodder sorghum so as to essentially allocate area under these crop for food and fodder consumption. In this plan, fodder sorghum was introduced and fodder grass was replaced. The cropped area was also increased marginally by 0.06 hectare. Optimal plan I revealed that by optimization of available resources, higher net income of Rs. 67142 per hectare could be attained and it was 6.95 per cent higher as compared to the existing plan. The averting expenditure was also decreased by 2.08 per cent as compared to the existing plan.

The optimal plan II presented in [Table-4] included dairying and poultry along with crop activities. This optimal plan revealed still higher net income of Rs. 137948 per hectare could be attained and it was 49.87 per cent higher as compared to the optimal plan I. The averting expenditure was also decreased by 0.97 per cent as compared to the optimal plan I. Thus in

Table-2 *Details of existing plan in seriously affected farms of Avaniyapuram study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.55	8500	38630
2.	Maize	0.07	2896	10650
3.	Vegetables	0.05	1985	8000
4.	Fodder grass	0.04	500	5500
	Total	**0.71**	**13881**	**62780**

Table-3 *Details of optimal plan I in seriously affected farms of Avaniyapuram study area*

Sl.No	Crops	Area(ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.62	8997	40280
2.	Maize	0.08	2636	10256
3.	Vegetables	0.01	1445	9020
4.	Fodder sorghum	0.06	514	7586
	Total	**0.77**	**13592**	**67142**

seriously affected farms, the best management practice suggested were the practicing of dairy and poultry activities along with undertaking averting expenditure.

Table-4 *Details of optimal plan II in seriously affected farms of Avaniyapuram study area*

Sl.No	Crops	Area(ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.60	9895	45890
2.	Maize	0.05	2038	11063
3.	Vegetables	0.06	958	10260
4.	Fodder sorghum	0.06	570	8653
5.	Dairy (in no.)	3	0	32452
6.	Poultry (in no.)	-	0	25630
	Total	**0.77**	**13461**	**133948**

Best management practices for low affected farms of Avaniyapuram study area

The existing plan for low affected farms (1.40 ha) are presented in [Table-5]. It could be seen from the table that the averting expenditure in the existing plan was Rs. 9397. The net income realized from the existing plan was higher with Rs. 122246. The optimal plan I maximizes the net income with the constraints specified in the model and the results are given in [Table-6]. The minimum land constraints included were paddy, maize and fodder sorghum. In this plan, fodder sorghum was introduced and fodder grass was replaced. The crop area was increased by 0.06 hectare. Optimal plan I revealed that by optimization of available resources, higher net income of Rs. 136879 could be attained and it was 10.69 per cent higher as compared to the existing plan. The averting expenditure was also decreased by 1.36 per cent as compared to the existing plan.

Table-5 *Details of existing plan in low affected farms of Avaniyapuram study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.75	4123	49626
2.	Maize	0.12	1683	12560
3.	Sugarcane	0.43	2051	45560
4.	Vegetables	0.06	980	8500
5.	Fodder grass	0.04	560	6000
	Total	**1.40**	**9397**	**122246**

Table-6 *Details of optimal plan I in low affected farms of Avaniyapuram study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.80	3956	55450
2.	Maize	0.05	1568	12806
3.	Sugarcane	0.50	1745	48623
4.	Vegetables	0.05	1000	12000
5.	Fodder sorghum	0.06	1000	8000
	Total	**1.46**	**9269**	**136879**

The optimal plan II presented in [Table-7] included dairy along with crop activities. This optimal plan revealed still higher net income of Rs.196984 could be attained and it was 30.51 per cent higher as compared to the optimal plan I. The averting expenditure was also decreased by 0.84 per cent as compared to the optimal plan I. Thus, in low affected farms, the best management practices suggested was undertaking of dairy activity along with undertaking averting expenditure. The best management practices suggested for low affected farms was superior as compared to seriously affected farms as the BMP suggested for low affected farms achieved a higher net farm income of Rs.196984 as compared to Rs. 133948 for seriously affected farms.

Table-7 *Details of optimal plan II in low affected farms of Avaniyapuram study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.80	3860	62626
2.	Maize	0.05	1986	15421
3.	Sugarcane	0.50	2153	55215
4.	Vegetables	0.05	650	12600
5.	Fodder sorghum	0.06	542	8510
6.	Dairy (in no.)	3	-	42612
	Total	**1.46**	**9191**	**196984**

Best management practices for seriously affected farms of Sakkimangalam study area

Details of the existing plan in the representative farm of Sakkimangalam under seriously affected category (0.64 ha) are furnished in [Table-8]. The existing plan included crops paddy, maize, vegetables and fodder grass. The averting expenditure in the existing plan was Rs.12574 and the net income from the existing plan was worked out to Rs. 60800 per hectare.

Table-8 *Details of existing plan in seriously affected farms of Sakkimangalam study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.5	7584	38210
2.	Maize	0.09	2745	9540
3.	Vegetables	0.03	1745	7450
4.	Fodder grass	0.02	500	5600
	Total	**0.64**	**12574**	**60800**

The optimal plan I maximizes the net income with the constraints specified in the model and the results are given in [Table-9]. The minimum land constraints included were paddy, maize and fodder sorghum so as to essentially allocate area under these crops. In this plan, fodder sorghum was introduced and the fodder

grass was replaced. The crop area was increased by 0.11 hectare. Optimal plan I revealed that by optimization of available resources, higher net income of Rs. 65502 could be attained and it was 7.18 per cent higher as compared to the existing plan. The averting expenditure was decreased by 5.62 percent as compared to the existing plan.

Table-9 *Details of optimal plan I in seriously affected farms of akkimangalam study area*

Sl.No	Crops	Area(ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.55	7432	39260
2.	Maize	0.1	2483	10450
3.	Vegetables	0.05	1452	8230
4.	Fodder sorghum	0.05	500	7562
	Total	**0.75**	**11867**	**65502**

The optimal plan II presented in [Table-10] included dairying and poultry along with crop activities. This optimal plan revealed still higher net income of Rs.134353 could be attained and it was 51.25 per cent higher as compared to the optimal plan I. The averting expenditure was decreased by 4.37 per cent as compared to the optimal plan I. Thus in seriously affected farms, the best management practice suggested were the practicing of dairy and poultry activities along with undertaking averting expenditure.

Best management practices for low affected farms of Sakkimangalam study area

The details of representative farm under low affected category of Sakkimangalam study area (1.33 ha) are furnished in [Table-11]. The existing plan included crops paddy, maize, vegetables and fodder grass. The averting expenditure in the existing plan was Rs. 11207. The net income realized from the existing plan was higher with Rs. 126126.

Table-10 *Details of optimal plan II in seriously affected farms of Sakkimangalam*

Sl.No	Crops	Area(ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.55	7241	40500
2.	Maize	0.1	2256	11020
3.	Vegetables	0.05	1352	8690
4.	Fodder sorghum	0.05	500	8900
5.	Dairy (in no.)	-	-	40083
6.	Poultry (in no.)	-	-	25160
	Total	**0.75**	**11349**	**134353**

The optimal plan I maximizes the net income with the constraints specified in the model and the results are given in [Table-12]. The minimum land constraints included were paddy, maize and fodder sorghum. In this plan fodder sorghum was introduced and the fodder grass was replaced. The cropped area was increased by 0.15 hectare. Optimal plan I revealed that by optimization of available resources, higher net income of Rs. 138080 could be attained and it was 8.66 per cent higher as compared to the existing plan. The averting expenditure was also decreased by 6.92 per cent as compared to the existing plan.

Table-11 *Details of existing plan in low affected farms of Sakkimangalam study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.7	5542	58500
2.	Maize	0.11	2215	10500
3.	Sugarcane	0.42	2000	43126
4.	Vegetables	0.06	950	9000
5.	Fodder	0.04	500	5000
	Total	**1.33**	**11207**	**126126**

Table-12 *Details of optimal plan I in low affected farms of Sakkimangalam study area*

Sl.No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.74	5023	65230
2.	Maize	0.11	1956	11230
3.	Sugarcane	0.48	2200	48620
4.	Vegetables	0.1	753	3500
5.	Fodder	0.05	500	9500
	Total	**1.48**	**10432**	**138080**

The optimal plan II presented in [Table-13] included dairy along with crop activities. This optimal plan revealed still higher net income of Rs.202796 could be attained and it was 31.91 per cent higher as compared to the optimal plan I. The averting expenditure was also decreased by2.22 per cent as compared to the optimal plan I. In low affected farms, the best management practices suggested was undertaking of dairy activity along with undertaking averting expenditure. The best management practices suggested for low affected farms was superior as compared to seriously affected farms as the BMP of low affected farms achieved a higher net farm income of Rs.202796 as compared to Rs. 134353 for seriously affected farms.

Table-13 *Details of optimal plan II in low affected farms of Sakkimangalam study area*

Sl. No	Crops	Area (ha)	Averting expenditure (Rs)	Net income (Rs)
1.	Paddy	0.74	4960	69450
2.	Maize	0.11	1800	11956
3.	Sugarcane	0.48	2190	50230
4.	Vegetables	0.1	750	3560
5.	Fodder	0.05	500	12000
6.	Dairy (in no.)	-	-	55600
	Total	**1.48**	**10200**	**202796**

Conclusion

In seriously affected farms of Avaniyapuram study area, the best management practices suggested was inclusion of diary and poultry in these farms along with undertaking averting expenditure. In low affected farms of Avaniyapuram study area, the best management practices suggested was inclusion of diary alone in these farms along with undertaking averting expenditure. The best management practices suggested for low affected farms was superior as compared to seriously affected farms as the BMP suggested for low affected farms achieved a higher net farm income of Rs. 196984 as compared to Rs. 133948 for seriously affected farms. Optimal plan I achieved a higher net income of 7.18 per cent and decline in averting expenditure by 5.62 per cent as compared to the existing plan. Optimal plan II revealed still higher net income of 51.25 per cent and decline in averting expenditure by 4.37 per cent as compared to the optimal plan I.

In seriously affected farms of Sakkimangalam study area also, the best management practices suggested was inclusion of diary and poultry in seriously affected farms along with undertaking averting expenditure. In low affected farms of Avaniyapuram study area also, the best management practices suggested was inclusion of diary alone in low affected farms along with undertaking averting expenditure. The best management practices suggested for low affected farms was superior as compared to seriously affected farms since the low BMP achieved a higher net farm income of Rs. 196984 and Rs. 202796 as compared to Rs. 133948 and Rs. 134353 for seriously affected farms in Avaniyapuram and Sakkimangalam study areas respectively.

Policy Implication

The results of best management practices revealed that based on the incidence of pollution, farmers could adopt combination of tolerant crops along with increased application of averting inputs and practice dairy and poultry activity to minimize losses due to sewage pollution. Thus, financial institutions should be encouraged to motivate the affected farmers of the region for starting of diary enterprises and poultry farm. Also, the present State Government's scheme of distributing milch animals and sheep to below poverty households could be extended to these

affected farmers. The Government should also give the averting inputs at zero price rates to the farmers and also provide crop loan for raising tolerant crops.

Application of research: This research could be applied in any environmental economic studies pertaining to sewage pollution

Acknowledgement / Funding: Author are thankful to Department of Agricultural Economics, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, 625 104

Author Contributions: Both the authors equally contributed

Abbreviations:
E.C.- Electrical Conductivity
BMP- Best Management Practices

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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