Archives of Business Research – Vol.5, No.12
Publication Date: Dec. 25, 2017
DOI: 10.14738/abr.512.4025.
Paidipati, K. K., & Padi, T. R. (2017). Optimal Programming Problems for Crop Planning and Agricultural Resource Management. *Archives of Business Research, 5(12),* 282-293.

Optimal Programming Problems for Crop Planning and Agricultural Resource Management

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ABSTRACT
In this paper the researchers have developed two linear programming problems for optimal allocation of agricultural land with the objectives of minimizing farming costs and maximizing the revenue. The formulation of constraints are based on cost constraint of type of cultivation expenditure, allowable budget constraint for type of cultivation method, cost constraint with type of crop, allowable budget on the type of crop, total availability of land, competitive price of market on the price of each crop, minimum supporting price on each unit of crop, total investment and total revenue, break even yield of the crop, etc. The data on various categories are obtained through secondary data sources. Optimal sizes of agricultural land for each crop are obtained after solving all the combinations of programming problems. The decision making policies are suggested after analyzing the outputs on the parameters for management of agricultural resources.

Key words: Optimal Programming Problem, Crop Planning, Agricultural Resource Management

INTRODUCTION

Agriculture is the prime sector of Indian Economy with occupancy around 60% of employment to the rural folk. The changing dynamics of living styles have great influence on switching from this conventional profession. Due to increased levels of literacy, employment opportunities in industrial and service sectors, the global changing perceptions of employment, etc made the agricultural sector has a least priority profession. These factors have created another dimension of the problem that scarcity in the sources of agricultural farming. The investments on different types of expenditure, for different types of crops in different types of lands (say Wet and Dry) are increased enormously. All these issues are the influencing factors on increased costs, limited resources land, seeds, fertilizers, etc. On the other hand the production/ yields of different crops, the selling price on different agricultural products and hence the revenue on the outputs is drastically decreased. The constraints of manpower, availability of agriculture land are the other specific problems under which the farmers are facing very vulnerable situations. The technological assistance of machinery and other management methods makes the significant gap between the generated revenue and spent investments. Widening gap between investment and revenue is alarming in the context of the farming. Mismatching in the proportions of owing the agriculture land and the families working on the agriculture leads to select other options for their livelihood. Emotional attachment to the farming, non accessibility of employment opportunities, lack of planning and information processing, non managerial attitudes of the farmer, etc are some of the significant issues on which the agricultural manager (the farmer) has to think for better agricultural outputs. Optimal crop planning is the need of the hour for which the farmer has to set the goals and to achieve the proposed objectives with the constraints.

LITERATURE REVIEW

K.S. Raju and D.N. Kumar (1999) proposed multicriterion decision-making methods in selecting the best compromised irrigation plan for the objectives such as the net benefits, agricultural production and labour employment at Sri Ram Sagar Project, Andhra Pradesh, India. D.K.Singh et al. (2001) developed a linear programming model for an optimal cropping pattern in a canal command area of Shahi distributory to get the more profits at different water levels availability. F. S. Royce et al. (2001) developed an optimized model of crop management for climate forecasting applications to explore the potential benefits on small and predetermined subsets of possible combinations of variables. Laxmi Narayan Sethi et al. (2002, 2011) developed linear programming models on groundwater balance, optimum cropping and groundwater management; applied to Coastal river basin of Orissa state in India. Further they proposed decision support systems through forecasting models to get crop planning during seasons in different soils, and it is maximized the agricultural profits. JE Annetts and E Audsley (2002) developed a multiple objective linear programming problems for optimization of profit and environmental outcomes to identify the best cropping and machinery options with profitable and improvement in results to the environment for farming. Takeshi Itoha et al. (2003) developed a linear programming problem for crop planning for agricultural management for getting the profit coefficients with uncertainty due to influence of future conditions for agricultural farms. Bhabagrahi Sahoo et al. (2005) have developed linear programming and fuzzy optimization models for planning and development of available land-water-crop system of Mahanadi-Kathajodi delta in eastern India, to optimize in the economic return, production and labour utilization, and the related cropping patterns. Millie Pant et al. (2010) proposed linear programming models for optimal allocation of water, optimal cropping pattern for a given land area and water availabilities to maximize the economic returns through a multi-reservoir model in the command area of Pamba- Anchankovil- vaippar (PAV) link project in Kerala of India for optimal releases from the reservoir and optimal crop plans are developed under adequate, normal and limited irrigation water. Baljinder Kaura et al. (2010) formulated a linear programming model for optimal crop planning to maximize the net returns and the saving of ground water applied to some parts of Punjab in India. K. Varalakhmi et al. (2011) developed a linear programming technique for optimal cropping plans for small and large farmers in Panyam mandal, Kurnool district, Andhra Pradesh and focused on studying the income and employment of the labours through allocation of resources and technologies. Y.Raghava Rani and P. Tirupathi Rao (2012) have developed three Linear Programming problems for the multi-crop model which consists of maximizing the net benefits, minimizing the costs and water resources for the two seasons; did a case study of Rajoli Banda Diversion scheme (RDS) area, Mahaboob Nagar, AP, India. Wankhade M.O. and Lunge H.S. (2012) developed a linear programming (LP) technique for optimum resource allocation and the efficiency in the agricultural production with the data on 10 major crops in the area of rain fed zone of Murtizapur Tahsil of Akola District in Maharashtra, India. Srinivasa Rao Mutnuru et al. (2013) studied a sustainable agricultural and water resource planning through formulating an optimization model for water utilization, land resources with maximum benefits applied to the region of Mewat district, Haryana, India. Reddy Harshavardhan and T Rao Padi (2017) have developed some stochastic models for Optimal Crop Planning for Agricultural Resource Management.

In this study, the researchers have developed two optimal crop planning problems, and then have formulated the programming problems using LPP techniques for exploring two types of decision variables namely, (1) the optimal area of extent for i^{th} crop in j^{th} type of expenditure, (2) the optimal yield of i^{th} crop in l^{th} type of land. The study has focused with the objectives of cost minimization, yield maximization of the crop subject to the constraints of balancing the resources like cost inputs, land availability, budget allocations, break even productions, etc.

OPTIMAL CROP PLANNING PROBLEMS

Around 25 to 30 crops are considered to be prominent and having the large impact on the farmers in the Indian context. The data is obtained from the sources of Ministry of Statistics and Program Implementation (MOSPI), New Delhi, Directorate of Economics and Statistics (DES), Hyderabad and also from some research projects organized by S.V. Agricultural University, Tirupati. All these data is summarized and considered only the valid data. The study confined to 10 major crops due to several data gaps, they are Cotton, Mirchi, Groundnut, Jute, Bengal gram, Corn, Black gram, Green gram, Red gram and Paddy. With the similar reasons, the study also confined to 9 types of expenditures namely ploughing, seeds, plantation labour, fertilizers, water facilities, miscellaneous, agricultural collection/harvesting, storage, etc.

In this study, two linear programming problems were proposed

1. Finding the optimal area of cultivation for i^{th} crop and j^{th} type of expenditure with an objective of minimizing the agricultural input cost **(Cost Minimization)**
2. Finding the optimal yield of i^{th} crop and lth type of land with an objective of maximizing the profits (**Revenue Maximization)**.

Formulation of objective function (cost minimization):

Let C_{ij} be the cost per unit (say 1 acre of land) on i^{th} type of crop with j^{th} type of expenditure; for i=1,2,…m(number of crop types); j=1,2….n(number of expenditure types); In this study m=10; n=9; The total cost on A_{ij} units of land for i^{th} type of crop with jth type of expenditure is $C_{ij}A_{ij}$; The total cost on A_{ij} units of land for all types of expenditures of i^{th} type of crop $\sum_{j=1}^{n} C_{ij}A_{ij}, for\, i = 1, 2, \ldots, n$; Hence, The total investment on production for all types of crops and for all types of expenditures for A_{ij} units of land is $Z_c = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}A_{ij}$; Since Z_c is the investment function, the objective is to minimize Z_c

Formulation of Constraints on Cost Minimization

1. Let B_j be the minimum essential overall cost to be spent for all types of crops (i=1,2,....m) and for A_{ij} units of land on j^{th} type of expenditure. Since the total cost on all types of crops (i=1,2,....m) and for A_{ij} units of land on j^{th} type of expenditure is $\sum_{i=1}^{m} C_{ij}A_{ij}; j = 1, 2, \ldots, n$; the cost constraint with jth type of expenditure is $\sum_{i=1}^{m} C_{ij}A_{ij} \geq B_j; j = 1, 2, \ldots, n$
2. Let D_j be the maximum allowable budget to a farmer for all types of crops (i=1,2,....m) and for A_{ij} units of land on j^{th} variety of expenditure. Which implies the constraint with maximum allowable budget is $\sum_{i=1}^{m} C_{ij}A_{ij} \leq D_j; j = 1, 2, \ldots, n$

3. Let L_i be the minimum required investment cost on i^{th} type of crop for all type of expenditures (j=1,2,....n) on all A_{ij} units of land. Then the cost constraint on i^{th} type of crop is $\sum_{j=1}^{n} C_{ij}A_{ij} \geq L_i; i=1,2,\ldots,m$
4. Let H_i be the maximum possible investment cost on i^{th} type of crop for all type of expenditures (j=1,2,....n) on all A_{ij} units of land. It implies that the budget constraint on i^{th} type of crop is $\sum_{j=1}^{n} C_{ij}A_{ij} \leq H_i; i=1,2,\ldots,m$
5. Let A_{ij} be the available agricultural land for i^{th} crop and j^{th} type of expenditure. The total extent area of the i^{th} crop for all types of expenditures is $A_i = \sum_{j=1}^{n} A_{ij}$ Since the total available land is fixed, the constraint on land availability for all crops is $\sum_{i=1}^{m}\sum_{j=1}^{n} A_{ij} \leq \sum_{i=1}^{m} A_i, for\, i=1,2,\ldots,m$

Nature of Decision Variables

Let A_{ij} be the number of agricultural units to be decided for i^{th} type of crop with j^{th} type of expenditure. $A_{ij} \geq 0$ is considered to be a decision variable is the First step. However, the specific decision variable is $A_i = \sum_{j=1}^{n} A_{ij} \geq 0, for\, i=1,2,\ldots.m$

Objective function for Revenue Maximization

Formulation of objective function

1. Let A_{ijk} be the number of units of land occupied with i^{th} crop which was cultivated with j^{th} type of expenditure in k^{th} type of season say Rabi, Kharif, Dalva etc (k =1, 2, ... l), such that $A_{ij} = \sum_{k=1}^{l} A_{ijk}$
2. Let R_{ijk} be the Revenue per unit of output (per bag) due to the i^{th} crop which was cultivated with j^{th} type of expenditure in k^{th} type of season, such that $R_{ij} = \sum_{k=1}^{l} R_{ijk}$
3. Let Y_{ijk} be the number of units of yield per one unit of land due to the i^{th} crop which was cultivated with j^{th} type of expenditure in k^{th} type of season, such that $Y_{ij} = \sum_{k=1}^{l} Y_{ijk}$

Revenue on i^{th} crop which was cultivated on all types of expenditure is $\sum_{j=1}^{n} R_{ij}A_{ij}Y_{ij}$; Hence, the total revenue on all types of crops in all the seasons which were grown all types of expenditures is $Z_R = \sum_{i=1}^{m}\sum_{j=1}^{k} R_{ij}A_{ij}Y_{ij}$. Since Z_R is the profit function. The objective is to maximize Z_R.

Constraint with Market Competitive Price:

1. Let M_{ijk} be the market competitive price (farmers are confined to sell the product

within the cost limit) per unit of the i^{th} crop which was grown on j^{th} type of expenditure in the k^{th} season. Which implies the marketing competitive price per unit of i^{th} crop grown on j^{th} type of expenditure is $M_{ij} = \sum_{k=1}^{l} M_{ijk}$ and the marketing competitive price per unit of i^{th} crop irrespective of type of expenditure and season is $M_i = \sum_{j=1}^{n} M_{ij}$ Since the total cost on A_{ij} units of land for all types of expenditures of i^{th} type of crop = $\sum_{j=1}^{n} C_{ij} A_{ij}, for\, i = 1, 2, \ldots, m;$ This cost has to be less than the minimum marketing competitive price. Hence the constraint with Marketing competitive price is $\sum_{j=1}^{n} C_{ij} A_{ij} \le M_i, for\, i = 1, 2, \ldots, m;$

2. Let S_{ijk} be the minimum supportive price (farmers has to sell the product with a minimum of this price) per unit of the i^{th} crop which was grown on j^{th} type of expenditure in the k^{th} season. Which implies the minimum supportive price per unit of i^{th} crop grown on j^{th} type of expenditure is $S_{ij} = \sum_{k=1}^{l} S_{ijk}$ and the minimum supportive price per unit of i^{th} crop irrespective of type of expenditure and season is $S_i = \sum_{j=1}^{n} S_{ij}$. Since the total revenue on all types of crops in all the seasons which were grown on all types of expenditures is $Z_R = \sum_{i=1}^{m} \sum_{j=1}^{k} R_{ij} A_{ij} Y_{ij}$ and it has to be more than the minimum supporting price per unit of each crop; the constraint with minimum supporting price and the generated revenue is $\sum_{j=1}^{k} R_{ij} A_{ij} Y_{ij} \ge S_i, for\, i = 1, 2, \ldots, m$
3. As R_{ijk} be the revenue per unit of the i^{th} crop which was grown on j^{th} type of expenditure in the k^{th} season. Which implies the revenue per unit of i^{th} crop grown on j^{th} type of expenditure is $R_{ij} = \sum_{k=1}^{l} R_{ijk}$ and the revenue per unit of i^{th} crop irrespective of type of expenditure and season is $R_i = \sum_{j=1}^{n} R_{ij}$ Since the total Revenue on A_{ij} units of land for all types of expenditures of i^{th} type of crop = $\sum_{j=1}^{n} R_{ij} F_{ij} A_{ij}, for\, i = 1, 2, \ldots, m;$ This total revenue has to be more than the total cost on A_{ij} units of land for all types of expenditures of i^{th} type of crop = $\sum_{j=1}^{n} C_{ij} A_{ij}, for\, i = 1, 2, \ldots, m;$ Hence the constraint with total revenue and total cost is $\sum_{j=1}^{n} R_{ij} F_{ij} A_{ij} \ge \sum_{j=1}^{n} C_{ij} A_{ij}, for\, i = 1, 2, \ldots, m;$

4. Let L_i be the minimum required investment cost on i^{th} type of crop for all type of expenditures (j=1,2,....n) on all A_{ij} units of land. Then the cost constraint on i^{th} type of crop is $\sum_{j=1}^{n} C_{ij}A_{ij} \quad L_i; i = 1,2,\ldots,m$
5. Let H_i be the maximum possible investment cost on i^{th} type of crop for all type of expenditures (j=1,2,....n) on all A_{ij} units of land. It implies that the budget constraint on i^{th} type of crop is $\sum_{j=1}^{n} C_{ij}A_{ij} \quad H_i; i = 1,2,\ldots,m$
6. Let Y_{ijk} be the yield of crop per unit land of the i^{th} crop which was grown on j^{th} type of expenditure in the k^{th} season. Which implies the yield per unit land of i^{th} crop grown on j^{th} type of expenditure is $Y_{ij} = \sum_{k=1}^{l} Y_{ijk}$. The total yield of i^{th} crop for A_{ij} units of land is $\sum_{j=1}^{n} Y_{ij}A_{ij}$. Let B_i be the break even yield of i^{th} crop, which implies the constraint with break even yield is $\sum_{j=1}^{n} Y_{ij}A_{ij} \quad B_i, for\, i = 1,2,\ldots m$

Nature of Decision Variables

Let A_{ij} be the number of agricultural units to be decided for i^{th} type of crop with j[th] type of expenditure. $A_{ij} \geq 0$ is considered to be a decision variable is the First step. However, the specific decision variable is $A_i = \sum_{j=1}^{n} A_{ij} \quad 0, for\, i = 1,2,\ldots.m$

Programming Problems:

1. **Linear Programming Problem for minimizing the cost** is

$$Min\, Z_c = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}A_{ij}$$

Subject to constraints

$$\sum_{i=1}^{m} C_{ij}A_{ij} \quad B_j; j = 1,2,\ldots,n$$

$$\sum_{i=1}^{m} C_{ij}A_{ij} \quad D_j; for\ j = 1,2,\ldots,n;$$

$$\sum_{j=1}^{n} C_{ij}A_{ij} \quad L_i; i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} C_{ij}A_{ij} \quad H_i; i = 1,2,\ldots,m$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} A_{ij} \quad \sum_{i=1}^{m} A_i, for\, i = 1,2,\ldots,m$$

And

$$A_i = \sum_{j=1}^{n} A_{ij} \quad 0, for\, i = 1,2,\ldots.m$$

2. **Programming Problem for revenue maximization** problem will be

$$Maximize\, Z_R = \sum_{i=1}^{m} \sum_{j=1}^{k} R_{ij} A_{ij} Y_{ij}$$

Subject to constraints

$$\sum_{j=1}^{n} C_{ij} A_{ij} \quad M_i\,, for\, i = 1,2,\ldots,m;$$

$$\sum_{j=1}^{k} R_{ij} A_{ij} Y_{ij} \quad S_i\,, for\, i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} R_{ij} F_{ij} A_{ij} \quad \sum_{j=1}^{n} C_{ij} A_{ij}\,, for\, i = 1,2,\ldots,m;$$

$$\sum_{j=1}^{n} C_{ij} A_{ij} \quad L_i; i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} C_{ij} A_{ij} \quad H_i; i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} Y_{ij} A_{ij} \quad B_i\,, for\, i = 1,2,\ldots m$$

and $A_i = \sum_{j=1}^{n} A_{ij} \quad 0, for\, i = 1,2,\ldots.m$

3. **Solution of Linear Programming Problems:**

The Proposed Programming Problem was solved with Longo 13.0 Version and the decision variables of the both the problems were extracted. The following are the programming code and the out puts obtained from the software.

Solution of Programming Problem-1									
crop/area	Plough. & machinery	seeds(kg)	plantation	Labour	fertilizers	water	Rent	picking charges	Storage (1quinta)
Cotton	112	39	83	733	0	133	3	25	903
Mirchi	914	163	500	350	83	200	400	11	2705
Groundnut	114	111	700	30	18	50	400	50	2492
Jute	57	8	83	67	3	0	1	25	93
Bengal	53	39	117	133	0	2876	2	50	97
Corn	150	13	100	170	233	100	400	0	586
black grams	53	39	83	133	0	631	2	50	97
green grams	19	5	25	100	0	11	400	0	711
Red grams	144	39	1167	100	0	2264	3	33	97
Paddy	257	111	100	100	67	0	567	0	4358

Solution of Programming Problem-2		
Crop yield	dry land	Wet land
cotton	1583	15
mirchi	1027	14
groundnut	953	15
Jute	5	78
Bengal grams	4	186
Corn	0	33
black grams	4	413
green grams	1	3
Red grams	22	1183
paddy	2	10

SUMMARY AND CONCLUSIONS

In the first problem, the programming problem has given the decision variables namely: the optimal land allocation for the expenditure wise. For Ploughing and Machinery, the number of Agricultural units for Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy are 112, 914, 114,57,53,150, 53, 19,144 and 257 respectively. The optimal land allocation in view of the expenditure on Seeds for the above mentioned crops Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy respectively is 39, 163, 111, 8, 39, 13, 39, 5, 39 and 111. The optimal land allocation in view of the expenditure on Plantation for the above mentioned crops Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy respectively are 83, 500, 700, 83, 117, 100, 83, 25, 1167 and 100. The optimal land allocation in view of the expenditure on Labour for the above mentioned crops respectively Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy are 733, 350, 30, 67, 133, 170, 133, 100, 100 and 100. The optimal land allocation in view of the expenditure on Fertilizers for the above mentioned crops Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy respectively are 0, 83, 18**,** 3, 0, 233, 0, 0, 0 and 67. The optimal land allocation in view of the expenditure on Water for the above mentioned crops Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy respectively are 133, 200, 50, 0, 2876, 100, 631, 11, 2264 and 0.

In the second problem, the optimal yields per acre in Dry land for the crops Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy are 1583, 1027, 953, 5, 4, 0, 0, 1, 22 and 2. The optimal yields per acre in Wet land for the crops Cotton, Mirchi, Groundnut, Jute, Bengal grams, Corn, Black grams, Green grams, Red grams, and Paddy are 15, 14, 15, 78, 186, 33 ,413 ,3 ,1183, 10. The formulating problems have suggested the optimal decision variables for cost minimization in the 1st problem and revenue maximization in the 2nd problem might be the suitable alternatives to the farmers to come out of the problem of non-economical forming. These results may be considered as the guide spots for arriving to the decision which is more scientific. Our problem will help the formers as well as the policy makers to decide the optimal land allocations for different crops and optimal prices for decision makers.

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APPENDIX

Table-1: Area of Extent (in Lakh acres) the Crop is cultivated (A_i)

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Mean
Cotton	9.34	8.71	8.53	9.13	7.67	7.6	8.79	8.68	9.14	9.41	9.41	10.28	11.14	9.06
Mirchi	27.52	27.49	25.73	26.34	25.2	26.6	26.38	26.48	27.99	28.04	27.75	28.34	29.25	27.16
Groundnut	26.23	24.28	22.77	22.64	21.49	23.66	27.52	27.86	26.51	26.69	27.56	26.22	26.82	25.40
Jute	1.03	1.04	1.02	1.05	1.04	1	0.92	0.9	0.94	0.96	0.9	0.91	0.86	0.97
Bengalgrams	29.34	29.34	30.26	29.52	26.99	30.8	29.03	29.04	28.71	28.48	27.45	27.52	27.64	28.78
Corn	6.51	6.03	4.48	5.07	4.54	5.43	7.32	7.28	6.79	5.83	6.3	5.77	6.51	5.99
Black Grams	7.4	6.87	6.56	6.24	5.94	5.99	6.64	6.74	5.62	6.29	6.64	5.42	5.95	6.33
GreenGrams	6.49	6.22	6.42	6.34	6.11	6.56	7.57	7.71	8.33	8.88	9.51	9.79	9.55	7.65
Red Grams	23.5	21.12	20.35	22.01	20.5	23.46	22.76	22.39	23.19	23.63	22.09	23.39	26.28	22.67
Rice	44.8	45.16	44.71	44.9	41.18	42.59	41.91	43.66	43.81	43.91	45.54	41.87	42.56	43.58

Table-2: Market sales Price (Ri) per quintal

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	**Mean (wet land)**	**Mean (dry land**
Cotton	1650	1775	1825	1875	1875	1925	1960	1980	1990	2030	3000	3000	3000	2145	2045
Mirchi	1000	1100	1200	1300	1330	1600	1700	1715	1715	1800	1830	1830	1850	1536	1436
Groundnut	1040	1155	1220	1340	1355	1400	1500	1520	1520	1550	2100	2100	2300	1546	1446
Jute	650	750	785	810	850	860	890	910	1000	1055	1250	1375	1575	982	882
BengalGrams	895	1015	1100	1200	1220	1400	1425	1435	1445	1600	1730	1760	2100	1410	1310
Corn	960	1105	1200	1320	1330	1370	1410	1520	1520	1700	2520	2520	2900	1644	1544
Black Grams	390	415	445	485	485	505	515	525	540	600	840	840	880	574	474
Green Grams	960	1105	1200	1320	1330	1370	1410	1520	1520	1700	2520	2760	3170	1683	1583
Red Grams	960	1105	1200	1320	1320	1360	1390	1400	1410	1550	2000	2300	3000	1563	1463
Paddy	440	490	510	530	530	550	560	570	580	645	850	950	1000	631	531
Total	8945	10015	10685	11500	11625	12340	12760	13095	13240	14230	18640	19435	21775		

Table-3: Minimum Break Even Crop Size (Bi) Per Acre (On Wet Land)

YEAR	Cotton	Mirchi	Groundnut	Jute	Bengal grams	Corn	Black grams	Green grams	Red grams	Paddy
2004-05	6.5	5.0	6.0	4.0	4.0	10.0	4.0	3.0	3.0	20.0
2005-06	5.0	5.0	5.0	4.5	4.0	11.0	3.0	4.0	4.0	22.0
2006-07	6.0	5.0	5.0	4.5	4.5	10.5	3.5	4.0	4.0	23.0
2007-08	5.5	6.0	6.0	4.0	4.0	10.0	4.0	3.5	4.5	23.0
2008-09	5.0	5.0	7.0	5.0	4.5	10.0	4.0	3.0	3.0	23.0
2009-10	6.0	6.0	6.5	5.0	4.5	11.0	4.5	3.0	3.5	24.0
2010-11	6.5	5.0	5.5	5.5	4.0	12.0	4.0	3.5	4.0	20.0
2011-12	6.0	5.0	6.0	4.5	4.0	11.5	4.0	3.5	4.5	24.0
2012-13	5.5	6.0	6.0	4.0	4.5	11.0	4.5	4.0	4.0	21.0
2013-14	5.0	6.0	5.0	5.0	4.5	10.0	3.5	4.0	3.5	22.0
2014-15	5.5	6.0	6.0	5.5	4.0	10.0	3.5	3.0	3.0	24.0
2015-16	6.0	5.0	6.5	5.5	4.5	12.0	4.0	3.0	3.5	23.0
2016-17	6.5	6.0	7.0	5.0	4.5	12.5	4.5	3.5	3.5	25.0
Average	6	5	6	5	4	11	4	3	4	23

Table-4: Minimum Break Even Crop Size (Bi) Per Acre (On Dry Land)

YEAR	Cotton	Mirchi	Ground nut	Jute	Bengal grams	Corn	Black grams	Green grams	Red grams	Paddy
2004-05	15	15	15	10	6	25	9	5	5	40
2005-06	14	15	14	9	6	30	9	6	6	35
2006-07	13	15	15	9	5	27	8	7	6	40
2007-08	14	14	15	10	6	39	6	6	7	38
2008-09	15	14	15	7	7	28	8	6	5	38
2009-10	14	10	14	8	8	28	7	7	6	39
2010-11	13	11	14	9	7	30	9	5	7	37
2011-12	13	12	12	10	9	32	8	5	5	38
2012-13	15	12	15	9	8	35	7	6	7	40
2013-14	14	13	14	9	8	29	8	6	6	38
2014-15	14	13	13	8	9	38	8	5	5	39
2015-16	15	11	12	7	8	39	8	6	6	39
2016-17	15	10	12	9	10	40	7	7	7	40
Average	14	13	14	9	7	32	8	6	6	39

Table-5: Types Of Expenditure Per Acre (Approx) On Wet Land (C_{ijk})

Crops	Plough, &machin	Seeds (kg)	Plant-ation	Labour	Fertil izers	water	Rent	picking charges	Storage (1quintal)	Total (H_{i1})
Cotton	2950	2000	500	11000	8000	2000	15000	1500	0	42950
Mirchi	3000	5000	3000	4500	5500	3000	15000	2000	100	41100
groundnut	3000	4000	4000	1000	3000	1500	15000	3000	100	34600
Jute	1500	400	500	1000	1000	0	15000	1500	0	20900
Bengal	1400	2000	700	2000	2900	0	15000	3000	100	27100
Corn	3500	1900	1000	2700	10000	2000	15000	2000	100	38200
black	1400	2000	500	2000	2900	0	15000	3000	100	26900
green	1400	2000	500	2000	3000	1000	15000	2000	100	27000
Red	3000	2000	700	1500	15500	0	15000	2000	100	39800
Paddy	5000	4000	1000	2000	5000	1000	20000	2000	100	40100
Total	26150	25300	12400	29700	56800	10500	155000	22000	800	338650

Table-6: Types Of Expenditure Per Acre (Approx) On Dry Land(C_{ijk})

Crops	ploughing & machinery	seeds(kg)	plantation	Labour	fertilizers	Rent	picking charges	Storage (1quintal)	Total(H_{i2})
Cotton	2950	2000	500	11000	8000	15000	1500	0	40950
Mirchi	3000	5000	3000	4500	5500	15000	2000	100	38100
groundnut	3000	4000	4000	1000	3000	15000	3000	100	33100
Jute	1500	400	500	1000	1000	15000	1500	0	20900
Bengal	1400	2000	700	2000	2900	15000	3000	100	27100
Corn	3500	1900	1000	2700	10000	15000	2000	100	36200
black	1400	2000	500	2000	2900	15000	3000	100	26900
green	1400	2000	500	2000	3000	15000	2000	100	26000
red grams	3000	2000	700	1500	15500	15000	2000	100	39800
Paddy	5000	4000	1000	2000	5000	20000	2000	100	39100
Total	26150	25300	12400	29700	56800	2E+05	22000	800	3E+05

Table-7: Minimum Support Prices (minimum Break Over Price)(S_i)

Crop Name	2004 -05	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16	**Total**	**Mci**
Cotton	1440	1575	1625	1675	1675	1690	1710	1730	1770	1820	1910	1950	2057	400
Mirchi	1650	1775	1825	1875	1875	1895	1920	1960	1970	1970	1990	2010	2271	600
Groundnu	1040	1155	1220	1340	1355	1370	1375	1410	1440	1475	1520	1545	1624	250
Jute	650	750	785	810	850	855	870	890	910	930	975	1015	1029	400
Bengal	705	755	775	795	795	825	825	840	875	910	925	1010	1003	600
Corn	795	845	865	885	885	925	935	935	955	960	990	1030	1100	120
Black	850	915	1025	1100	1120	1170	1200	1225	1240	1275	1315	1335	1377	300
Green	960	1105	1200	1320	1330	1340	1365	1380	1395	1425	1440	1475	1573	350
Red	960	1105	1200	1320	1320	1325	1340	1365	1390	1415	1435	1450	1562	350
Paddy	440	490	510	530	530	545	570	595	625	650	675	725	6885	900

Table-8: Types Of Expenditure Per Acre(Approx) On Dry Land(C_{ijk})

Crops	plough& machine	Seeds (kg)	Plant ation	labour	Fertil izers	water	Rent	Picking charges	Storage (1quin)	Total (hj)	cost per bag(C_{i1})
Cotton	2950	2000	500	11000	8000	2000	15000	1500	0	42950	7158.33
Mirchi	3000	5000	3000	4500	5500	3000	15000	2000	100	41100	8220.00
GroundNut	3000	4000	4000	1000	3000	1500	15000	3000	100	34600	5766.67
Jute	1500	400	500	1000	1000	0	15000	1500	0	20900	4180.00
BengalGrams	1400	2000	700	2000	2900	0	15000	3000	100	27100	6775.00
Corn	3500	1900	1000	2700	10000	2000	15000	2000	100	38200	3472.73
black grams	1400	2000	500	2000	2900	0	15000	3000	100	26900	6725.00
green grams	1400	2000	500	2000	3000	1000	15000	2000	100	27000	9000.00
Red grams	3000	2000	700	1500	15500	0	15000	2000	100	39800	9950.00
Paddy	5000	4000	1000	2000	5000	1000	20000	2000	100	40100	1743.48

Table-9: Types Of Expenditure Per Acre(Approx) On Wet Land(C_{ijk})

Crops	Plough & machine	seeds	plantation	labour	fertilizers	Rent	picking charges	Storage	Total	cost per bag (C_{i2})
Cotton	2950	2000	500	11000	8000	15000	1500	0	40950	2925.00
Mirchi	3000	5000	3000	4500	5500	15000	2000	100	38100	2930.77
Ground Nut	3000	4000	4000	1000	3000	15000	3000	100	33100	2364.29
Jute	1500	400	500	1000	1000	15000	1500	0	20900	2322.22
BengalGrams	1400	2000	700	2000	2900	15000	3000	100	27100	3871.43
Corn	3500	1900	1000	2700	10000	15000	2000	100	36200	1131.25
black grams	1400	2000	500	2000	2900	15000	3000	100	26900	3362.50
green grams	1400	2000	500	2000	3000	15000	2000	100	26000	4333.33
red grams	3000	2000	700	1500	15500	15000	2000	100	39800	6633.33
Paddy	5000	4000	1000	2000	5000	20000	2000	100	39100	1002.56