A STRATEGY FOR OPTIMAL ALLOCATION OF IRRIGATION WATER UNDER SOMASILA PROJECT IN ANDHRA PRADESH

By

CHALLA SREELATHA
M.Sc.(Ag.)

THESIS SUBMITTED TO THE
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN THE FACULTY OF AGRICULTURAL SCIENCES
(AGRICULTURAL ECONOMICS)

DEPARTMENT OF AGRICULTURAL ECONOMICS
COLLEGE OF AGRICULTURE
ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY
RAJENDRANAGAR, HYDERABAD – 500 030

JULY 2006

CERTIFICATE

Ms. **CH.SRILATHA** has satisfactorily prosecuted the course of research and that the thesis entitled **"A STRATEGY FOR OPTIMAL ALLOCATION OF IRRIGATION WATER UNDER SOMASILA PROJECT IN ANDHRA PRADESH"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 24.7.2006
Place: Hyderabad

(G.V.KRISHNA RAO)
Major Advisor

CERTIFICATE

Ms. CH.SRILATHA has satisfactorily prosecuted the course of research and that the thesis entitled **"A STRATEGY FOR OPTIMAL ALLOCATION OF IRRIGATION WATER UNDER SOMASILA PROJECT IN ANDHRA PRADESH"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 24.7.2006
Place: Hyderabad

(G.V.KRISHNA RAO)
Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"A STRATEGY FOR OPTIMAL ALLOCATION OF IRRIGATION WATER UNDER SOMASILA PROJECT IN ANDHRA PRADESH"** submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURE** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Ms. CH.SRILATHA** under my guidance and supervision. The subject of the thesis has been approved by the Students Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of investigation have been duly acknowledged by the author of the thesis.

(G.V.KRISHNA RAO)
Chairman of the Advisory Committee

Thesis approved by the Student Advisory Committee

Chairman : **Dr. G.V.KRISHNA RAO**
Professor
Department of Agricultural Economics
College of Agriculture, ANGRAU
Rajendranagar, Hyderabad – 500 030

Member : **Dr. Y.ESWARA PRASAD**
Professor &Head
Department of Agricultural Economics
College of Agriculture, ANGRAU
Rajendranagar, Hyderabad – 500 030

Member : **Dr.B.S.KULKARNI**
Professor & Univ.Head
Department of Statistics & Mathematics
College of Agriculture, ANGRAU
Rajendranagar, Hyderabad – 500 030

Member : **Sri G.KRISHNA KANTH**
Assistant Professor
Department of Statistics & Mathematics
College of Agriculture, ANGRAU
Rajendranagar, Hyderabad – 500 030

CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ACKNOWLEDGEMENTS

By the grace of **Lord Srikrishna,** *I have tried to pull my humble efforts to fulfill the task assigned to me by the chairman of my advisory committee* **Dr.G.V.Krishna Rao,** *Professor, Department of Agricultural Economics, College of Agriculture, Rajendranagar, Hyderabad. I am profoundly indebted to him for his advise, help and encouragement throughout my research work.*

I am highly grateful to the revered member of my advisory committee **Dr.Y.Eswara Prasad,** *Professor and Head, Department of Agricultural Economics, College of Agriculture, Rajendranagar, Hyderabad for his meticulous guidance given throughout my research work.*

I pay my heartfelt regards to **Dr. I. Narender,** *Retd. Professor,* **Dr. D.V. Subba Rao** *and* **Dr. K. Suhasini,** *Associate Professors, Department of Agricultural Economics for their generous help, valuable guidance during the course of study.*

I express my sincere gratitude to **Prof. K.R.Chowdry** *(Retd.) President Indian Rural Development Congress (All India Organization of Academecians & Professionals), Former Profesor and Head, Dept. of Agricultural Economics, College of Agriculture, Rajendranagar, Hyderabad for his valuable suggestions and able guidance during the period of research.*

I express my deep sense of gratitude to **Dr.B.S.Kulkarni,** *Professor & Univ. Head and* **Sri K.Krishnakanth,** *Assistant Professor, Department of Statistics and Mathematics, College of Agriculture, Rajendranagar, Hyderabad for their kind help in statistical analysis of thesis data.*

"A real Professor always teaches sincerely with spiritual philosophy". I am thankful to the almighty in providing such a colossal personality. I have no other satisfaction than to express my deep sense of gratitude to my guru, the in defatigable individual **Dr.T.V. Neelakanta Sastry,** *Associate Professor, Department of Agricultural Economics, S.V. Agricultural College, Tirupati who with all his interest, dedication and empathy has devoted his valuable time patiently to mend my thinking from conception to completion of this task. Though I fail to verbalize the influence he has on me, I have no qualms in admitting that his logical, critical and methodological approach has ignited in me a desire to perform and excel. His constant untiring interest and pains taking guidance were the main sources of inspiration without which, this study could not have been as methodological extensive and hopefully useful as it is now and would have remained my dream forever. I am fortunate to have blessed with privilege of working under his esteemed guidance. I owe him a huge debt of gratitude forever for all that I got from him.*

*I wish to extend my sincere **thanks** to my respected teachers Dr.P.Raghuram, Professor, Smt.I.Bhavani Devi Assistant Professor and Dr. S.Subba Reddy, Professor and Head, Department of Agricultural Economics, S.V.Agricultural College, Tirupati for their help and cooperation.*

I am gratefully acknowledge the project preparation cell, Somasila Project circle, Nellore for providing all necessary details for the present study.

*The persons whom I can never thank but without whose love and affection I could not have achieved my goal are my beloved parents **Smt Ch.Nagarajamma, Sri Ch.Ramana Reddy** and Brothers **Pavan and Sudheer**.*

*I am proud of my strength, my sense of pride, my love and my best half **srikanth** who backed me throughout this study and literally made possible to accomplish this task. His help, support, mental togetherness in times of frustration and ability to bear me can never be substituted. I derived immense inspiration to work from the loveliest creation in our world, a source of fulfillment, our son **Srikesh**, with out whose presence this work would have been unfinished .I derived a true family support from them, who hold the key of my life.*

*I express my profound sense of gratitude and honour to my in laws **Sri G.Ramana Reddy** and **Smt G.Vani Bhavani** and brother in law **G.Srinath Reddy**, sister-in-law **G.Srilatha** and Brother **A.Srinath Reddy** for their moral support, well wishes and cooperation during the course of my study.*

I owe my cordial thanks to my friends in particular Sriharitha, Sujathalakshman, Jayapradhadileep, Srividyaln, Suneetha, Suryakumari and Aruna, Who were on my side to add courage and confidence and helped me during my Ph.D Studies. I extend warmest thanks to my little friends Kavisree, Sowjisudheer, Vara, and Sreenu for their cheerful company during my PhD studies.

Finally I am grateful to Achrya N.G Ranga Aricultural University for rendering financial support during my doctoral programe.

*I express my thanks to **Mr. Ashok** for the neat and excellent execution of this manuscript.*

Ch. Srilatha

Challa Sri Latha

DECLARATION

I, **CH.SRILATHA**, hereby declare that the thesis entitled **"A STRATEGY FOR OPTIMAL ALLOCATION OF IRRIGATION WATER UNDER SOMASILA PROJECT IN ANDHRA PRADESH"** submitted to the Acharya N.G. Ranga Agricultural University for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURE** is a result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier in any manner.

Ch. Srilatha

Date: 24.07.06

(CH.SRILATHA)

Place: Hyderabad

Author	:	**CHALLA SRI LATHA**
Title of the thesis	:	**A STRATEGY FOR OPTIMAL ALLOCATION OF IRRIGATION WATER UNDER SOMASILA PROJECT IN ANDHRA PRADESH**
Submitted for the award of degree	:	**DOCTOR OF PHILOSOPHY**
Faculty	:	**AGRICULTURE**
Department	:	**AGRICULTURAL ECONOMICS**
Major advisor	:	**Dr. G.V.KRISHNA RAO**
University	:	**ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY**
Year of submission	:	**2006**

ABSTRACT

The present study is an attempt to analyze the possibilities and prospects of increasing the net farm income by better resource allocation through optimum enterprise system. Somasila command area was purposively selected for the present study, as it is one of the agriculturally major command areas of Andhra Pradesh.

A multi stage stratified purposive cum random sampling procedure was adopted to the present study. The entire command area divided into three regions viz., head, middle and tail regions. From each region first two mandals with maximum command area were purposively selected. All the villages in the selected mandals based on command area were arranged in descending order and the first two villages from each mandal were selected for a detailed study. The list of farmers from the selected 12 villages of three regions of command area, were obtained from the village officials. From the list of farmers in each village, five each from small and large farmers were selected at random. Thus, the number of farmers selected from each village was ten and that total number of farmers selected for purpose of present study was 120. The data on inputs and outputs of crop enterprises were collected from the respondents for the agricultural year 2003-2004.

Linear programming was used to develop optimum plans. A total of twenty-four optimum plans were developed for small and large farms of head, middle and tail regions of Somasila Project command area. The objective

function for the model in this study was to maximize the annual net farm returns from crop enterprises subject to the resource constraints specified in the model. To accomplish the objectives of the study, a few variations in the basic model were incorporated. The model was first run with the existing water supply level (Model 1). Later with 10 percent decrease in water supply (Model 2), 20 percent decrease in water supply (Model 3) and 30 percent decrease in water supply (Model 4) were assumed and corresponding models were solved to study the effect of irrigation water on cropping pattern, income, employment and resource use pattern.

The results of the study revealed that there exists sub-optimal allocation of resources in the existing plans of small and large farmers. The process of optimization under different water supply conditions resulted in the improvement in the net farm returns of both the categories of farmers in the study area. However, the optimum model developed at existing water availability resulted in higher net farm returns as compared to other models developed at 10, 20 and 30 percent reduction in the water supply on small and large farms of head, middle and tail regions. The process of optimization led to increase in the area under high valued crops and thus reducing the number of crops.

The effect of irrigation water on net farm income, employment and other inputs were examined by decreasing water availability by 10, 20 and 30 percent over the existing level. It is also evident that the decline in the net farm returns, employment and use of other inputs were more pronounced on both the categories of farms of the three regions when water availability was reduced by 30 percent.

The sensitivity analysis with reduced availability of water by 10, 20 and 30 percent levels revealed that the farmer's income could be increased over the existing plan if the normative plans were adopted.

INTRODUCTION

CHAPTER – I

INTRODUCTION

Agriculture is accounting for 25 per cent of the nation's Gross Domestic Product (GDP), 15 per cent of exports and 60 per cent of the employment continues to be the main stay of the economy. Having achieved laudable success in agricultural production in the last 50 years, India has transformed herself from a food deficit to a food surplus country. Still there are many challenges, which Indian agriculture is facing in the fast changing market economy. Relating to the natural resources and production base, water has emerged as the most crucial factor for sustaining the agricultural sector in the coming years.

India accounts for 16 per cent of the world's human population and nearly 30 per cent of the cattle with only 2.4 per cent of the land area and 4 per cent of water resources. Even if the full irrigation potential is exploited, about 50 per cent of the country's cultivated area will remain unirrigated, particularly with current level of irrigation efficiency.

The demand for water for agricultural purposes is estimated to increase to produce increasing quantities of food, horticultural produce and raw material for the industry. The requirement of water by different sectors by 2025 is estimated to be 105 M.ha m, but the share of water for agriculture is expected to reduce from the present level of 85 per cent to 71 per cent of 2025.

On the other hand, the demand for water for agricultural purposes is estimated to increase from 50 M.ha.m in 1985 to 70 M.ha.m in 2050. During the same period, the demand of water for non-agricultural use will multiply four fold from 7 M.ha.m to 28 M.ha m.

The importance of water as a valuable resource for agriculture can never be over emphasized. The increasing need for crop production for the growing population is causing the rapid expansion of irrigation throughout the world. The area under irrigation in India was only 19.4 M ha in 1947 and has increased to 22.6 M ha before the five year plan commenced i.e. 1950-51. Irrigation was given highest priority in the first three five years plans. The share of irrigation to the total expenditure was more than 25 per cent for the 6th, 7th and 8th five years plan period. The increase in irrigated area has been on an average 2.1 M ha per year during 6th plan, 2.6 M ha per year during 7th plan period and 2.5 M ha per year during the 8th plan period. The ultimate irrigation potential comprising major, medium and minor irrigation sub-sectors is estimated at 139.89 M ha out of this, the potential so far created is 96.9 M ha (68 %) at the end of the 8th (1997) plan.

Andhra Pradesh is endowed with many major rivers, important among them being Godavari, Krishna, Vamsadhara and Penna. The states share of dependable flows at 75 per cent dependability from the river system is estimated at 2746 TMC (Thousand Million Cubic feet). This breaks up into 1480 TMC from the Godavari System, 811 TMC from Krishna, 98 TMC from the Pennar and the rest from other smaller rivers. Before independence, the total irrigation potential created was 2.704 M.ha upto 1951. After independence, high priority was given to irrigation development for rapid economic growth and planned irrigation development was started to achieve the goal. As a result the investments on irrigation schemes in the states increased substantially. In the span of 46 years, from 1951-52 to 1996-97 an additional irrigation potential of about 2.26 M.ha has been created bringing the total to 4.963 M.ha.

The population increase, coupled with improved purchasing power associated with economic growth would enhance not only the demand for cereal foods, but also the demand for other products. According to recent estimates, the country will need about 260-264 million metric tones of food grains, 130-150 million metric tonnes of milk, 151-193 million metric tonnes of vegetables, 80-106 million metric tonnes of fruits, 10-14 million metric tones of fish and 12 million metric tonnes of edible oils to provide adequate nutrition to 1.35 billion people by 2020 AD. The expanding demand for agriculture commodities together with limited availability of farm resources (water and labour which are highly transferred to non agricultural sectors) needs a careful exploitation of production possibilities and ways for increasing the efficiency of resources on various sizes of farm.

Rainfed lands are not only low in productivity and sustainability but are also more prone to risks, as compared to those in irrigated areas. These are also the location for greater concentration of poor and hungry persons. This can be obviated to some extent by expanding irrigated areas through improving water management and water use patterns. Presently, the problem faced by the country is not only the development of water resources, but also the efficient management of the developed water resources in a sustainable manner. By adopting efficient water management/conservation practices, substantial portion of agricultural lands could be brought under irrigation.

The main concern of productive agriculture is the effective and efficient supply of water to crop fields. Since irrigation potential is created at huge cost, it is necessary to derive maximum benefit from the created potential. A large amount of water is wasted in conveyance and distribution systems. As such 50 per cent of water is reached to field from major reservoirs and the efficiency of the irrigation system is only 35 per cent and major irrigation schemes are running sub optimally.

In agriculture as in any other business, the efficiency is achieved by the optimum utilization of resources. Optimum allocation of land and other resources is defined as to what crop activities to undertake, how much land to allocate to each crop activity and what method and combination of inputs to use on each crop, so that net farm returns are maximum. Increasing costs of agricultural inputs and dwindling profitability of crop production has been making agriculture a loosing proposition. In view of this, it is necessary that the available inputs should be used economically and efficiently. The efficiency of farming depends on such combination of resources that is most economical to secure a given output. The relation between the money value of outputs and inputs is thus a measure of efficiency. The higher the output per unit of input, the greater is the efficiency of a given resource and conversely greater the efficiency of resources, the greater would be the output. The maximization of efficiency is therefore, a condition for the maximization of income. The efficiency of each factor input is maximized when its contribution to production is maximum. The equilibrium of factor inputs, is denoted by the point at which the marginal productivity of the factor inputs is equal to their prices. That is, at this point an optimum combination of factors making for the highest efficiency is achieved. The rational use of resources on farm can be achieved by determining scientific optimal enterprise mix resulting in increased farm returns and employment.

The present study is an attempt to analyze the possibilities and prospects of increasing the net farm income by better resource allocation through optimum production pattern of crops.

1.1 OBJECTIVES OF THE STUDY

1. To study the existing resource use pattern of selected farmers under three regions in the command area of Somasila Project.
2. To develop optimal enterprise mix for the sampled farmers and compare the same with existing situation.

3. To examine the income and employment opportunities through optimal reorganization of resources

4. To suggest policy measures for efficient water use in the command area of Somasila Project.

1.2 SCOPE OF THE STUDY

Irrigation being the most limiting constraint for wide spread adoption of new high yielding, fertilizer responsive crop varieties, attempts to make the best use of available supply is crucial for future agricultural development. The availability of water at farm level decides the level of input use and ultimately the crop yield.

The findings of the study would be very useful to the farmers of the study area to identify the irrationality in existing production patterns and resource use and to suggest appropriate production plans for efficient utilization of scarce resources resulting in increasing net farm income and employment. The study also throws light on future potentialities of increasing net farm income and employment under different levels of water availability.

1.3 LIMITATIONS OF THE STUDY AREA

The study was conducted in a limited period of time and area of particular agro-climatic and social economic situation and obviously suffers from drawbacks and any generalization of the results could not be wholly unbiased. This study did not consider the risks and uncertainty situation in farming and marketing. The necessary primary data were collected from the farmers based on their recall memory by interview method and hence has inherent limitations.

1.4 ORGANIZATION OF THE THESIS

The thesis is presented in five chapters. The first chapter devotes to the introduction of problem, objectives, and the scope of the study. The second chapter attempts a critical review of the past work done. The third chapter deals with the sampling design, method of collection of data and description of the analytical tools. The fourth chapter presents analysis of the results and discussion. The last chapter throws light on the summary and conclusions emerged from the study.

REVIEW OF LITERATURE

CHAPTER – II

REVIEW OF LITERATURE

A brief review of literature pertaining to the present study is presented in this chapter. For any investigation the findings of earlier studies may possibly give indications of the problems and provide guidelines for the study. For better exposition the review of literature is presented under the two following heads.

2.1 USE OF LINEAR PROGRAMMING TECHNIQUE

2.2 PROSPECTS OF AUGMENTING FARM INCOME AND EMPLOYMENT THROUGH REORGANIZATION OF RESOURCES

2.1 USE OF LINEAR PROGRAMMING TECHNIQUE

In India linear programming (LP) was first used in agricultural planning by Desai (1960). In this pioneering work, Desai used LP for developing optimal plans for farms in Ahmedabad district. The optimal plans gave significantly higher income over the existing plans in his study.

Kahlon and Johl (1962) in their study on the application of budgeting and linear programming in farm management analysis reported that, linear programming might be preferred where the choice was to be made among many alternatives and high accuracy needed. It enabled even a less skilled worker to reach an optimum solution. Therefore, linear programming is considered a useful tool of farm management analysis even in under developed countries.

Desai (1962) from the comparison of budgeting and linear programming techniques in farm management with marginal analysis found that, the net returns obtained from programming was higher than the net returns of alternative plans developed with the budgeting technique.

Meenakshi Malya (1962) stated that the linear programming offers a great scope for its usage with advantage and even alternative plans could be worked out for different prices. She concluded that the pressing need for reorganisation of the limited resources made the application of linear programming, a necessary step towards efficient farm business management.

To develop optimum farm plans for subsistence and commercial farmers in Bangalore district, Ramanna (1966) applied linear programming technique. He reported that a substantial increase in net farm returns could be realised by proper reorganisation of available resources even with the available technology. He also pointed out the prospects of higher net farm returns under improved technology with additional resources.

Randhawa and Heady (1966) applied inter-regional programming model to determine an optimal allocation of land among different crops and regions of India. They used gross returns to develop optimal production pattern, but found that it would be better if net returns were used in the analysis. They also pointed out that cash costs in their study formed a small proportion of the total cost and then reported that the situation had changed and the proportion of variable cost to the total cost had increased and the concept of gross returns seemed to have lost its relevance.

Sirohi and Gangawar (1968) assessed the possibility of increasing net farm returns through reorganization of resources by employing linear programming. The results of their study showed that by reallocation of resources, net farm returns could be increased to the extent of 24 to 42 per cent.

Gangwar and Ghakar (1975) developed optimum plans at the existing and improved level of technology by using variable capital programming model. They concluded that, there was scope for increasing farm returns even at the existing level of technology, if adequate working capital was made available to the farmers.

Venkatram (1975) used variable resource programming in order to evaluate the benefits of different levels of capital availability on the adoption of new farm technology and net farm returns to farmers in Mandya district, Karnataka.

Lakshminarayana and Rajagopalan (1977) studied the problem of optimal cropping pattern and water release from canals and tube wells in Bari Doab basin in Indus using a linear programming model with all input data in deterministic form for a water resource system consisting of canals, tube wells and drainage.

Linear programming technique was employed by Singh *et al.* (1977) to assess the impact of dairy enterprise on productivity and employment. They concluded that the normative plans developed with and without dairy not only affected the productivity and employment but also the requirements of capital and credit on the farms. The capital and credit requirements increased with the diary activity. It was also found in the optimum plans, that two buffaloes for small, three for medium and eight for large farmers to be necessary to maximize their net farm returns.

The impact of optimal allocation of supervised production credit on different farm size groups was assessed by Arora and Prasad (1978) by employing linear programming. The results revealed that the gains of optimal credit allocation were more on small farm followed by medium and large farms.

Nadda *et al.* (1978) explored the possibilities of optimising farm returns for the farmers of different zones in Himachal Pradesh. They concluded that existing cropping pattern, where diversification of agriculture observed, was found sub-optimal. The normative cropping pattern involved fewer crops, indicating a tendency towards specialisation.

Eswaramoorthy (1980) developed optimum water use pattern for lower Bhavani project area in Tamil Nadu taking into consideration of the existing pattern of ground water use. Linear programming technique was used to allocate water among competing crops at different time periods with monthly water budget constraints and labour constraints. He concluded that the programming served as the best optimization technique for handling water allocation problems.

Hiremath and Sirohi (1980) employed linear programme to evolve irrigation practices for optimal, inter temporal, inter-regional and inter crop allocation of irrigation water with the objective function of maximizing the total value output from irrigated crops.

Kausik and Gangwar (1980) used linear programming to study the optimum utilization of irrigation water for synthetic farm situation in the Jui Lift Canal area.

Palanisami (1980) observed that farmers at the head region of the lower Bhavani project, Coimbatore, Tamil Nadu had grown high demanding crops and got more than adequate water than tail end farmers. Thus, the supplies to tail end farmers were highly unpredictable and non-existent. He also concluded that availability of water and types of crops grown were directly related. He also reported that as distance increased and time taken to irrigate the crop had also increased. At the same time he had also observed that number of wells increased as distance increased.

Selvarajan and Subramanian (1981) used linear programming technique for optimizing water use and concluded that there existed ample scope for increasing farm income and employment through optimization and water augmentation.

Elumalai (1982) developed optimum cropping pattern for a portion of irrigated command area of Parambikulam Aliyar project in Tamil Nadu using linear programming technique. He formulated crop plans by effectively using water and other resources.

Ganesan (1982) used linear programming technique to optimize the irrigation water at farm level at different reaches *viz.,* head, middle and tail under canal in Parambikulam Aliyar Project Area, Coimbatore District, Tamil Nadu.

Thorve and Galgalikar (1985) used linear programming to study the impact of dairy enterprise on costs and returns and concluded that mixed farming with dairy had a positive effect on the income of the farmers in all the size groups.

Selvarajan (1986) studied the water use planning in Amaravathi river basin in Tamil Nadu. He used linear programming model in evolving area level optimization in the command area.

Satpue (1988) developed optimal crop plans for Jayakwadi project in Maharastra under existing and improved level of technology by using linear programming technique. The model included 30 constraints and 86 crop activities at existing level of technology.

Singh and Saini (1988) employed linear programming to integrate improved technology of crop and dairy production for increasing income and employment. They concluded that the optimisation of resources under different farm plans resulted in increased income on marginal, small, medium and large farms. Adoption of improved technology in both the crop and dairy production increased the income of the farmers by 116 per cent (small) to 232 per cent (marginal) as compared to the existing plan.

Kanade *et al.* (1989) employed linear programming to find out the optimal utilization of available irrigation water in the command area of mula irrigation project in Maharatra. In the optimal plan, sunflower during the *kharif* and safflower during the *rabi* season had been introduced. The area under *kharif* Jowar and summer groundnut had increased. The cropping intensity worked out to 174 and 147 per cent with 30 and 50 per cent water availability

Parasurama reddy *et al.* (1989) analysed the resource use pattern in the command area of upper Krishna project in Karnataka and concluded that educating the farmers for reorganization of resources with the existing level of owned funds and crop loan facilities would enable them to realize better net farm returns.

Subbarayan and Singh (1989) reported that optimal allocation of water among crops resulted in an increase of 24 per cent in net returns when compared with the existing situation. On optimization, the total water use in the command area was about 88 per cent of the existing situation.

Sastry and Venkatram (1993) applied the linear programming to develop optimum enterprise system for farmers in Chittoor district, Andhra

Pradesh. They indicated greater scope for increasing the net farm income on small farms by mere reorganisation of resources even under existing technology and with available funds. Further, they found that the effect of optimisation of resources at existing technology both under restricted and unrestricted capital was insignificant on large farms.

Ushasri *et al.* (1994) employed linear programming to examine the prospects of income and employment in rural areas of Krishna district of Andhra Pradesh and concluded that specialisation in a few crop enterprises along with cross bred buffalo unit would give more income than that of diversification.

Linear programming was used by Sree Lakshmi and Sastry (1995) to determine the income and employment prospects of farmers in Chandragiri mandal of Chittoor district. Their study indicated that the simultaneous provision of credit and adoption of new technology would enhance the income and employment opportunities on small and large farms.

Sharma *et al.* (1996) explored the potentiality and adequacy of liberal credit facility and the recommended levels of technology in raising incomes of the rural poor above poverty line under different farming systems through optimal allocation by using linear programming technique. They concluded that simultaneous provision of recommended technology and liberal credit increased the net returns considerably.

Goswamy (1997) employed linear programming to appraise indigenous farming systems of West Garo Hills district of Meghalaya. He developed three optimum plans *viz.,* Plan I with existing resources, Plan II with existing resources and relaxation of capital constraint in different seasons and Plan III with existing resources and simultaneous relaxation of capital and human labour constraints. He concluded that the systematic farm planning was paying proposition under the existing technology with the existing resource base on the hill farms.

Rao (1997) examined the issues of sustainable development, in terms of interdependencies of resources and technologies in a linear programming framework. He formulated a linear programming model with two alternative objective functions – one, in terms of income and another in terms of energy with a set of constraints that stand for economic and ecological requirements. He concluded that soil conservation could be achieved with smaller area under forests.

Deoghare et.al (1997) while doing economic analysis of farms had applied the linear programming to find out the optimal resource use and credit needs. He had prepared four different plans with restricted capital and adequate credit each for existing and recommended levels of technology.

To derive the normative demand function for borrowing of credit, Jahagirdar *et al.* (1997) employed the parametric linear programming model.

They had formulated two plans for estimating credit requirement at existing and recommended levels to technology.

Saini *et al.* (1998) had arrived at optimal use of energy inputs for the maximisation of net energy using linear programming technique. They had formulated four different plans for energy efficiency and returns efficiency each at existing and recommended levels of technology.

Ramakrishnaiah and Sastry (1998) used linear programming to develop optimum crop and livestock pattern for farmers in Nandyal Mandal, Andhra Pradesh. They developed eight different models, four each for small and large farmers at existing and recommended technology with limited and unlimited capital.

Tilekar and Nimbalkar (2000) applied linear programming to study the effect of optimization on the cropping pattern and income in and outside mula irrigation command area. The optimal plan suggested to grow fewer crops compared to the existing situation and resulted in the increase of net income by 14.92 per cent.

Shareef and Murthy (2001) used the linear programming technique to develop optimum plans for efficient utilisation of water at farm level. The model was used to prepare four plans (I, II, III, IV) according to various water availability levels each for head, middle and tail regions of K.C. canal irrigation system, Andhra Pradesh.

2.2 PROSPECTS OF AUGMENTING FARM INCOME AND EMPLOYMENT THROUGH REORGANIZATION OF RESOURCES

Johl and Kahlon (1963) employed linear programming to determine the cropping pattern that resulted in higher returns in Ludhiana district, Punjab. The results showed that returns to the fixed resources increased from Rs.5,060.27 to Rs.5,210.80 in the optimum cropping pattern. Capital was found to be the most limiting factor to enhance the farm returns. When capital borrowing activity was included in the model, the returns to the fixed farm resources increased from Rs.5,060.27 to Rs.9,420.27 in the normative cropping plan.

Singh (1970) used linear programming technique to know the possibilities of increasing the income and labour absorption through optimal combinations of crop and dairy enterprises on farms of Eathah district of Uttar Pradesh. He developed optimum plans under existing as well as improved technology with limited and unlimited capital. He concluded that inclusion of dairy was profitable with both the limited and unlimited capital situations.

Singh *et al.* (1972) in their study on production possibilities and resource use pattern on small farms in three regions of Uttar Pradesh examined the prospects of increasing farm income through better resource allocation. It was observed that the farm resources were not utilised optimally under existing cropping pattern and suggested that reorganisation of production programme would increase the farm income even under the existing resource availability.

Venkatram (1975) examined the effect of credit on income and explored the possibility of increasing the net farm returns at different levels of external finance under existing and improved technology situations in Mandya district of Karnataka by employing linear programming technique. He concluded that either a marginal increase in the quantum of loan or change in technology alone would fail to augment the income of farmers. An increase in the loan funds availability by 50 per cent over the existing loan limits facilitated the farmers to adopt improved technology which enabled them to augment their net returns to the tune of Rs.10,931.

Vijayakumar (1976) examined the credit needs of irrigated and unirrigated farms under existing and improved technology situations in Bangalore South taluk of Karnataka using linear programming technique. He concluded that the optimum plans with additional capital through borrowings under improved technology could result in substantial increase in income of both the categories of farms.

By using linear programming technique, Kesava Reddy (1979) developed optimum crop and dairy mix for farmers in Bangalore district. The results of the study indicated one cross bred cow for small farmers, one cross bred cow and one local buffalo for medium farmers and none for large farmers in normative plans of crop and dairy mix. As a result the net farm returns increased by 45.77 per cent for small, 42.25 per cent for medium and 57.88 per cent of large farmers over existing plan. He concluded that the introduction of dairy along with crops would be more profitable only in case of small and medium farmers.

Mruthyanjaya and Sirohi (1979) in their study stated that the net returns were higher and more stable in the optimal plan with dairy than the optimal plans without dairy. The results showed that the mixed farming with dairy could not only increase net returns but also add stability to farm income. As a result of inclusion of dairy, both human and bullock labour employment improved.

Bhatia and Gangwar (1980) explored the possibilities of increasing income and employment through dairying on small farms in the Karnal district, Haryana. They inferred that the farm income could be increased substantially by adopting improved technology for both crop and livestock production. They also indicated that dairy provides additional employment of human labour on small farms with additional capital.

Nanja Reddy (1980) employed linear programming to examine the income and employment potential on small farms in Bangalore district, Karnataka. It was observed that the net farm returns increased to the extent of 50 and 16 per cent on unirrigated and irrigated small farms respectively by mere reallocation of resources at existing technology. The results also indicated the prospects of raising the income by 110 per cent on unirrigated farms and by 14 per cent on irrigated farms when capital constraint is relaxed.

Sirohi *et al.* (1980) in their study on the role of dairy and poultry enterprises for increasing income and employment on farms in the union territory of Delhi observed a substantial increase in income and employment on the small and marginal farms through the optimisation of resources with the help of liberal credit facilities.

Selvarajan and Subramanian (1981) in their study Economic impact of resource use optimization and water augmentation in farms of Parambikulam Aliyar Project region stated that resource use optimization would increased income by 25.97 per cent, net income by 33.11 per cent, family labour income by 76.91 per cent and farm business income by 45.13 per cent. The effect of water augmentation was to increase the gross income by 20.56 per cent, net income by 22.67 per cent, family labour income by 23.81 per cent and farm business income by 22.90 per cent.

Nagaraja and Venkataram (1983) in their study An optimum cropping pattern and its impact of net farm returns in Daddaballapur taluk, Bangalore district of Karnataka reported that optimal plans would enhance net farm returns by 94 and 125 per cent on small and large farms respectively. They further revealed that rational allocation of resources facilitated increased labour of 57 woman days on small farms, 8 man days and 8 woman days on large farms.

Dangat and Patil (1985) explored the possibilities of increasing farm income through diversification for farmers in Ahamadnagar district, Maharastra. They reported that the increase in income over the existing plan was 36, 57 and 33 per cent on small, medium and large farms of *kharif* zone respectively, while the increase was 12, 83 and 52 per cent on small, medium and large farms respectively in *rabi* zone. The study further revealed that the increase in income was 116 per cent on small farms, 208 per cent on medium farms and 110 per cent on large farms under capital relaxation.

Singh and Subbarayan (1986) employed linear programming for optimising the use of energy inputs on different size groups of farms in Meerut district of Uttar Pradesh. The results of their study showed that on small farms, the net returns per hectare in the existing plan was Rs.7,503.75 and the net returns per hectare in the normative plan increased by 14.98 per cent. On medium and large farms, the net returns per hectare increased by 17.52 and 16.32 per cent respectively.

Gracy (1987) in her study in Bangalore North taluk of Karnataka stated that the reorganisation of resources with the available loan funds of Rs.2,500 and Rs.2,000 at the existing interest rate of 11 per cent enabled large and small farmers to realise Rs.18,246.94 and Rs.6,504.71 of net farm returns, an increase of 60.06 and 123.39 per cent over the existing situation respectively. She also reported that resource reorganisation resulted in decreased labour use on large farms. However, the labour use was relatively more on small farms over the existing plan.

Singh and Sharma (1988) analysed the possibilities for increasing income through optimum combination of different enterprises and found that the dairy enterprise was the major source of income which showed increased income about 209% under optimal plan in Mid-Western Region of Uttar pradesh.

Singh and Chaurasia (1990) employed linear programming technique to examine the possibilities of increasing income and employment through progressive farm practices on vegetable farms in Deoria, Uttar Pradesh. The results indicated that the farmers preferred relatively more labour intensive enterprises than income generating enterprises. This study also revealed that the reorganization of existing resources increased the net returns but decreased employment. However, when progressive farmer's practices were adopted with capital borrowing, both net returns and employment increased by 173 per cent and 29 per cent respectively.

Gogoi and Bhowmick (1990) in their study on resource allocation in farms of flood-prone and flood-free areas in Sibsagar sub-division of Assam concluded that the small farms showed greater potentiality of increasing farm income as compared to medium and large farms. The study also revealed that the increase in labour employment due to optimisation was more on small farms.

Gajanana and Sharma (1990) used the linear programming technique to assess the income and employment prospects by reallocating the resources. They concluded that there was a significant scope for enhancing the returns on farms by the optimization of resources.

Goswamy and Meenakshisundaram (1992) revealed from their study conducted in West Garo Hills district of Meghalaya, that by mere reallocation of existing resources, farmers could increase their net income from Rs.1,807 to Rs.2,854 *i.e.,* an increase of 57.93 per cent. Further by relaxing capital constraint, the level of present income could be pushed further to Rs.4,416 *i.e.,* an increase of 144.41 per cent.

Jain and Singh (1993) conducted a study on the prospects of increasing income and employment through edible oil seeds production in Gurgaon district of Haryana state. Optimisation of existing resources for maximizing the net returns (Gross income – Cost A1) to fixed factors was done by employing linear programming technique. The study revealed that the increase in net returns to fixed factors in the optimal plan was more on small and medium by 35 and 23 per cent respectively than on large farms (7.83 %), when compared with existing farm situation. The results also showed that the employment of human labour under rape seed and mustard had increased from 15.90, 20.0 and 15.70 per cent on small, medium and large farms in the existing plan to 18.10, 31.20 and 28.00 per cent respectively in the same order.

Sastry and Venkatram (1993) explored the prospects of increasing income and employment under restricted and unrestricted capital availability as well as at existing technology and improved technology by employing linear programming technique. The results of the study indicated that the small and large farmers of Chittoor revenue division could increase the net farm income by 37.47 and 0.95 per cent, 48.96 and 1.06 per cent, 110.40 and 57.65 and 153.02 per cent and 67.91 per cent over existing plan by adopting optimum plans I, II, III and IV respectively. Further, the study revealed that the total employment of human labour was higher than the existing plan on both the categories of farms. Adoption of improved technology coupled with adequate capital lead to increase in the men and women labour employment to the extent of 43.03 and 26.47 per cent and 20.81 and 68.95 per cent on small and large farms respectively.

An improved method of water allocation to different canals in a canal system in Uttar Pradesh, India, was devised using a linear programming technique by Radheyshyam *et al.* (1994). Model results were compared with the existing, and three alternate operation policies in which optimal allocation takes place at different stages of water distribution. All alternative policies were superior to the existing operation policy. The policy in which optimal allocation begins at the branch canal level had the greatest return amongst all policies studied.

Sree Lakshmi and Sastry (1995) in their study Optimum Enterprise system for farmers in Chandragiri Mandal of Chittoor district indicated immense scope to increase the net farm returns by mere reallocation of resources even with the existing technology and available funds. The net farm returns could increase by 24.99 and 21.93 per cent over the existing situations on small and large farms respectively. The process of optimisation leads to decrease in men and bullock labour on small farms and men and tractor use on large farms over the existing plan. However, there was increase in the woman labour employment to the extent of 42.05 and 70.92 woman days on small and large farms respectively over the existing production plans.

Lathar *et al.* (1996) examined the prospects of enhancing the income of marginal and small farmers in Haryana through diversification of farming. The results of their study revealed that marginal and small farmers were found to be quite close to the optimum plan (P_1), which was derived by considering the commonly present crop production activities at the existing level of technology. However, with the adoption of advanced production technology by the top 10 per cent of the progressive farmers for various crops and high value farm products which also included vegetable crops, mushroom, marigold and cross bred cows (P_2), the returns over the variable costs could increase by 356 and 184 per cent over the base period for marginal and small farms respectively. Further, it was found that the magnitude of gainful employment under plan P_2 was increased by 30 and 70 per cent over base period in the case of marginal and small farms respectively.

Saini *et al.* (1996) in their study Impact of diversification on small farms economy in Himachal Pradesh revealed that the diversification of arable farming systems with commercial enterprises *viz.,* high yielding milch animals, poultry birds, bee keeping, floriculture etc., resulted in a marked increase in the farm income ranging from 6 to 138 per cent on small farms. The increase in human labour employment as a result of diversification ranged from 17 to 51 per cent in optimum plans. They concluded that the capital and credit requirements increased with the extent of diversification.

Sharma *et al.* (1996) in their study Role of diversification in eradication of farm poverty; A case study of Alwar district of Rajasthan State reported that mere optimal allocation of resources at the existing level of technology and restricted capital availability increased the net returns of group I (irrigated farms) farmers by 73 per cent and in case of group II (unirrigated farms) by 88 per cent. The per capita income of group I farmers reached above the poverty line when the resources are allocated optimally under the existing technology while that of group II farmers remained below the poverty line. An interesting feature of the study was that even with restricted capital the crop, dairy and goat farming system ensured an income above the poverty line for both the groups of farmers.

Dhawan *et al.* (1997) in their study on impact of fruit cultivation on general crops and milk production in Punjab indicated tremendous potential particularly on small farms for improving incomes and employment by making judicious use of borrowed funds. They concluded that the existing returns from fruit orchards were too meagre to warrant their entry into the production programmes of the farmers.

Goswamy (1997) in his study Economic appraisal of indigenous farming systems of West Garo hills district of Meghalaya reported that under existing resource level (Plan I) the present income of Rs. 17,637.50 had increased to Rs. 25,789.22 indicating an increase of 46.22 per cent over the existing plan. Under the relaxation of capital in plan II and capital borrowing and the human labour hiring in plan III, the income generation was raised to Rs.28,999.73 in the optimum plan II and Rs. 29,358.54 in the optimum plan III indicating and increase of 64.22 and 66.46 per cent respectively over the existing situation. The employment of human labour had increased in all the optimum plans. However, a significant increase of 25.46 per cent in the employment was noticed in the optimum plan III.

The advantage of optimal plans in increasing both income and employment was revealed clearly in Deoghare's (1997) economic study on farm holdings in Karnal district of Haryana. The employment of human labour was increased by 86.30, 50.98, 26.62 and 10.81 per cent with existing technology and by 112.16, 70.77, 50.67 and 19.01 per cent with recommended technology on optimal plans of marginal, small, medium and large farms respectively. Similarly the net returns were increased by 11.93, 32.08, 25.91 and 20.64 per cent with existing technology on marginal, small, medium and large farms respectively while the corresponding figures for recommended technology were 39.34, 45.92, 33.71 and 29.18 per cent.

Saini *et al.* (1998) in their energy management study for sustainable hill management - a case of Himachal Pradesh identified that the net returns for small and large farms were increased by 62 to 661 per cent and by 67 to 316 per cent respectively. But the increment in net returns in energy-optimized plans was very little.

Ramakrishaiah and Sastry (1998) in their study An optimum crop and livestock pattern for farmers in Nandyal mandal of Kurnool district, Andhra Pradesh found that net farm returns could be increased by mere reallocation of resources even with the existing technology and available funds. The extent of increase in the net farm returns was 100.14 and 81.27 per cent on small and large farms respectively over the existing plan returns. The optimum model designed with relaxed borrowing at recommended technology increased the employment of men, women and bullock pairs by 35.44, 18.01 and 53.48 per cent and 125.46, 114.55 and 133.79 per cent on small and large farmers respectively.

Tilekar and Nimbalkar (2000) in their study Optimization of farm income in and outside Mula Irrigation command area; use of Linear

Programming Technique revealed that optimal plans were able to enhance net farm income to the extent of 37.33, 10.68, 15.30 and 18.08 per cent on marginal, small, medium and large farms respectively.

Shareef and Murthy (2001) in their study Optimum plans for increasing income, employment and water use at farm level in three regions of K.C Canal Irrigation system in Andhra Pradesh had examined the prospects of increasing income and employment through better reallocation of resources as indicated in optimal plan. The results showed that the increase in net income according to four different levels of water availability was 49.32, 47.28, 43.44 and 38.90 per cent for head region; 44.38, 42.65, 39.58 and 36.63 per cent for middle region, and 36.03, 35.56, 32.53 and 26.68 per cent for tail region over the existing plan. The employment of human labour was increased in the optimal plans by 6.38 to 16.70 per cent for head region, 2.51 to 4.32 per cent for middle region and 5.16 to 12.11 per cent over the existing plans.

Suresh and Reddy (2002) in their study An economic study of efficient use of irrigation water under Tambaraparani command area of Tamil Nadu revealed that rational use of presently available resources enabled to increase the net farm income by 25.08, 61.96 and 54.51 percent among the farmers of head, middle and tail regions respectively over the existing plans. The optimum plans designed at 10, 20 and 30 per cent increase in water availability indicated the high prospects of raising the net farm returns by 52.35, 57.60 and 60.44 per cent, 74.17, 78.99 and 80.10 per cent and 61.08, 66.82 and 71.25 present among the farmers of head, middle and tail region respectively.

Kiresur *et al.* (2004) in their study Optimum plans for sustainable farming systems in Northern Eastern Dry zone in Karnataka revealed that the net returns of small, medium, and large farms under farming system increased by 21.50 per cent, 4.24 per cent and 7.81 per cent respectively over the existing plans through the reorganization of resources. When the capital and labour were relaxed, the net returns were increased by 46.64, 32.84, and 15.97 per cent respectively over the existing plan for the above said categories of farms.

Prasad (2004) in his study optimum herd size, income and employment potential of common buffalo breeds revealed that the optimum herd size inclusive of all the three breeds was 2, 2, 3, 3 and 2 as against the 4, 5, 6, 4 and 4 in the existing situation for the size groups landless (I), marginal (II), small (III), medium (IV) and large (V) farms respectively. The income realized from diary farming under the existing situation was Rs.14.50, Rs.33.82, Rs.47.46, Rs. 12.28 and Rs.11.09 per day for the landless, marginal, small, medium and large size-groups respectively, while it was Rs.49.43, Rs.72.77, Rs.63.83, Rs.19.37 and Rs.28.68 under optimal situation for the above group. The employment per day per animal in terms of number of man-days under the existing situation was 0.28, 0.38, 0.29, 0.31 and 0.30, while it was 0.59, 0.51, 0.46, 0.41 and 0.49 in the optimum situation for the landless, marginal, small, medium and large size-groups respectively.

Application of linear programming technique in the field of water resource research has been well established from afore said studies. So in this study linear programming technique was made use at farms level (head, middle and tail regions) and the detailed description of its analytical framework is presented in chapter III. Taking into consideration the relevance of the study region sensitivity analysis was made under three situations of water scarcity and optimum plans drawn.

METHODOLOGY

CHAPTER – III

METHODOLOGY

The present study was undertaken in the Somasila Project command area, a large surface irrigation system in Nellore district of Andhra Pradesh with the specific objective of determining the income and employment prospects of farmers through optimum reorganization of resources. This chapter deals with the description of the study area, procedural details adopted in sampling design, method of data collection and analytical tools applied in attaining the stated objectives. The contents of this chapter are presented under the following heads.

3.1 SAMPLING DESIGN

3.2 COLLECTION OF DATA

3.3 ANALYTICAL TOOLS

3.1 SAMPLING DESIGN

A multistage stratified random sampling technique and purposive sampling techniques are adopted together for the present study.

3.1.1 Selection of the Area

Somasila project constructed across the river pennar was selected purposively for the present study, as it is one of the major command areas of Andhra Pradesh. The entire command area is divided into three regions viz., head, middle and tail region. From each region the first two mandals with maximum command area were purposively selected. Accordingly the selected mandals were Kaluvoya and Ananthasagaram from head region, Atmakur and Chejerla from middle region and Podalakur and Kavali from tail region.

All the villages in the selected mandals based on command area were arranged in descending order and the first two villages from each mandal were selected purposively for a detailed study. The selected villages were Kulluru and Nukanapalli from Kaluvoya mandal and Ananthasagaram and Inagalur from Ananthasagaram mandal of head region. Depuru and Vasili from Atmakur mandal and Chejerla and Paderu from Chejerla mandal of middle regions and Budamgunta and Kottapalli from Kavali mandal and Ayyavaripalem and Navur from Podalakur mandal of tail region respectively.

3.1.2 Selection of Farmers

The list of farmers from the selected 12 villages of the three regions of command area were obtained from the village officials. The categorization of farmers into small and large farms was carried out on the basis of land holdings as per the criterion adopted by IRDP. In this classification, two acres of dry land was considered equal to one acre of wet land in accordance with income generation capacity of dry and wet lands. The farmers with two hectares and less were considered as small, while the farmers having more than 2 hectares were grouped as large farmers.

From the list of farmers in each village, five each from small and large farmers were selected at random. Thus, number of farmers selected from each village was ten and that total number of farmers selected for the purpose of present study was 120. The details are furnished in Table 3.1.

Table 3.1: Sample size of selected farms

Region	Mandal	Village	No of selected farms		Total
			Small	Large	
Head	Kaluvoya	Kulluru Nukana palli	5 5	5 5	10 10
	Ananthasagaram	Ananthasagaram Inagalur	5 5	5 5	10 10
Middle	Atmakur	Depur Vasili	5 5	5 5	10 10
	Chejerla	Chejerla Paderu	5 5	5 5	10 10
Tail	Kavali	Budamgunta Kothapalli	5 5	5 5	10 10
	Podalakur	Ayyavaripalem Navur	5 5	5 5	10 10
		Total	60	60	120

3.2 COLLECTION OF DATA

The schedule was developed in conformity with the set objectives. The data on technical coefficients of crop enterprises were collected from the selected respondents for the agricultural year 2003-2004 by survey method.

3.3 ANALYTICAL TOOLS

Optimum allocation of resources is defined as one, with given physical, technical and resource conditions, showing those activities to undertake and how much of each resource to allocate to each activity so that the net farm returns are maximised in a year. Among the various analytical tools available for allocation of available but limited farm resources among alternative enterprises, linear programming is one of the most widely and best understood operations research techniques. It is indeed a powerful technique, which can effectively handle large number of linear constraints and variables (activities) simultaneously. Hence, the deterministic linear programming technique was employed to develop farm plans under varied irrigation supply situations.

3.3.1 Selection of Processes or Activities

A thorough knowledge of the activities or the processes practiced by the farmers becomes very important while working out the solutions for profit maximisation problems through linear programming technique. An understanding of the availability of resources and the competition for the scarce resources by the enterprises is also equally important.

The crops grown by the sample farmers were paddy(1001), Paddy(1009), sunflower (Morden), sunflower (Hybrid), groundnut (JL-24), bajra, sugarcane, brinjal, in *kharif* season and paddy, cotton, chillies, cowpea, greengram and gingelly in *rabi* season.

3.3.2 Mathematical Formulation of the Model

In linear programming analysis, a linear function of a number of variables is to be maximised subject to a number of constraints in the form of linear equalities and inequalities. In mathematical form, one-year (two seasons) linear programming model can be expressed in the following way.

$$\text{Maximise } Z = \sum_{j=1}^{n} C_j X_j$$

j= 1 to n activities

Subject to following constraints

1. $\sum_{j=1}^{n} a_{ij} X_j \geq b_i$ (i = 1, ……….K constraints)

2. $\sum_{j=1}^{n} a_{ij} X_j \leq b_i$ (i = K+1,………. m constraints)

3. $\sum_{j=1}^{n} a_{ij} X_j = b_i$ (i = m+1, ………. v constraints)

4. X_j, b_i $\geq$ 0 (non negativity constraint)

where,

Z = is the objective function to be maximized in the year.

C_j= is the value of j^{th} activity during *kharif* and *rabi* seasons of the year.

X_j = is the unit of j^{th} production activity during *kharif* and *rabi* seasons of the year.

a_{ij} = amount of i^{th} resource required by one unit of j^{th} activity

b_i = supply levels of i^{th} resource or input in the specified units.

3.3.3 Objective Function

The objective function for the model in this study was to maximise the annual net farm returns from crop enterprises subject to the resource constraints specified in the model.

In this model, the value of objective function (the optimum solution) which was to be maximised included the sum of the year's net cash flow. The final cash flow into the objective function was the result of changes arising from production, marketing, borrowing and debt management during the year. In interpreting the results of the model, the value of the objective function was adjusted by subtracting owned funds.

3.3.4 Basic Assumptions

Besides the general assumptions of linearity, divisibility, non-negativity, additivity, finiteness and certainty the following particular assumptions were made in developing the model. In this study, the problem of resource organization is dealt at the average farm level. Each farm is assumed to be an economic decision making unit. The farm operator is free to make decisions regarding the business that is limited only by legal and contractual arrangements.

The concept of time used was essentially short run and the model had an operational period of twelve months. All activities or processes such as crop production, marketing, borrowing, transfer of cash, etc were transacted and terminated at the end of the year. It was also assumed that each farm was operated with the objective of maximising net farm returns subject to the described constraints only.

Closely related to the above assumptions, the study, to start with was in static framework. It was assumed that the input and product markets were perfectly competitive and also the yield and price expectations of the farmers to be single valued.

3.3.5 Resource Level and Constraints

The row vector in the matrix refers to the constraints in the model. The different types of constraints included in the model were physical resource constraints, product constraints, minimum and maximum area constraints and financial constraints.

3.3.5.1 Resource Constraints

Land: Land is the most important limiting factor and is the basic resource of production and all the land related activities are expressed on hectare basis. A crop grown in a particular season in this land was considered as a separate activity as returns from land differed from one season to another.

Labour: The availability of family labour was estimated from the average days each sample farmer's family worked on his farm in each production phase. In the study area, family labour was employed for all operations on the farm. Considering this, restrictions were set on the availability of family labour. However, the hired labour was available in required number for the farmers.

Similarly the bullock labour force available on the farm was arrived at, by multiplying the number of workdays with the available bullock pairs on the farm. Most of the farmers were hiring tractors and accordingly constraint on the availability of tractor services was incorporated in the model.

Farm Yard Manure: The farm yard manure produced on the farm was not sufficient to meet the requirements on the farms of sample farmers and majority of them purchased additional quantities of FYM whenever required. Therefore, the constraint was set on the availability of farm produced farm yard manure.

Fertilizer: Fertilizer was converted into N, P and K nutrients and availability of these nutrients as well as the requirement for different crop activities was worked out. Constraints on the availability of N, P and K for *kharif* and *rabi* seasons were incorporated in the model.

3.3.5.2 Irrigation Constraint

Irrigation water is quantified by multiplying the area and the average depth of water. One hectare-centimeter (ha-cm) is the volume of water necessary to cover an area of one hectare (10,000 m^2) to a depth of 1 cm. One ha-cm equals to 100 cubic metre. The availability at different reaches *viz.*, head, middle and tail were collected from the Project Preparation Cell, Somasila Division, Nellore and were incorporated in the model.

3.3.5.3 Product Constraints

Product constraint rows facilitate the allocation of crop products produced between consumption and marketing. Production inventory at the beginning of the farm operation was supplemented by output from the crop production activities.

3.3.5.4 Family Consumption Requirement

This constraint ensures that the minimum requirement of the household is met from the farm itself. The response of the farmers on their minimum requirements of farm products was used to account this constraint. Accordingly, annual paddy requirement was converted into land equivalent to meet the family consumption requirement.

3.3.5.5 Financial Constraints

Financial constraints specify the resource limitation imposed due to cash availability, credit supply and debt management.

Cash availability: The working capital availability with farmers sometimes may not be sufficient to meet the requirements of different agricultural operations. Nevertheless, it may also limit the scope for adoption of improved production practices. Regarding the availability of funds at the beginning of year (*kharif*) a direct estimation was not possible, it was deemed appropriate to use the variable expenses (paid out costs) on the farm as a proxy for this.

For the availability of cash in *rabi*, the constraint was set as equal to zero because the programming model facilitated transfer of cash from one season to the other.

Credit supply: If the farmers' equity capital is not sufficient to meet the production expenditure, they may borrow from outside sources as and when required. Farmers in the study area usually borrowed short term loans only in *kharif* season. Accordingly, the credit availability was specified in *kharif* season in the models.

Debt management: Borrowing creates debt which the borrower must repay or carry over as liability to the subsequent season(s) and finally to the end of the year. Each unit of borrowing created one unit of debt and was carried over until repayment was made. As soon as repayment was activated, debt was cleared along with appropriate interest amount. Further, it was specified in the model in such a way that no borrower had a debt at the end of the year. Hence the constraints on debt management were set equal to zero.

3.3.5.6 Maximum Constraint

Factors like risk, uncertainties, high input costs, supervision and marketing problems associated with certain enterprises may prevent the farmers from taking up these enterprises beyond certain limits.

While allocating the resources, it becomes all the more important to see that the resources allocated to these enterprises do not go beyond the limits set by the farmers. Hence, maximum area that could be brought under high yielding and more profitable crops was specified based on the responses of the sample farmers.

3.3.6 Activities in the Model

The activities specified in the model include

- Crop production activities
- Labour hiring activities

- Crop sales or marketing activities
- Purchasing activities
- Borrowing activities
- Repayment activities
- Cash transfer activities

3.3.6.1 Crop production activities

The crop activities indicated the production technology that was followed currently by the farmers in the command area. The information regarding the crop production activities with existing technology was obtained from the selected respondents.

3.3.6.2 Labour hiring activities

In addition to family labour, each farmer could employ if required, outside human as well as bullock labour or tractor power to perform various farm operations. Hence, human labour hiring, bullock labour hiring and tractor hiring activities and their respective wage rates were incorporated in the model for *kharif* and *rabi* seasons separately.

3.3.6.3 Crop selling or marketing activities

When a crop is harvested on a farm, it is put into respective crop supply or output row with a negative sign. This output is later available for sale and/or family consumption. The *kharif* crop outputs are available for marketing during *rabi* season and the *rabi* crop outputs are available for marketing at the end of the year.

The average prices for different crops were based on the survey data. The harvest prices per unit of *kharif* output of crop enterprises were included in the *rabi* cash availability rows with negative sign. While the prices of *rabi* output of crop were included in the objective function with positive sign.

3.3.6.4 Purchasing activities

These activities pertained to purchase of farm yard manure and plant nutrients like N, P and K in *kharif* and *rabi* season that permit purchasing.

3.3.6.5 Borrowing activities

Borrowing sources considered in this model were co-operatives and commercial banks. It is to be noted here that theoretically though farmers can borrow in both seasons, the general practice is that farmers are advanced crop loans once at the beginning of the crop year. Hence, borrowing was confined to the beginning of the *kharif* season, whereas the debt was managed in both the seasons of the year. Borrowing one rupee each from these sources produced one rupee of credit supply (positive entry in the credit row) and created one rupee of debt (negative entry in *kharif* and *rabi* debt management rows).

3.3.6.6 Repayment activities

Farmers repay their loans with the incomes they obtained from the sale of crops. The repayments were allowed to occur in the *rabi* season or at the end of the year. Repayment of one rupee of debt reduces cash by one rupee plus interest as shown by positive entry in the cash availability row (Rs.1.04 if repaid half yearly i.e. in *rabi* season and Rs.1.08 if repaid by the end of the year at the rate of 8 per cent interest) and discharge one rupee of debt (Positive entry in the debt management row).

3.3.6.7 Cash transfer activities

Cash from borrowing and/or from sale of crop output which is not used in particular season may be transferred from one season to the next season (*kharif* to *rabi*, *rabi* to objective function). Each rupee thus transferred reduced cash in the season from which cash is taken (positive entry in cash availability row) and adds one rupee to the cash available in the season to which it is transferred (negative entry in the *rabi* cash availability row). Surplus cash at the end of the year is transferred to the objective function.

3.3.7 Input and Output Coefficients

The individual elements in the linear programming matrix refer to input and output coefficients which indicate resource requirements per unit (hectare) of each activity considered in the model. The input coefficients included in this study were land, labour, farm yard manure, plant nutrients (N, P and K), irrigation water and capital. Capital referred to funds required to meet the cost of seeds, fertilizers, farm yard manure, plant protection chemicals, insurance charges, marketing expenses and wages of human and bullock labour and tractor power. The output coefficients referred to the average yields obtained by the average sample farmer from one unit of each crop activity. These output coefficients were specified in the model with negative signs.

Coefficients of borrowing, repayment, debt management and cash transfer activities were also included in the matrix as detailed earlier.

The average prices, which the sample farmers paid and received, were considered as the input-output prices in this study.

3.3.8 Variations of the Model

Profit maximization has been assumed as the objective function of the farmers and optimal plans for the small and large farms in the three regions viz., head, middle and tail were developed with the help of linear programming.

Inadequate water supply was experienced by the farmers in number of years, the reduction in water supply ranging from 10 to 30 per cent. So, sensitivity analysis was also done with varying water levels representing three abnormal situations to study the impact on cropping pattern, income level and the use of inputs and input service.

The model was first run with the existing water supply level (Model 1). Later with 10 per cent decrease in water supply (Model 2) 20 per cent decrease in water supply (Model 3) and 30 per cent decrease in water supply (Model 4) were assumed and corresponding models were solved to examine the effect of irrigation water on cropping pattern, in come, employment and resource use pattern.

AGRO-ECONOMIC FEATURES

CHAPTER - IV

AGRO-ECONOMIC FEATURES

The chapter deals with brief explanation of agro-economic features like soils of that particular region, irrigation, rainfall. It also depends on socio-economic features like land holding, distribution, cropping pattern, area under different crops, occupational distribution of the people, and availability of farm machinery and implements etc. In order to have a comprehensive idea about the various techno-economic aspects of the study area, an attempt was made to discuss briefly regarding these features in this chapter.

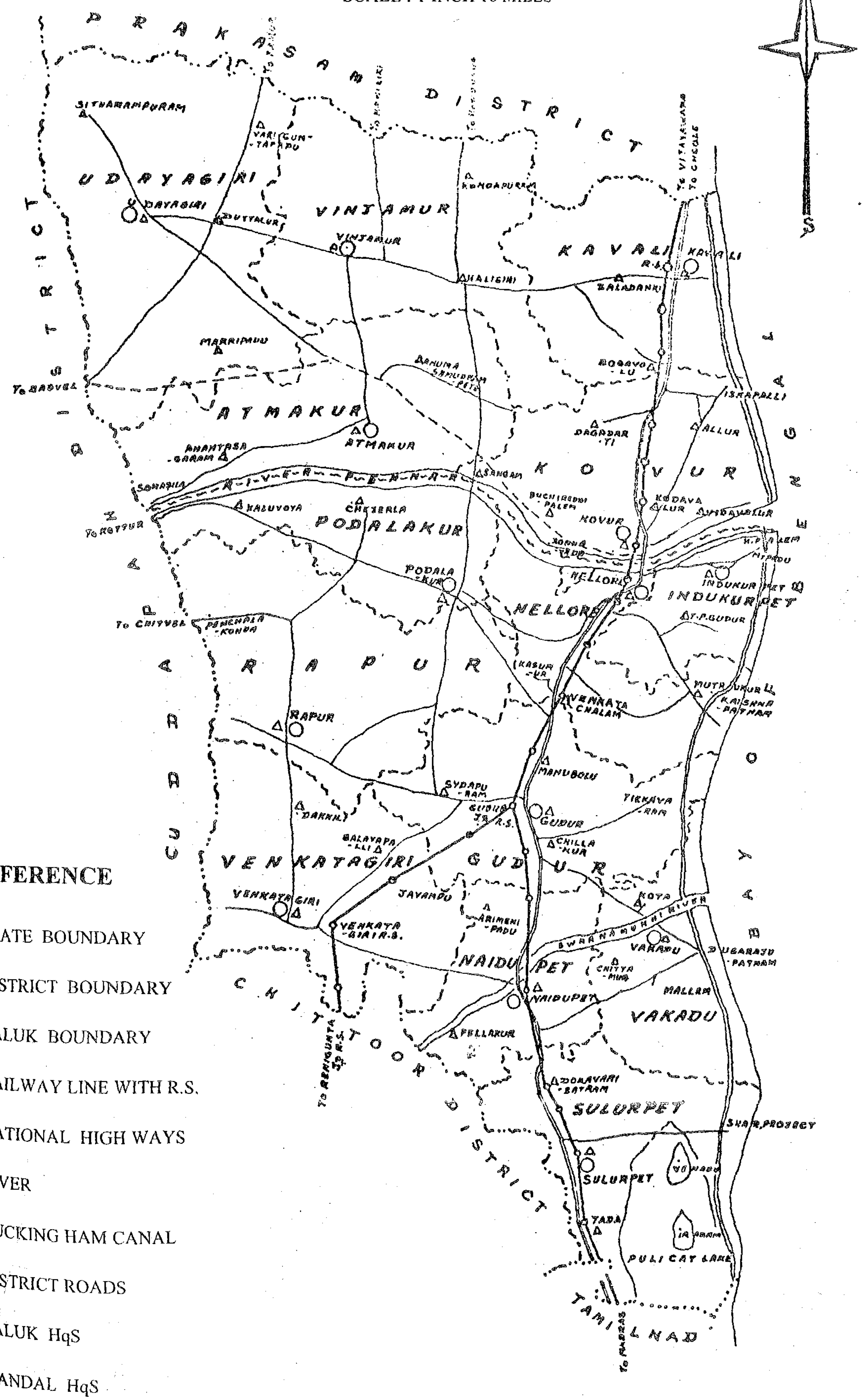
4.1 GEOGRAPHICAL FEATURES

Nellore district lies between 13°30' and 15°55' Northern latitude and 79°51', 80°16' of Eastern longitude. The mean sea level is 18.69 metres. Prakasam district on the North, Bay of Bengal on the East, Chittoor district of Andhra Pradesh and Changalpet district of Tamilnadu on South and Velugondalu range of hills in West which separates Nellore district from Cuddapah district.

Nellore district is the Southern most coastal district of Andhra Pradesh, and Tamilnadu is adjacent about 150 km. length of North to South and 100 mm breadth from East to West. It is roughly rectangular as shown in the Fig. 1.

NELLORE DISTRICT MAP

SCALE : 1 INCH 16 MILES



REFERENCE

STATE BOUNDARY

DISTRICT BOUNDARY

TALUK BOUNDARY

RAILWAY LINE WITH R.S.

NATIONAL HIGH WAYS

RIVER

BUCKING HAM CANAL

DISTRICT ROADS

TALUK HqS

MANDAL HqS

The district comprised of 46 Revenue mandals, 3 Revenue divisions and extended over an area of 13,160 km. There are 928 Gram Panchayats with 3 municipal towns and 1204 villages in which 1131 are inhabited and 69 villages are uninhabited.

Table 4.1 : Demographic features (2001 census) of Nellore district

S.No.	Particulars	Unit	Year 2001
1.	Total population	Lakhs	26.59
2.	Males	Lakhs	13.43
3.	Females	Lakhs	13.22
4.	Rural	Lakhs	20.56
5.	Urban	Lakhs	6.09
6.	Literates	Lakhs	15.47
7.	Cultivators	Lakhs	2.27
8.	Agril. labourers	Lakhs	5.36
9.	Density	(per sq.km)	203

Source : Hand Book of District Statistics, Chief Planning Office, Nellore

4.2 DEMOGRAPHIC FEATURES

The population of the district as per 2001 census is 26,59,661 out of which the population of Males are 13.43 lakhs, and the population of Females are 13.22 lakhs and the Rural and Urban population were 20.56 and 6.09 lakhs respectively.

The cultivator are 2,27,242 and agricultural labourers are 5,35,783 of which the population of male agricultural labour are 263217 and the population of female labour are 272565. Literacy rate of Nellore district is 70.36 per cent.

4.3 CLIMATIC FACTORS

4.3.1 Rainfall

The annual average precipitation for the district during 2003-04 for all the mandals is 935 mm of which 57.91 per cent from North East monsoon and 31.40 per cent from South West monsoon.

Table 4.2 : Season wise rainfall distribution of Nellore district (2003-2004)

	Season	Period	Rainfall (normal) in mm	%
1.	South West Monsoon	June - September	293	31.40
2.	North East Monsoon	October - December	542	57.91
3.	Winter period	January – February	8	0.86
4.	Hot Weather period	March - May	92	9.83
			935	**100.00**

Source : Hand Book of District Statistics, C.P.O., Nellore, Statistical Abstracts, Andhra Pradesh – 2005

About 70 per cent of the total rainfall is received during North-East Monsoon. Nellore district is considered to be a rain shadow area for South West Monsoon and the cropping programme relies heavily on North East Monsoon. The distribution is most uneven, not only season wise, but within a season as well.

4.4 SOILS

Table 4.3 : The classification and the distribution of various soils in the district

S.No.	Type of soil	Distribution (%)
1.	Red loams	41.0
2.	Coastal sands	34.0
3.	Clay loams (black)	15.0
4.	Laterite etc.	5.0
5.	Deltoic alluvium	5.0

Red loams constitute the bulk of cultivable land, along with clay loams and alluvials, coastal sands are extensively spread belt. Basing on soil sample tests conducted for the past two decades over the total district, it is found that the cultivated lands are generally low in Nitrogen, medium to low in phosphorus and medium to high in potash, zinc, boron and Magnesium deficiencies are also noticed in patches.

4.5 IRRIGATION

The main sources of irrigation in the given district are canals, wells and tanks. The total gross area under irrigation in this district 2,29,404 ha. Pennar delta system of irrigation covers 1,65,600 ha and the remaining is covered by other sources in which the cahin of rainfed tanks from the bulk sources of irrigation with single cropped wet lands, as ayacuts.

Table 4.4 : Source wise area, under irrigation (in hectares)

Source	2003-04
Canals	11,36,696
Tanks	4,89,560
Tube well & Filter points	11,95,261
Other wells	6,74,258
Other sources	1,38,094
Net area irrigated	36,33,869
Gross area irrigated	47,80,683

Source : Statistical Abstracts, Andhra Pradesh-2005

Major irrigation

The major sources of water is pennar river and 1,65,600 ha is being irrigated under pennar delta system. There are two anicuts to this river one at Sangam and the other at Nellore. These canals take off from Sangam anicut, carrying flood waters to Kanigiri Reservoir, Nellore tank and Duvvur tank respectively. These two canals, which independently irrigates 28,000 ha the second canal feeds to Surveypalli tank.

4.6 DESCRIPTION OF THE SOMASILA PROJECT COMMAND AREA

4.6.1 Somasila Project Command Area

Somasial project is located on the border of Kadapa and Nellore districts, across river Pennar at Somasila village, Ananthasagaram Mandal,


సూచిక
సూచీపటము
సోమశిల ప్రాజెక్టు
మన్నేరు నది
పిల్లపేరు నది
సీతారామపురం
ఉదయగిరి
కలిగిరి
కావలి
నందిపాడు
సంగం
సంగం ఆనకట్ట
సోమశిల
సోమశిల రిజర్వాయరు
అనంతసాగరం చెరువు
కండలేరు నది
కండలేరు పథకము
వెంకటాచలసత్రం
గూడూరు
రాజంపేట

Nellore district. River Pennar originatets on the slope of Nandi hills in Karnataka state and the basin of Pennar river is drained by a number of tributaries viz., Cheyyeru, Papagni, Chitravathy, Kundu and Sagileru. The total catchment area of Somasila Project is 48,666 sq km of which 6937 sq km lies in Karnataka state and 41729 sq km lies in Andhra Pradesh.

Somasila project envisages storage of 78 TMC of water at FRL of 330' contour. The total ayacut contemplated under the project is 1,65,600 ha. Out of which stabilization of wet ayacut under Pennar delta and existing tanks in uplands is 1,10,000 ha and new ID ayacut is 55,600 ha. Somasila project consists of three canals namely Kavali canal (67.50 km), north feeder channel (72.92 km) and south feeder channel (72.15 km).

4.6.2 Climate and Rainfall

The study area experiences semi arid tropical climate. Hot weather is observed during March, April and May and Cool weather from November to February. The mean annual maximum and minimum temperatures are 41°C and 26°C respectively. The average rainfall of 935 mm was recorded annually of which about 70 per cent recorded during North-East monsoon from October to December. The rest of the rainfall is distributed fairly in other seasons though the quantum of rainfall is low.

4.6.3 Soils

The soils in the study area are black cotton, alluvival, sandy and red loamy with good moisture retention capacity.

4.6.4 Cropping Pattern

Paddy, sugarcane, sunflower, groundnut, bajra during *Kharif* and cotton, chilies greengram and cowpea during *Rabi* are grown extensively in the study area. Other crops like brinjal, gingelly are also grown by the farmers.

4.7 SEASONS OF CROPS

There are two main seasons for this district, viz., *Kharif* and *Rabi*. For all practical purposes, the *kharif* is under to net wet condition and the rainfed is most uncertain due to uncertain fallow up rains periodical cyclone storing in October-November.

4.7.1 *Kharif*

Nellore district is peculiarly, a rain shadow district, as far as South West monsoon is concerned. Due to erratic distribution of rain in *kharif* the upland farmers take least interest in *kharif* sowings even though they get early showers. Due to which the main *kharif* season is April-September. But this season has two distinct sowing periods and so sub-divided into early *kharif* and *kharif*. Early *kharif* from April and the main *kharif* starts from July.

4.7.2 *Rabi*

Rabi season is the main season for this district, in this season also sowings takes place distinctly in two periods and hence sub divided into main *rabi* and late *rabi*.

4.7.3 Fluctuations in seasonal conditions

Abberation in weather season have become hall mark for Nellore district. Essentially thee are three crop seasons. The main season i.e. *kharif*, locally its called as Modalikaru or Pedakaru, late *rabi* and early k*harif* are the 2nd and third seasons for this district. The main season gets postponed, if south west monsoon fails to yield the minimum precipitation or sowings will be completed early, if good rains are received and again subjected to drought later in regular.

Table 4.5: Area under principle crops of Nellore district (2003-2004)

(hectares)

Crop	Nellore district	AP
Paddy	154916	2974637
Sunflower	13293	490757
Groundnut	14129	1493259
Bajra	1228	138115
Sugarcane	5694	208969
Brinjal	386	21469
Cotton	9993	836892
Chillies	3805	250317
Cowpea	2805	30633
Gingelly	2977	161408
Greengram	4307	680511

Source : Statistical abstracts Andhra Pradesh 2005

4.7.4 Cropping pattern

The cropping pattern, usually is determined by many factors, the more important of which are climate, soil, topography and distance from market etc.

It is evident from the details furnished in Table 4.5 that the principle crops grown in study area (Nellore) most important crops grown in the district are paddy, groundnut, sunflower, cotton which occupied 1,54,916, 14,129, 13,293, 9,993 hectare respectively. Other principle crops grown in the district are bajra, sugarcane, brinjal, greengram, gingelly etc.

4.8 LAND UTILISATION

The land utilization pattern in a region gives a wide picture of land use, current fallows, land put to non agricultural use and net area sown. This gives scope to understand the potentialities of the area. Hence the land utilization pattern are presented in the Table 4.6.

Table 4.6 : Land utilization pattern in Nellore district (2003-2004)

S.No.	Particulars	Area (ha)	Percentage of total geographical area
1.	Forests	2,464,00	18.72
2.	Barren and uncultivated land	1,61,046	12.24
3.	Land put to on-agricultural uses	2,34,593	17.83
4.	Permanent pastures and grazing lands	99,727	7.58
5.	Miscellaneous grooves and trees not included in net sown area	15,489	1.18
6.	Cultivable waste	88,512	6.73
7.	Other fallows	94,622	7.19
8.	Current fallows	69,501	5.28
9.	Net sown area	3,06,152	23.26
10.	**Total geographical area**	**13,16,042**	**100.00**

Source : Statistical abstracts, Andhra Pradesh, 2005

The total geographical area of the district is 1316 thousand ha. The net area sown in the district is 306 thousand ha which constitute 23.26 percent of the total geographical area. The district has 18.72 per cent of its area under forests. The area under current and other follows is 5.28 per cent and 7.19 per cent respectively of the total geographical area. This indicates that most of the area is not being utilized for agricultural purpose. The land under cultivable waste, bareen and uncultivable land and land put to non-agricultural uses are 6.73, 12.24 and 17.83 per cent respectively. The area under permanent pasture is 7.58 per cent where as area under miscellanies tree crops is negligible and some of the barren land could be used for growing trees and pastures.

RESULTS & DISCUSSION

CHAPTER – V

RESULTS AND DISCUSSION

The present study has an objective to examine the changes in income and employment under different water availability situations. The results obtained in this study and inferences drawn in the discussion refer to an average farm situation of small and large farmers. Linear programming technique was employed to develop twenty four optimal plans for farmers of the Somasila Project command area of Nellore district, Andhra Pradesh. The results of the study have been presented and discussed under the following heads.

5.1 CHARACTERISTICS OF THE AVERAGE FARM

5.2 CROPPING PATTERN AND NET FARM RETURNS UNDER EXISTING SITUATION

5.3 CROPPING PATTERN UNDER DIFFERENT OPTIMAL PLANS

5.4 NET FARM RETURNS UNDER DIFFERENT OPTIMAL PLANS

5.5 IMPACT OF IRRIGATION WATER ON NET FARM RETURNS

5.6 LABOUR USE UNDER DIFFERENT OPTIMAL PLANS

5.7 IMPACT OF WATER AVAILABILITY ON EMPLOYMENT

5.8 MATERIAL INPUT USE UNDER DIFFERENT OPTIMAL PLANS

5.9 SHADOW PRICES

5.10 POLICY MEASURES

5.1 CHARACTERISTICS OF AVERAGE FARM

In this section, average family size and average farm size were worked out from the sample data. The characteristics of average farm situation for small and large farms of head, middle and tail regions are presented in Table 5.1.

The average size of the family of small farmers was 9.06, 8.63 and 7.73 members as against 6.57, 5.72 and 7.23 members in the case of large farmers under head, middle and tail regions respectively. This indicates that the average size of the family was inversely related to the size of holding.

Farm size is one of the crucial factors that affects the magnitude and efficiency of production and income for the farm families. Historically, net farm income has been highly correlated with the farm size.

The average size of irrigated land of large farmers varied from 2.43 hectares in head region to 2.01 ha in the tail region. The selected large farmers of middle region owned 2.09 ha. On an average, the small farmers of head, middle and tail region owned 0.98, 0.94 and 0.93 ha of irrigated land respectively. It is interesting to note that the size of the land holding of small and large farmers under head region was higher than that of the farmers under middle and tail regions.

Table 5.1 Characteristics of average farms of different regions of Somasila Project command area

S.No.	Item	Head region		Middle region		Tail region	
	Family size	Small	Large	Small	Large	Small	Large
a.	Men	3.29	2.12	3.56	2.57	2.92	2.86
b.	Women	3.15	2.53	2.92	1.92	2.53	2.25
c.	Children	2.62	1.92	2.15	1.23	2.28	2.12
	Total	9.06	6.57	8.63	5.72	7.73	7.23
	Average farm size (ha)	0.98	2.43	0.94	2.09	0.93	2.01

5.2 CROPPING PATTERN AND NET FARM RETURNS UNDER EXISTING SITUATION

The details on existing production pattern, cropping intensity, net farm returns and water use of small and large farms under head, middle and tail regions were computed and are presented in Table 5.2.

In *kharif*, paddy which is the main food crop was raised on 0.55 and 1.33, 0.50 and 1.16, 0.58 and 1.14 ha by the small and large farmers under head, middle and tail regions respectively and accounted for more than 50 per cent of the *kharif* irrigated land. Bajra another food crop occupied nearly 10 per cent on small farms of head region and middle region and occupied nearly 5 percent on large farms of head region. Groundnut, an important oil seed crop of the study area was grown on 0.10 and 0.24 ha, 0.08 and 0.19 ha and 0.12 and 0.28 ha by the small and large farmers under head, middle and tail regions respectively.

Small and large farmers of head, middle and tail regions grew sunflower, another oil seeds crop on 0.12 and 0.52 ha, 0.12 and 0.48 ha and 0.18 and 0.48 ha of *kharif* irrigated land respectively. Sugarcane, an important commercial crop of the study region occupied 0.11 and 0.18 and 0.15 and 0.26 ha on the small and large farms of head and middle regions respectively. Nearly 2 and 5 per cent of the *kharif* irrigated land of small and large farmers under head and tail region respectively was occupied by brinjal, a vegetable crop.

Table 5.2: Existing cropping pattern of small and large farmers under head, middle and tail regions

Crop	Head region				Middle region				Tail region			
	Small		Large		Small		Large		Small		Large	
	Area(ha)	Percent	Area(ha)	Percent	Area(ha)	Percent	Area(ha)	Percent	Area(ha)	Percent	Area(ha)	Percent
***Kharif* irrigated land**												
Paddy (1001)	0.34	34.69	0.72	29.63	0.32	34.04	0.63	30.14	0.58	62.37	0.62	30.85
Paddy (1009)	0.21	21.43	0.61	25.10	0.18	19.15	0.53	25.36	-	-	0.52	25.87
Sunflower (hybrid)	-	-	0.30	12.35	-	-	0.28	13.40	-	-	0.27	13.43
Sunflower (morden)	0.12	12.25	0.22	9.05	0.12	12.77	0.20	9.57	0.18	19.35	0.21	10.45
Groundnut	0.10	10.20	0.24	9.87	0.08	8.51	0.19	9.09	0.12	12.90	0.28	13.93
Bajra	0.08	8.16	0.10	4.12	0.09	9.57	-	-	-	-	-	-
Sugarcane	0.11	11.23	0.18	7.41	0.15	15.96	0.26	12.44	-	-	-	-
Brinjal	0.02	2.04	0.06	2.47	-	-	-	-	0.05	5.38	0.11	5.47
Fallow	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.98	100.00	2.43	100.00	0.94	100.00	2.09	100.00	0.93	100.00	2.01	100.00
***Rabi* Irrigated land**												
Paddy (Molagulakulu)	0.32	32.66	0.68	27.99	0.32	34.04	0.53	25.36	0.42	45.16	0.50	24.88
Cotton	0.17	17.35	0.42	17.28	0.15	15.96	0.38	18.18	0.11	11.83	0.36	17.91
Chillies	0.02	2.04	0.07	2.88	0.05	5.32	0.12	5.74	-	-	-	-
Cowpea	0.09	9.18	0.13	5.35	0.04	4.26	0.09	4.31	-	-	-	-
Greengram	0.08	8.16	0.08	3.29	0.04	4.26	0.11	5.26	0.18	19.35	0.38	18.91
Gingelly	0.05	5.10	0.15	6.17	0.05	5.32	0.13	6.22	0.15	16.13	0.29	14.43
Sugarcane	0.11	11.22	0.18	7.41	0.15	15.96	0.26	12.44	-	-	-	-
Fallow	0.14	14.29	0.72	29.63	0.14	14.89	0.47	22.49	0.07	7.53	0.48	23.88
Total	0.98	100.00	2.43	100.00	0.94	100.00	2.09	100.00	0.93	100.00	2.01	100.00
Cropping intensity (%)	185.71		170.37		185.11		177.51		192.47		176.12	
Net Farm Returns (Rs.)	33187.79		74307.16		31716.76		71489.29		28054.68		49526.29	
Net Farm Returns per hectare of cultivated area (Rs.)	33865.09		30579.08		33741.23		34205.40		30166.32		24639.95	
Irrigation water available (ha-cm)	180		420		177		360		145		322	
Water used (ha-cm)	176		402		175		360		145		322	
Cash used (Rs.)	18007.14		49492.36		17832.67		45369.88		17609.93		41869.95	

Small and large farmers of head, middle and tail regions were growing paddy on 0.32 and 0.68, 0.32 and 0.53 and 0.42 and 0.50 ha respectively during *rabi* season. More than 15 per cent of the *rabi* irrigated land was allocated by farmers of the three regions for the production of cotton except the small farmers of tail region. Green gram, a pulse crop was cultivated by the small and large farmers of head, middle and tail regions on 0.08 and 0.08, 0.04 and 0.11 and 0.18 and 0.38 ha respectively. Gingelly occupied 0.05 and 0.15, 0.05 and 0.13 and 0.15 and 0.29 ha respectively on the above said categories of farms of the three regions. Chillies accounted for 5 per cent of the *rabi* irrigated area on small and large farms of middle region. The same in head region ranged from 0.02 ha on small farms to 0.07 ha on large farms. Cowpea occupied 0.09 and 0.13, 0.04 and 0.09 ha on the small and large farms of head and middle regions respectively.

The proportion of fallow land during *rabi* on the small and large farms of head, middle and tail regions were 14.29 and 29.63, 14.89 and 22.49 and 7.53 and 23.88 per cent respectively.

The net farms returns were Rs.33,187.79, Rs.31,716.76 and Rs.28,054.68 on the small farms of head, middle and tail regions respectively while the same were Rs.74,307.16, Rs.71,489.29 and Rs.49,526.29 on large farms of head, middle and tail regions respectively.

The cropping intensity was 185.71 and 170.37, 185.11 and 177.51 and 192.47 and 176.12 per cent on the small and large farms of head, middle and tail regions respectively.

It is clear from the analysis that farmers grew more number of crops in the existing plan to reduce risk of loss or failure of one crop by the gain in the other.

5.3 CROPPING PATTERN UNDER DIFFERENT OPTIMUM PLANS

The basic models HS_1 (small farmers, head region), HL_1 (Large farmers, head region), MS_1 (small farmers, middle region), ML_1 (Large farmers, middle region), TS_1 (small farmers, tail region) and TL_1 (large farmers, tail region) were developed with existing water level and additional runs were made with 10 per cent, 20 per cent and 30 per cent decrease in water availability to study the effect on cropping pattern, income and employment of farm resources.

5.3.1 Small Farmers of Head Region

The details of the crop mix in the existing and optimum plans of small farmers under head region are presented in Table 5.3

The optimum model HS_1 was developed with existing water availability. The purpose of this model was to explore the possibilities of reorganizing the farm resources through planning and to examine the possibilities of increasing income and employment.

Table 5.3: Cropping pattern of different optimum plans under head region – small farmers

Crop	Existing Plan		Model HS_1		Model HS_2		Model HS_3		Model HS_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
Kharif irrigated land										
Paddy (1001)	0.34	34.69	-	-	-	-	-	-	-	-
Paddy (1009)	0.21	21.43	0.42	42.86	0.31	31.63	0.20	20.41	0.20	20.41
Sunflower (morden)	0.12	12.25	0.06	6.12	0.17	17.35	0.28	28.57	0.23	23.47
Groundnut	0.10	10.20	0.20	20.41	0.20	20.41	0.20	20.41	0.20	20.41
Bajra	0.08	8.16	-	-	-	-	-	-	-	-
Sugarcane	0.11	11.23	0.20	20.41	0.20	20.41	0.20	20.41	0.13	13.27
Brinjal	0.02	2.04	0.10	10.20	0.10	10.20	0.10	10.20	0.10	10.20
Fallow	-	-	-	-	-	-	-	-	0.12	12.24
Total	0.98	100.00	0.98	100.00	0.98	100.00	0.98	100.00	0.98	100.00
Rabi irrigated land										
Paddy (Molagulakulu)	0.32	32.66	0.29	29.59	0.21	21.43	0.20	20.41	0.20	20.41
Cotton	0.17	17.35	0.25	25.51	0.25	25.51	0.09	9.18	-	-
Chillies	0.02	2.04	0.10	10.20	0.10	10.20	0.10	10.20	0.10	10.20
Cowpea	0.09	9.18	-	-	-	-	-	-	-	-
Greengram	0.08	8.16	0.14	14.29	0.22	22.45	0.39	39.80	0.55	56.12
Gingelly	0.05	5.10	-	-	-	-	-	-	-	-
Sugarcane	0.11	11.22	0.20	20.41	0.20	20.41	0.20	20.41	0.13	13.27
Fallow	0.14	14.29	-	-	-	-	-	-	-	-
Total	0.98	100.00	0.98	100.00	0.98	100.00	0.98	100.00	0.98	100.00
Cropping intensity (%)	185.71		200.00		200.00		200.00		187.76	
Net Farm Returns (Rs.)	33187.79		50963.47		49957.13		48592.51		43763.25	
Net Farm Returns per hectare of cultivated area (Rs.)	33865.09		52003.54		50976.66		49584.19		44656.38	
Irrigation water available (ha-cm)	180		180		162		144		126	
Water used (ha-cm)	176		180		162		144		126	
Cash used (Rs.)	18007.14		15551.44		14607.48		13944.53		12338.47	

On *kharif* irrigated land, all the crops except bajra, which were in the existing plan, entered the optimum plan with changes in the acreage. The optimum model HS_1, suggested to increase the area under paddy (1009), groundnut, sugarcane and brinjal from 0.21, 0.10, 0.11 and 0.02 ha in the existing plan to 0.42, 0.20, 0.20 and 0.10 ha respectively. But the optimum plan indicated a decline in Sunflower area from 0.12 ha in existing plan to 0.06 ha. Paddy (1001) and bajra, which occupied 0.34 and 0.08 ha in the existing plan were eliminated.

In *rabi*, the results of the optimal model indicated to increase the area under the production of cotton, chillies and greengram. The allocation of land for cotton, chillies and greengram was 0.25, 0.10 and 0.14 ha respectively. There was no perceptible change in the allocation of land for the production of paddy. Sugarcane occupied the same area as in *kharif*. The plan did not favour the inclusion of cowpea and gingelly.

The resource optimization led to increase in the intensity of cropping from 185.71 per cent in the existing plan to 200 per cent in the optimal plan HS_1. The net farm returns and the net farm returns per hectare of cultivated area were higher by Rs.17,775.68 (53.56 per cent) and Rs.18,138.45 (34.88 per cent) respectively over the existing plan. The optimum plan resulted in complete utilization of available irrigation water (180 ha cm).

The optimum model HS_2 developed by decreasing 10 per cent of water supply resulted in different cropping pattern to that of model HS_1. On *kharif* irrigated land, the area under groundnut, sugarcane and brinjal remained the same as in optimum model HS_1. However, it recommended to increase the area for sunflower from 0.06 ha (6.12 per cent) in model HS_1 to 0.17 ha (17.35 per cent) in model HS_2. The model also suggested to reduce the area for paddy (1009) from 0.42 ha in HS_1 to 0.31 ha in model HS_2 due to reduction in the water availability.

During *rabi*, sugarcane continued to occupy the same area is in *kharif.* The area under cotton and chillies remained the same as in model HS_1. The area under paddy declined from 0.29 ha in model HS_1 to 0.21 ha in model HS_2. Consequently, the area under less water consuming greengram crop increased from 0.14 ha in model HS_1 to 0.22 ha in model HS_2. The cropping intensity remained the same as in model HS_1.

The cropping pattern suggested by model HS_2 resulted in the realization of Rs.49,957.13 as net farm returns. The net farm returns were increased by Rs.16,769.34 over the existing plan.

The impact of 20 per cent decrease in the water supply was analyzed through model HS_3. On *kharif* irrigated land, groundnut sugarcane and brinjal occupied the same area as in the previous optimal models. Due to less availability of irrigation water, the area under paddy (1009) decreased by 0.11 ha over model HS_2. However, the plan suggested to increase the area from 0.17 ha in model HS_2 to 0.28 ha for the production of sunflower.

Paddy occupied 20.41 per cent of the *rabi* irrigated land. There was no change in the allocation of area for chillies (0.10 ha). The plan suggested to decrease the area under cotton from 0.25 ha in model HS_2 to 0.09 ha in model HS_3. The area under greengram increased from 0.22 ha in model HS_2 to 0.39 ha. Sugarcane continued in the *rabi* season with the same extent of land as in *kharif*. Cowpea and gingelly did not enter this plan also.

There was no change in the cropping intensity (200 per cent) though the irrigation water availability reduced by 20 per cent. The farmers were able to realize Rs.48,592.51 as net farm returns. The net farm returns per hectare of cultivated area was increased by Rs.15,719.10 over the existing plan.

The programming model with 30 percent decrease in water supply (Model HS_4) resulted in different cropping pattern from that of previous models. This model suggested to allocate minimum area (0.20 ha) for the production of paddy in each season. Groundnut and brinjal occupied the same area on *kharif* irrigated land as in the previous models. The plan indicated to double the area under the production of sunflower compared to the existing situation. Due to shortage of irrigation water, the model suggested to reduce the area for sugarcane from the 0.20 ha in the previous optimal models to 0.13 ha, leaving 0.12 ha of *kharif* irrigated land to be uncultivated.

More than half of the *rabi* cultivated area was occupied by greengram. Chillies entered the plan with the same acreage as in the previous models.

Cotton which was in model HS_1, HS_2 and HS_3 was completely eliminated in this model.

The cropping intensity declined from 200 per cent in model HS_3 to 187.76 per cent in model HS_4. The cropping pattern suggested by the model HS_4 helped small farmers of head region to realize Rs.43,763.25 as net farm returns.

5.3.2 Large Farmers of the Head Region

The details of the crop mix in the existing and optimum plans of large farmers under head region are presented in Table 5.4

Model HL_1, which was designed with currently available water suggested to increase the area for the production of paddy (1009), groundnut, sugarcane and brinjal from 0.61, 0.24 , 0.18 and 0.06 ha in the existing plan to 1.08, 0.40, 0.50 and 0.20 ha in the optimal plan respectively during *kharif*, eliminating less remunerative enterprises viz., paddy (1001), sunflower (morden variety) and bajra. Also, this plan showed marginal decrease in the area of sunflower (hybrid) from 0.30 ha in the existing plan to 0.25 ha in optimal plan HL_1.

On irrigated land in *rabi*, the plan indicated to increase the area of commercial crops like cotton and chillies and pulse crop namely greengram from the current level and thus occupied 0.60 ha, 0.30 ha and 0.56 ha respectively by the above mentioned crops. However, the area of paddy declined from 0.68 ha in the current plan to 0.47 ha. The model did not favour

Table 5.4: Cropping pattern of different optimum plans under head region – large farmers

Crop	Existing Plan		Model HL_1		Model HL_2		Model HL_3		Model HL_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
Kharif irrigated land										
Paddy (1001)	0.72	29.63	-	-	-	-	-	-	-	-
Paddy (1009)	0.61	25.10	1.08	44.44	0.80	32.92	0.51	20.99	0.32	13.17
Sunflower (morden)	0.22	12.35	-	-	-	-	-	-	-	-
Sunflower (hybrid)	0.30	9.05	0.25	10.29	0.53	21.81	0.82	33.74	1.30	53.50
Groundnut	0.24	9.87	0.40	16.46	0.40	16.46	0.40	16.46	0.40	16.46
Bajra	0.10	4.12	-	-	-	-	-	-	-	-
Sugarcane	0.18	7.41	0.50	20.58	0.50	20.58	0.50	20.58	0.41	16.87
Brinjal	0.06	2.47	0.20	8.23	0.20	8.23	0.20	8.23	-	-
Fallow	-	-	-	-	-	-	-	-	-	-
Total	2.43	100.00	2.43	100.00	2.43	100.00	2.43	100.00	2.43	100.00
Rabi irrigated land										
Paddy (Molagulakulu)	0.68	27.99	0.47	19.34	0.32	13.17	0.16	6.58	0.28	11.52
Cotton	0.42	17.28	0.60	24.69	0.60	24.69	0.60	24.69	-	-
Chillies	0.07	2.88	0.30	12.34	0.30	12.34	0.30	12.35	0.30	12.35
Cowpea	0.13	5.35	-	-	-	-	-	-	-	-
Greengram	0.08	3.29	0.56	23.05	0.71	29.22	0.87	35.80	1.44	59.26
Gingelly	0.15	6.17	-	-	-	-	-	-	-	-
Sugarcane	0.18	7.41	0.50	20.58	0.50	20.58	0.50	20.58	0.41	16.87
Fallow	0.72	29.63	-	-	-	-	-	-	-	-
Total	2.43	100.00	2.43	100.00	2.43	100	2.43	100.00	2.43	100.00
Cropping intensity (%)	170.37		200.00		200.00		200.00		200.00	
Net Farm Returns (Rs.)	74307.16		107006		106775		106544		101871	
Net Farm Returns per hectare. of cultivated area (Rs.)	30579.08		44035.39		43940.33		43845.27		41922.22	
Irrigation water available (ha-cm)	420		420		378		336		294	
Water used (ha-cm)	402		420		378		336		294	
Cash used (Rs.)	49492.36		64129.82		60788.85		57447.89		51937.82	

the inclusion of cowpea and gingelly. Sugarcane continued to occupy the same area as in *kharif.*

The cropping intensity increased from 170.37 per cent in the existing plan to 200 per cent in the model HL_1 due to complete utilization of land resource. The net farm returns were higher by Rs.32,698.84 over the existing plan.

The optimum model HL_2 (10 per cent decrease in water availability) suggested same crops with changes in the acreage as in model HL_1. During *kharif*, groundnut, sugarcane and brinjal occupied the same area as in model HL_1. The model indicated to double the area under the production of sunflower (Hybrid) and to reduce the area from 1.08 ha in model HL_1 to 0.80 ha in model HL_2 for the production of paddy.

Due to inadequate water availability, paddy enters the plan with the reduction in the acreage by 0.15 ha over the optimum model HL_1, during *rabi* season. As a result the area under the production of greengram which requires less water increased to 0.71 ha. Cotton and chilies occupied the same area as in the previous model. Sugarcane continued to occupy the same area as in *kharif* season.

The cropping intensity remains the same as in the optimum model HL_1, though there was less water availability. The net farm returns and net farm returns per hectare of cultivated area were Rs.1,06,775 and Rs.43,940.33 respectively.

The resource optimization model with 20 per cent decrease in the water availability (HL_3) recommended the same acreage for the production of groundnut (0.40ha), sugarcane (0.50 ha) and brinjal (0.20 ha) as in the previous models during *kharif.* However, it indicated drastic reduction in the area for paddy production from 1.08 ha in HL_1, and 0.80 ha in HL_2 to 0.51 ha on account of less water availability. Sunflower which requires less irrigation water appeared with more acreage in this plan. Its area increased from 0.25 ha in HL_1 to 0.82 ha in HL_3.

During *rabi*, the model suggested to reduce the area for paddy by 50 per cent over the previous model. Consequently, the area for green gram increased from 0.71 ha in HL_2 to 0.87 ha in HL_3. There was no change in the allocation of land for the production of cotton and chillies.

The cropping intensity remained the same as in the previous optimum models. The crop mix suggested by HL_3 enabled the farmers to realize a net farm returns of Rs.1,06,544.

The results of optimum model HL_4 designed with 30 per cent decrease in the availability of irrigation water suggested to grow fewer crops compared to the previous plans. Sunflower (hybrid) emerged as the most significant enterprise with acreage of 1.30 ha occupying 53.50 per cent of the *kharif* irrigated land due to shortage of irrigation water availability. The remaining 46.50 per cent of *kharif*-irrigated land was allocated for the production of paddy (13.17 per cent), groundnut (16.46 per cent) and sugarcane (16.87 per cent).

During *rabi*, 59.26 per cent of the land was occupied by greengram followed by chillies (12.35 per cent) and paddy (11.52 per cent). Sugarcane continued to occupy the same area as in *kharif*. Brinjal and cotton found in the existing as well as in the previous optimum plans were completely eliminated.

The cropping intensity was 200 per cent due to complete land use both in *kharif* and *rabi* seasons inspite of decline in the water availability by 30 per cent. The results of optimum model HL_4 revealed that it was possible for the large farmers in the head region to get a net farm income of Rs.1,01,871. The per hectare net farm returns of cultivated area were increased from Rs.43,845.27 in HL_3 to Rs.41,922.22 in HL_4.

5.3.3 Small Farmers of Middle Region

The reorganization of resources with the existing irrigation water availability (MS_1) suggested to increase the area for paddy, groundnut and sugarcane from 0.18, 0.08 and 0.15 ha in the current plan to 0.48, 0.20 and 0.20 ha in optimum model MS_1 during *kharif*. As a result, the area under sunflower (morden) declined from 0.12 ha in the existing plan to 0.06 ha. Also bajra and paddy (1001) found in the existing plan were eliminated (Table 5.5).

The model recommended to allocate more land for cotton and chillies by eliminating cowpea, greengram and gingelly which were grown in the

Table 5.5: Cropping pattern of different optimum plans under middle region – small farmers

Crop	Existing Plan		Model MS_1		Model MS_2		Model MS_3		Model MS_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
***Kharif* irrigated land**										
Paddy (1001)	0.32	34.04	-	-	-	-	-	-	-	-
Paddy (1009)	0.18	19.15	0.48	51.06	0.37	39.36	0.34	36.17	0.38	40.43
Sunflower (morden)	0.12	12.77	0.06	6.38	0.17	18.09	0.32	34.04	0.09	9.57
Groundnut	0.08	8.51	0.20	21.28	0.20	21.28	0.20	21.28	0.20	21.28
Bajra	0.09	9.57	-	-	-	-	-	-	-	-
Sugarcane	0.15	15.96	0.20	21.28	0.20	21.28	0.08	8.51	0.04	4.26
Fallow	-	-	-	-	-	-	-	-	0.23	24.47
Total	0.94	100.00	0.94	100.00	0.94	100.00	0.94	100.00	0.94	100.00
***Rabi* irrigated land**										
Paddy (Molagulakulu)	0.32	34.04	0.18	19.15	0.23	24.47	0.27	28.72	0.22	23.40
Cotton	0.15	15.96	0.41	43.62	-	-	-	-	-	-
Chillies	0.05	5.32	0.15	15.96	0.15	15.96	0.15	15.96	0.15	15.96
Cowpea	0.04	4.26	-	-	0.26	27.66	-	-	-	-
Greengram	0.04	4.26	-	-	0.10	10.64	0.44	46.81	0.53	56.38
Gingelly	0.05	5.32	-	-	-	-	-	-	-	-
Sugarcane	0.15	15.96	0.20	21.28	0.20	21.28	0.08	8.51	0.04	4.26
Fallow	0.14	14.89	-	-	-	-	-	-	-	-
Total	0.94	100.00	0.94	100.00	0.94	100.00	0.94	100.00	0.94	100.00
Cropping intensity (%)	185.11		200.00		200.00		200.00		175.53	
Net Farm Returns (Rs.)	31716.76		46868.55		45933.67		40658.21		34881.88	
Net Farm Returns per hectare of cultivated area (Rs.)	33741.23		49860.16		48865.61		43253.41		37108.38	
Irrigation water available (ha-cm)	177		177		159.30		141.6		123.9	
Water used (ha-cm)	175		177		159.30		141.6		123.9	
Cash used (Rs.)	17832.67		15311.68		14659.44		12806.25		11035.65	

existing production programme. Consequently, the area under the production of cotton and chillies during *rabi* increased from 0.15 and 0.05 ha in the existing plan to 0.41 and 0.15 ha respectively. But the area for paddy declined from 0.32 ha in the existing plan to 0.18 ha. Sugarcane continued to occupy the same area as in *kharif* season.

The cropping intensity increased from 185.11 per cent in the existing plan to 200 per cent in model MS_1. The crop mix suggested by Model MS_1 helped in realization of Rs.46,868.55 as net farm returns.

The optimum model developed by decreasing 10 per cent of water supply resulted in the same cropping pattern as that of optimum plan MS_1 except decrease in the area of paddy from 0.48 ha in MS_1 to 0.37 ha and increase in the area of sunflower from 0.06 ha in MS_1 to 0.17 ha. There was no change in the area of groundnut (0.20 ha) and sugarcane (0.20) during *kharif* season. Cotton which occupied 0.41 ha in model MS_1 was completely eliminated from the plan, yielding its area to cowpea (0.26 ha) and greengram (0.10). There was a marginal increase in the area of paddy from 0.18 ha in MS_1 to 0.23 ha. However, chillies occupied the same acreage as in MS_1.

The cropping intensity remained the same as in model MS_1. The cropping pattern suggested by model MS_2 resulted in the realization of Rs.45,933.67 as net farm returns. The net farm returns were increased by Rs.14,216.91 over the existing plan.

The impact of 20 per cent decline in the water supply was anlaysed through model MS_3. This plan suggested to reduce the area of paddy and sugarcane from 0.37 ha and 0.20 ha in model MS_2 to 0.34 ha and 0.08 ha respectively during the *kharif* season due to scarcity of irrigation water. As a result, the area of sunflower almost doubled. The area under the production of groundnut remained the same as in the previous optimum plans.

During *rabi,* the plan suggested to increase the area of greengram from 0.10 ha in MS_2 to 0.44 ha by completely eliminating cowpea,which found in MS_2 with 0.26 ha. There was a slight increase in the area of paddy over MS_2. Chillies continued to occupy the same area as in the previous models.

The crop mix recommended by the model MS_3 enabled the small farmers of middle region to realize Rs.40,658.21 as net farm returns.

The optimum plan developed with 30 per cent decrease in the water availability (Model MS_4) included the same crops as in the previous model with changes in the allocation of land resource. The area for the production of sunflower was declined drastically from 0.32 ha in MS_3 to 0.09 ha, keeping 0.23 ha of *kharif* irrigated land fallow due to paucity of irrigation water. Also, the area of sugarcane was declined from 0.08 ha in MS_3 to 0.04 ha. The proportionate area under paddy increased from 36.17 per cent in MS_3 to 40.43 per cent in MS_4.

About 56 per cent of the *rabi* irrigated land was occupied by greengram followed by paddy (23.40 per cent) and chillies (15.96 per cent).

The cropping intensity dropped from 200 per cent in the previous optimum plans to 175.53 per cent in MS_4 due to under use of 0.23 ha of *kharif* land. The net farm returns were higher by Rs.3,165.12 over the existing plan.

5.3.4 Large Farmers of Middle Region

The optimum farm plan ML_1 developed for the large farmers of middle region suggested to increase the area under paddy (1009), groundnut and sugarcane from 0.53, 0.19 and 0.26 ha in the existing plan to 0.67, 0.60 and 0.60 ha respectively. The process of reallocation of land resource resulted in the decline of land use for sunflower (Hybrid) from 0.28 ha in the existing plan to 0.22 ha and elimination of paddy (1001) and sunflower (morden variety) (Table 5.6).

During *rabi*, the plan recommended to increase the area of cotton, chillies and cowpea from the present level of 0.38 , 0.12 and 0.09 ha to 0.60 , 0.40 and 0.36 ha by eliminating greengram and gingelly and by drastically reducing area of paddy from 0.53 ha in the current plan to 0.13 ha. Sugarcane continued to occupy the same area as in *kharif*.

The cropping intensity increased from 177.51 per cent in the existing plan to 200 per cent due to complete utilization of land in both the seasons. The present income of Rs.71,489.29 had increased to Rs.99,199.60 indicating an increase of 38.76 per cent over the existing plan.

The optimum model ML_2 (10 per cent decrase in water availability) suggested almost the same cropping pattern as that model ML_1 during *kharif*.

Table 5.6: Cropping pattern of different optimum plans under middle region – large farmers

Crop	Existing Plan		Model ML_1		Model ML_2		Model ML_3		Model ML_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
***Kharif* irrigated land**										
Paddy (1001)	0.63	30.14	-	-	-	-	-	-	-	-
Paddy (1009)	0.53	25.36	0.67	32.06	0.66	31.58	0.55	26.32	0.50	23.92
Sunflower (Hybrid)	0.28	13.40	0.22	10.53	0.23	11.00	0.54	25.84	0.88	42.11
Sunflower (morden)	0.20	9.57	-	-	-	-	-	-	-	-
Groundnut	0.19	9.09	0.60	28.71	0.60	28.71	0.60	28.71	0.60	28.71
Sugarcane	0.26	12.44	0.60	28.71	0.60	28.71	0.40	19.14	0.11	5.26
Fallow	-	-	-	-	-	-	-	-	-	-
Total	2.09	100.00	2.09	100.00	2.09	100.00	2.09	100.00	2.09	100.00
***Rabi* irrigated land**										
Paddy (Molagulakulu)	0.53	25.36	0.13	6.22	0.14	6.70	0.25	11.96	0.30	14.35
Cotton	0.38	18.18	0.60	28.71	0.34	16.27	-	-	-	-
Chillies	0.12	5.74	0.40	19.14	0.40	19.14	0.40	19.14	0.40	19.14
Cowpea	0.09	4.31	0.36	17.22	-	-	-	-	-	-
Greengram	0.11	5.26	-	-	0.61	29.19	1.04	49.76	1.28	61.24
Gingelly	0.13	6.22	-	-	-	-	-	-	-	-
Sugarcane	0.26	12.44	0.60	28.71	0.60	28.71	0.40	19.14	0.11	5.26
Fallow	0.47	22.49	-	-	-	-	-	-	-	-
Total	2.09	100.00	2.09	100.00	2.09	100.00	2.09	100.00	2.09	100.00
Cropping intensity (%)	177.51		200.00		200.00		200.00		200.00	
Net Farm Returns (Rs.)	71489.29		99199.60		96404.00		87284.00		76873.03	
Net Farm Returns per hectare of cultivated area (Rs.)	34205.40		47463.92		46126.32		41762.68		36781.35	
Irrigation water available (ha-cm)	360.00		360.00		324.00		288.00		252.00	
Water used (ha-cm)	360.00		340.58		324.00		288.00		252.00	
Cash used (Rs.)	45369.88		54429.33		53018.53		49341.30		44216.63	

47

During *rabi*, paddy was favoured in 0.14 ha, maintaining the same area for chillies as in optimum plan ML_1. The plan indicated to reduce the area of cotton by 0.26 ha over the model ML_1 and completely eliminated cowpea. Consequently, greengram, which did not enter the previous optimal plan, appeared in this plan with 0.61 ha.

There is no change in the intensity of cropping between ML_1 and ML_2. but net farm returns declined from Rs.99,199.60 in optimum plan ML_1 to Rs.96,404 in optimum model ML_2.

The optimum model ML_3 recommended to reduce the area of paddy and sugarcane from 0.66 ha and 0.60 ha in model ML_2 to 0.55 ha and 0.40 ha due to decrease in the water availability by 20 per cent. As a result, the area under the production of sunflower increased from 0.23 ha in the optimum plan ML_2 to 0.54 ha. Groundnut maintained the same area as in previous optimum models.

During *rabi*, the plan recommended the expansion of area from 0.61 ha in ML_2 to 1.04 ha for greengram. This plan did not favour the inclusion of cotton. The area under paddy showed an increase from 0.14 ha in the previous optimum plan to 0.25 ha. The plan also favoured the same area as in the previous optimum plans for chillies.

The intensity of cropping was 200 per cent. This normative plan helped the large farmers of middle region to realize Rs.87,284.00 as net farm returns.

The optimum model ML_4 developed with 30 per cent decrease in water availability favoured the extension of area under sunflower from 0.54 ha in ML_3 to 0.88 ha, by reducing area of sugarcane to the extent of 0.29 ha over the ML_2. There was no change in the allocation of land for groundnut production and it remained the same as in the previous models. Half an hectare of land was allotted for paddy production during *kharif.*

Sixty one per cent of the *rabi* irrigated land was occupied by greengram followed by chillies (19.4 per cent) and paddy (14.35 per cent). Sugarcane occupied the same area as in *kharif.*

The reduction in the water availability by 30 per cent over the existing level did not result in under utilization of land resource either in *kharif* or *rabi*. Hence, the intensity of cropping remained as in the previous normative plans. The optimization plan resulted in the realization of Rs.76,873.03 as net farm income.

5.3.5 Small Farmers of Tail Region

The details of crop mix in the existing and optimum plans of small farmers under tail region are presented in Table 5.7.

Model TS_1, which was designed with currently available water included fewer activities compared to the existing plan. The plan suggested to increase the area of groundnut and brinjal from 0.12 and 0.05 ha in the existing plan to 0.36 and 0.40 ha in optimal plan TS_1 respectively during *kharif* season. As a

Table 5.7: Cropping pattern of different optimum plans under tail region – small farmers

Crop	Existing Plan		Model TS_1		Model TS_2		Model TS_3		Model TS_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
***Kharif* irrigated land**										
Paddy (1001)	0.58	62.37	0.17	18.28	0.23	24.73	0.18	19.35	0.19	20.43
Sunflower (morden)	0.18	19.35	-	-	-	-	-	-	-	-
Groundnut	0.12	12.90	0.36	38.71	0.30	32.26	0.35	37.63	0.63	67.74
Brinjal	0.05	5.38	0.40	43.01	0.40	43.01	0.40	43.01	-	-
Fallow	-	-	-	-	-	-	-	-	0.11	11.83
Total	0.93	100.00	0.93	100.00	0.93	100.00	0.93	100.00	0.93	100.00
***Rabi* irrigated land**										
Paddy (Molagulakulu)	0.42	45.16	0.23	24.73	0.17	18.28	0.22	23.66	0.21	22.58
Cotton	0.11	11.83	0.40	43.01	0.40	43.01	0.11	11.83	-	-
Greengram	0.18	19.35	0.30	32.26	0.36	38.71	0.60	64.52	0.72	77.42
Gingelly	0.15	16.13	-	-	-	-	-	-	-	-
Fallow	0.07	7.53	-	-	-	-	-	-	-	-
Total	0.93	100.00	0.93	100.00	0.93	100.00	0.93	100.00	0.93	100.00
Cropping intensity (%)	192.47		200.00		200.00		200.00		188.17	
Net Farm Returns (Rs.)	28054.68		41728.96		41406.22		39820.15		35229.73	
Net Farm Returns per hectare of cultivated area (Rs.)	30166.32		44869.85		44522.82		42817.37		37881.43	
Irrigation water available (ha-cm)	145.00		145.00		130.50		116.00		101.50	
Water used (ha-cm)	145.00		129.45		126.93		116.00		101.50	
Cash used (Rs.)	17609.93		14099.17		13674.16		12826.91		11873.33	

result, land allotted for paddy declined from 0.58 ha in the existing plan to 0.17 ha in the model TS_1. Also, sunflower was eliminated from the plan.

On *rabi* irrigated land, paddy, cotton and greengram occupied 0.23, 0.40 and 0.30 ha respectively. The area under cotton and greengram increased by 0.29 and 0.12 ha while that of paddy decreased by 0.19 ha respectively over the existing plan. The plan did not favour the inclusion of gingelly.

Due to complete utilization of land in both the seasons, cropping intensity increased from 192.47 per cent in the existing plan to the maximum attainable level of 200 per cent in the model TS_1. The net farm returns were higher by Rs.13,674.28 over the existing plan.

Model TS_2 was designed at 10 per cent decrease in the water availability in both the seasons. In this plan, there was a marginal decline in the area for groundnut production which was offset by increase in the area of paddy to the same extent. Paddy and groundnut occupied 0.23 and 0.30 ha respectively. Brinjal maintained the same area as in Model TS_1 on *kharif* irrigated land.

The allocation of land for *rabi* paddy declined from 0.23 to 0.17 ha while that of greengram increased from 0.30 to 0.36 ha between models TS_1 and TS_2. Cotton occupied one acre of *rabi* irrigated land.

The intensity of cropping remained the same as in Model TS_1. The net farm returns increased from Rs.28,054.68 in the existing plan to Rs.41,406.22.

The optimum model TS_3 evolved by decreasing 20 per cent of water supply suggested crop activities similar to that of model TS_2 with slight decrease (0.05 ha) in the area for paddy and by the same extent of increase for the production of groundnut over the model TS_2 during *kharif.* Greengram, a predominant pulse crop of the study area occupied about 65 per cent of *rabi* irrigated area followed by paddy (23.66 per cent) and cotton (11.83 per cent). It is important to note that cotton area declined by 72.50 per cent over the previous optimum models.

The plan did not exhibit any change in the intensity of cropping. The net farm returns were increased from Rs.28,054.68 in the existing plan to Rs.39,820.15.

The results of normative plan TS_4 developed with 30 per cent decline in the water supply recommended for the complete elimination of brinjal during *kharif* and cotton during *rabi* which were found not only in the existing plan but also in all the previous optimum plans. This might be due to scarcity of irrigation water. There was no much variation in the allotment of land resource for other crop activities except a significant increase in the area of groundnut from 0.35 ha in model TS_3 to 0.63 ha during *kharif* and in increase of 0.12 ha for the production of greengram during *rabi* over the model TS_3.

The cropping intensity declined from 200 per cent in the previous optimum model to 188.17 per cent due to under utilization of *kharif* irrigated land (0.11 ha). However, the small farmers of tail region realized Rs.35,229.73 as net farm returns.

5.3.6 Large Farmers of Tail Region

The optimum model TL_1 recommended to increase the area under paddy (1009), groundnut and brinjal from 0.52, 0.28 and 0.11 ha in the current production programme to 1.11, 0.60 and 0.30 ha respectively by eliminating paddy (1001) and sunflower during *kharif* season. On *rabi* irrigated land, paddy, cotton and greengram occupied 0.40, 0.88 and 0.73 ha respectively indicating a decrease of 0.10 ha in the case of paddy and an increase of 0.52 ha and 0.35 ha under cotton and greengram respectively over the existing plan. The plan did not favour the inclusion of less remunerative gingelly crop. The process of optimization led to complete utilization of land in both the seasons and this resulted in the increase of cropping intensity from the current level of 176.12 to 200 per cent. The production programme indicated by the model TL_1 helped the large farmers of tail region to realize Rs.70,713.59 as net farm returns exhibiting an increase of Rs.21,187.30 over the existing plan (Table 5.8).

Model TL_2 suggested a different crop mix from that of model TL_1 by including sunflower (hybrid) on 0.23 ha. As a result, the area under paddy declined by 20.72 per cent over the model TL_1. Groundnut and brinjal occupied the same area as in model TL_1 during the *kharif*. Greengram

Table 5.8: Cropping pattern of different optimum plans under tail region – large farmers

Crop	Existing Plan		Model TL_1		Model TL_2		Model TL_3		Model TL_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
***Kharif* irrigated land**										
Paddy (1001)	0.62	30.85	-	-	-	-	-	-	-	-
Paddy (1009)	0.52	25.87	1.11	55.22	0.88	43.78	0.65	32.34	0.60	29.85
Sunflower (Hybrid)	0.27	13.43	-	-	0.23	11.44	0.46	22.89	0.20	9.95
Sunflower (morden)	0.21	10.45	-	-	-	-	-	-	-	-
Groundnut	0.28	13.93	0.60	29.85	0.60	29.85	0.60	29.85	0.60	29.85
Brinjal	0.11	5.47	0.30	14.93	0.30	14.93	0.30	14.93	0.30	14.93
Fallow	-	-	-	-	-	-	-	-	0.31	15.42
Total	2.01	100.00	2.01	100.00	2.01	100.00	2.01	100.00	2.01	100.00
***Rabi* irrigated land**										
Paddy (Molagulakulu)	0.50	24.88	0.40	19.90	0.40	19.90	0.40	19.90	0.40	19.90
Cotton	0.36	17.91	0.88	43.78	0.57	28.36	0.26	12.94	-	-
Greengram	0.38	18.91	0.73	36.32	1.04	51.74	1.35	67.16	1.52	75.62
Gingelly	0.29	14.43	-	-	-	-	-	-	-	-
Fallow	0.48	23.88	-	-	-	-	-	-	0.09	4.48
Total	2.01	100.00	2.01	100.00	2.01	100.00	2.01	100.00	2.01	100.00
Cropping intensity (%)	176.12		200.00		200.00		200.00		180.09	
Net Farm Returns (Rs.)	49526.29		70713.59		67635.05		64556.52		57897.70	
Net Farm Returns per hectare of cultivated area (Rs.)	24639.95		35180.89		33649.28		32117.67		28804.83	
Irrigation water available (ha-cm)	322.00		322.00		289.80		257.60		225.40	
Water used (ha-cm)	322.00		322.00		289.80		257.60		225.40	
Cash used (Rs.)	41869.95		52998.41		49916.91		46834.47		41599.27	

occupied more than 50 per cent of *rabi* land followed by cotton (28.36 %) and paddy (19.90%).

The cropping intensity remained the same as in Model TL_1. The net farm returns were increased by 36.56 per cent over the existing plan.

The normative plan TL_3 designed at 20 per cent decrease in the water supply suggested to allocate the same extent of land resource as in the previous optimal plans for the production of groundnut and bringal during *kharif* and paddy during *rabi*. However, it recommended increase to the area of sunflower (hybrid) by 0.23 ha while reducing the area of paddy by the same extent over the model TL_2 during *kharif*. Similarly, during *rabi*, the area under cotton declined by 0.31 ha leading to increase in the area of greengram by the same magnitude over model TL_2.

The cropping intensity was 200 per cent. The net farm returns increased from Rs.49,526.29 in the current plan to Rs.64,556.52 an increase of Rs.15,030.23.

The optimum model TL_4 indicated to keep 0.31 ha of *kharif* land and 0.09 of *rabi* land as fallow and this resulted in decline in the cropping intensity by 20 per cent over models TL_1, TL_2 and TL_3. This was due to shortage of water supply to the extent of 30 per cent over the existing water availability.

The model did not favour any alternation in the level of production of groundnut and brinjal during *kharif* and paddy during *rabi*. The area under paddy and sunflower declined from 0.65 and 0.46 ha in model TL_3 to 0.60 and

0.20 ha in Model TL_4 respectively during *kharif*. Due to shortage of irrigation water, greengram a less water consuming crop occupied 75 per cent of the *rabi* land.

The crop mix suggested by the model enabled the large farmers of tail region to realize Rs.57,897.70 as net farm returns.

From the preceding discussions it can be inferred that there was sub-optimal allocation of resources in the existing plans of small and large farmers. The process of optimization under different water supply conditions resulted in the improvement in the net farm returns of both the categories of farmers in the study area. However, the optimum model developed at existing water availability resulted in higher net farm returns as compared to other models developed at 10, 20 and 30 per cent reduction in the water supply on the small and large farms of head, middle and tail regions. The process of optimization led to increase in the area under high valued crops and thus reducing the number of crops. Crops like bajra, cowpea and gingelly did not appear to be congenial to the objective of maximization of profits, with the result they were completely eliminated from the optimum plans. Paddy, sunflower, groundnut, sugarcane, brinjal, cotton and greengram were the crops included in the optimum plans. The optimum solutions envisaged significant changes in the land use pattern. There was a shift in cropping pattern from bajra, cowpea and gingelly as they were the less remunerative crops to sunflower, groundnut, sugarcane, brinjal and cotton, that are more economic comparatively. Greengram despite of its being relatively a less profitable crop occupied larger proportion of *rabi* irrigated land in all the optimum plans because of its low irrigation, labour and nutrient requirements.

Optimal plans showed marked change in gross cropped area and cropping intensity over the existing plans on both the categories of farms of head, middle and tail regions. Gross cropped area increased in optimal plans over the currently practiced plans of small and large farmers.

In case of crops with minimum area restriction and crops with maximum area under remunerative crops increased and less remunerative crops appeared with the minimum area as suggested.

It may be noted that the small farmers of tail region (optimal models TS_1 and TS_2) and large farmers of middle region (Model ML_1) did not make use of available irrigation water during *kharif* season. The finding with respect to under utilization of irrigation water, which is a scarce and costly input, is quite surprising. The under utilization of water is caused by several factors viz., improper field channels to carry water from canal to the fields and favouring dry or lightly irrigated crops in irrigation scarcity areas so that even the meager irrigation availability is not fully utilized. For instance, it is customary to grow bajra, cowpea, gingelly, greengram etc in the study area. These findings are in conformity with the findings of Nadda et al. (1978), Ushasree et al. (1994), Tilekar and Nimbalkar (2000), Shareef and Murthy (2001).

5.4 NET FARM RETURNS UNDER DIFFERENT OPTIMUM PLANS

The prime objective of the study was to explore the possibilities of augmenting net farm returns of farmers from the various activities under varied water availability situations. The net farm returns for small and large farmers of head, middle and tail regions of the command area are presented in Table from 5.9 to 5.11.

5.4.1 Small Farmers of Head Region

The small farmers of head region, on an average, realized Rs.33,187.79 as net farm returns from existing production progrmame. Model HS1 offered scope for augmenting net farm returns to Rs.50,963.47, an increase of 53.56 per cent over the existing situation. Thus, it is evident that the small farmers can increase their net farm returns by mere reallocation of resource.

Model HS2 (10 per cent reduction in water supply) results suggested the prospects of raising the net farm returns to Rs.49,957.13 recording a raise of 50.53 per cent over the existing returns.

The net farm returns in model HS3 (20 per cent reduction in water availability) were higher by Rs.15,404.72 over the existing returns. The results of the optimal plan designed at 30 per cent decrease in the water availability indicated raising of net farm returns from Rs.33,187.79 in the current plan to Rs.43,763.25 recording an increase of 31.87 per cent over the existing plan (Table 5.9).

Table 5.9: Net farm returns of small and large farmers under different optimum models – Head region (in Rs.)

Category/ Model	Existing plan (E-Plan)	Model-H_1	Change over E-Plan	Model-H_2	Change over E-Plan	Model-H_3	Change over E-Plan	Model-H_4	Change over E-Plan
Small farmers	33187.79	50963.47	17775.68 (53.56)	49957.13	16769.34 (50.53)	48592.51	15404.72 (46.42)	43763.25	10575.46 (31.87)
Large farmers	74307.16	107006.00	32698.84 (44.00)	106775.00	32467.84 (43.69)	106544.00	32236.84 (43.38)	101871.00	27563.84 (37.09)

Figures in the parentheses indicate the percentages

5.4.2 Large Farmers of Head Region

The net farm returns under optimum model HL_1 (existing water availability) were Rs.1,07,006 as against the present net farm returns of Rs.74,307.16 which accounted for 44 per cent increase in income over the existing plan (Table 5.9).

The optimum model HL_2 in which water availability was reduced by 10 per cent had paved the way for securing Rs.1,06,775 as net farm income by the large farmers and exhibited 43.69 per cent increase in income over the current plan.

The optimal model HL_3 which was designed at 20 per cent decrease in water supply enabled the farmers to increase the net farm income by Rs.32,236.84 (43.38 per cent) over the existing plan.

Model HL_4 (30 per cent decrease in water availability) suggested the possibilities of raising net farm returns to Rs.1,01,871, registering an increase of 37.09 per cent over the present level of income.

5.4.3 Small Farmers of Middle Region

The net farm returns under model MS_1 (existing water availability) were Rs.46,868.55 as against the present net farm returns of Rs.31,716.76 which accounted for 47.77 per cent increase in income over the existing plan (Table 5.10)

Model MS_2 (10 per cent decrease in the water availability) indicated opportunities to increase the income from Rs.31,716.76 in the current plan to

Rs.45,933.67 in MS_2. The net farm returns of model MS_2 were 44.82 per cent higher than the returns in the existing plan.

Planning under 20 per cent decrease in the water availability (Model MS_3) helped the small farmers of middle region to increase the income by Rs.8,941.45 (28.19 %) over the existing income.

The programming model MS_4 designed at 30 per cent decline in the water availability suggested the possibilities of raising net farm returns to Rs.34,881.88 registering an increase of 9.98 per cent over the current level of net farm income.

5.4.4 Large Farmers of Middle Region

On an average, the large farmers of middle region realized Rs.71,489.29 in the existing production plan. Model ML_1 offered scope for augmenting net farm returns of Rs.99,199.60, an increase of 38.76 per cent over the existing situation (Table 5.10).

The net farm returns in model ML_2 (10 per cent decrease in water supply) was higher by Rs.24,914.71 (34.85 %) over the currently practiced plan.

The results of model ML_3 indicated the possibilities of raising the net farm returns to Rs.87,284 recording a raise of 22.09 per cent over the existing income.

Table 5.10: Net farm returns of small and large farmers under different optimum models – middle region (in Rs.)

Category/ Model	Existing plan (E-Plan)	Model-M_1	Change over E-Plan	Model-M_2	Change over E-Plan	Model-M_3	Change over E-Plan	Model-M_4	Change over E-Plan
Small farmers	31716.76	46868.55	15151.79 (47.77)	45933.67	14216.91 (44.82)	40658.21	8941.45 (28.19)	34881.88	3165.12 (9.98)
Large farmers	71489.29	99199.60	27710.31 (38.76)	96404.00	24914.71 (34.85)	87284.00	15794.71 (22.09)	76873.03	5383.74 (7.53)

Figures in the parentheses indicate the percentages

Model ML_4 (30 per cent reduction in the water availability) offered scope to raise net farm income by Rs.5,383.74 (7.53%) over the current level of income.

5.4.5 Small Farmers of Tail Region

The net farm returns under model TS_1 (existing water availability) were Rs.41,728.96 as against present net farm returns of Rs.28,054.68 which accounted for 48.74 per cent increase in income over the existing plan. This indicates the scope to enhanse their net farm returns by mere reorganization of resources (Table 5.11).

Model TS_2 (10 per cent reduction in water supply) resulted an increase in net farm returns by Rs.13,351.54 registering an increase of 47.59 per cent over the existing plan.

The programming model TS_3 (20 per cent reduction in water availability) helped to realize Rs.39,820.15 as net farm income, recording 41.94 per cent of increase over the existing returns.

Model TL_4 (30 per cent reduction in water availability) indicated the possibilities of raising the net farm returns to Rs.35,229.73 recording an increase of 25.58 per cent over the existing level of net farm returns.

5.4.6 Large Farmers of Tail Region

The net farm returns under model TL_1 were Rs.70,713.59 as against the present net farm returns of Rs.49,526.29. The increase in the net farm returns in model TL_1 was 42.78 per cent over the existing situation (Table 5.11).

Table 5.11: Net farm returns of small and large farmers under different optimum models – Tail region (in Rs.)

Category/ Model	Existing plan (E-Plan)	Model-T_1	Change over E-Plan	Model-T_2	Change over E-Plan	Model-T_3	Change over E-Plan	Model-T_4	Change over E-Plan
Small farmers	28054.68	41728.96	13674.28 (48.74)	41406.22	13351.54 (47.59)	39820.15	11765.47 (41.94)	35229.73	7175.05 (25.58)
Large farmers	49526.29	70713.59	21187.30 (42.78)	67635.05	18108.76 (36.56)	64556.52	15030.23 (30.35)	57897.70	8371.41 (16.90)

Figures in the parentheses indicate the percentages

Model TL_2 (10 per cent decrease in water availability) offered scope of raising net farm returns by Rs.18,108.76 (36.56 %) over the existing plan.

The large farmers of tail region realized Rs.64,556.52 through the reorganization of resources at 20 per cent decline in water availability (Model TL_3) recording a raise of 30.35 per cent over the present level of income.

Optimal plan TL_4 enabled the farmers to increase the net farm returns by Rs.8,371.41 (16.90 per cent) over the income obtained from current crop mix.

The analysis of net farm returns indicated that there is an ample scope for enhancing the net farm returns on the small and large farms of head, middle and tail regions through mere reorganization of farm resources. However, the potentiality of increasing the returns was more on the farms of head region compared to middle and tail regions under different water availability situations.These findings are in conformity with the findings of Singh et al. (1972), Nanja Reddy (1980), Subbarayan and Singh (1989), Gajanata and Sharma (1990), Sreelakshmi and Sastry (1995), Sharma et al. (1996), Ramakrishnaiah and Sastry (1998). Tilekar and Nimbalkar (2000), Shareef and Murthy (2001), Suresh and Reddy (2002), Kiresur et al. (2004).

5.5 IMPACT OF IRRIGATION WATER ON NET FARM INCOME

The optimum models were developed with 10, 20 and 30 per cent decrease in the availability of water to examine its influence on cropping pattern, income and employment opportunities. The details of the impact of irrigation water on net farm returns on the farms of head, middle and tail regions are presented in Table 5.12 to 5.14.

5.5.1 Head Region

The net farm returns indicated by models $HS_1$and HL_1 were Rs.59,963.47 and Rs.1,07,006 for the small and large farmers of head region respectively under existing water availability. When water availability was reduced by 10 per cent over the existing water availability, the net farm returns decreased to Rs.49,957.13 on small farms and Rs.1,06,775.00 on large farms. The decrease of Rs.1006.34 (1.97%) and Rs.231 (0.22%) on the small and large farms respectively could be attributed to reduction of water supply by 10 per cent. The net farm returns of small and large farmers in model HS_3 and HL_3 were declined to Rs.48,592.51 and Rs.1,06,544 respectively when the irrigation water supply reduced by 20 per cent. The reduction in net farm returns were Rs.2,370.96 (4.65%) and Rs.462 (0.43%) on small and large farms respectively over the optimization models with existing water availability (Table 5.12).

The optimization models of small and large farms with 30 per cent decline in the water availability indicated the possibilities of realizing a net farm income of Rs.43,763.25 and Rs.1,01,871.00 respectively indicating a decline of 14.13 per cent and 4.79 per cent on the above said categories of farms over the optimal plans with existing water availability.

Table 5.12: Impact of irrigation water on net farm returns of small and large farmers - Head regions (in Rs.)

Category / model	Model - H_1	Model – H_2	Change over Model – H_1	Model – H_3	Change over Model – H_1	Change over Model – H_2	Model – H_4	Change over Model – H_1	Change over Model – H_2	Change over Model – H_3
Small farmers	50963.47	49957.13	-1006.34 (1.97)	48592.51	-2370.96 (4.65)	-1364.62 (2.73)	43763.25	-7200.22 (14.13)	-6193.88 (12.39)	-4829.26 (9.94)
Large farmers	107006.00	106775.00	-231.00 (0.22)	106544.00	-462.00 (0.43)	-231.00 (0.22)	101871.00	-5135.00 (4.79)	-4904.00 (4.59)	-4673.00 (4.39)

Figures in the parentheses indicate the percentages

5.5.2 Middle Region

A comparison of results of model M_1, M_2, M_3 and M_4 indicates the impact of irrigation water, when the availability of water decreased by 10, 20 and 30 per cent respectively. The net farm returns indicated by models MS_1 and ML_1 were Rs.46,868.55 and Rs.99,199.60 for small and large farmers of middle region respectively. When the water availability was reduced by 10, 20 and 30 per cent, the net farm returns declined to Rs.45,933.67, Rs.40,658.21 and Rs.34,881.88 on small farms and Rs.96,404, Rs.87,284 and Rs.76,873.03 on large farms respectively.

The reduction of net farm returns over the optimal plans with existing water availability by Rs.934.88 (1.99%), Rs.6,210.34 (13.25%), and Rs.11,986.67 (25.58%) on the small farms and Rs.2,795.60 (2.82%), Rs.11,915.60 (12.01%), Rs.22,326.57 (22.51%) on the large farms could be attributed to the scarcity of water resource and the consequential changes in crop mix (Table 5.13).

5.5.3 Tail Region

The impact of variations in the water availability can be assessed by comparing the models developed with existing water availability (Model TS_1 and TL_1) and reduction in the irrigation water supply by 10, 20 and 30 per cent (TS_2, TS_3 and TS_4 and TL_2, TL_3 and TL_4). The net farm returns of small and large farms of tail region with existing water availability were Rs.41,728.96 and Rs.70,713.59 respectively. On the other hand, if water availability was

Table 5.13: Impact of irrigation water on net farm returns of small and large farmers – middle regions (in Rs.)

Category / model	Model - M_1	Model – M_2	Change over Model – M_1	Model – M_3	Change over Model – M_1	Change over Model – M_2	Model – M_4	Change over Model – M_1	Change over Model – M_2	Change over Model – M_3
Small farmers	46868.55	45933.67	-934.88 (1.99)	40658.21	-6210.34 (13.25)	-5275.46 (11.48)	34881.88	-11986.67 (25.58)	-11051.79 (24.06)	-5776.33 (14.21)
Large farmers	99199.60	96404.00	-2795.60 (2.82)	87284.00	-11915.60 (12.01)	-9120.00 (9.46)	76873.03	-22326.57 (22.51)	-19530.97 (20.26)	-10410.97 (11.93)

Figures in the parentheses indicate the percentages

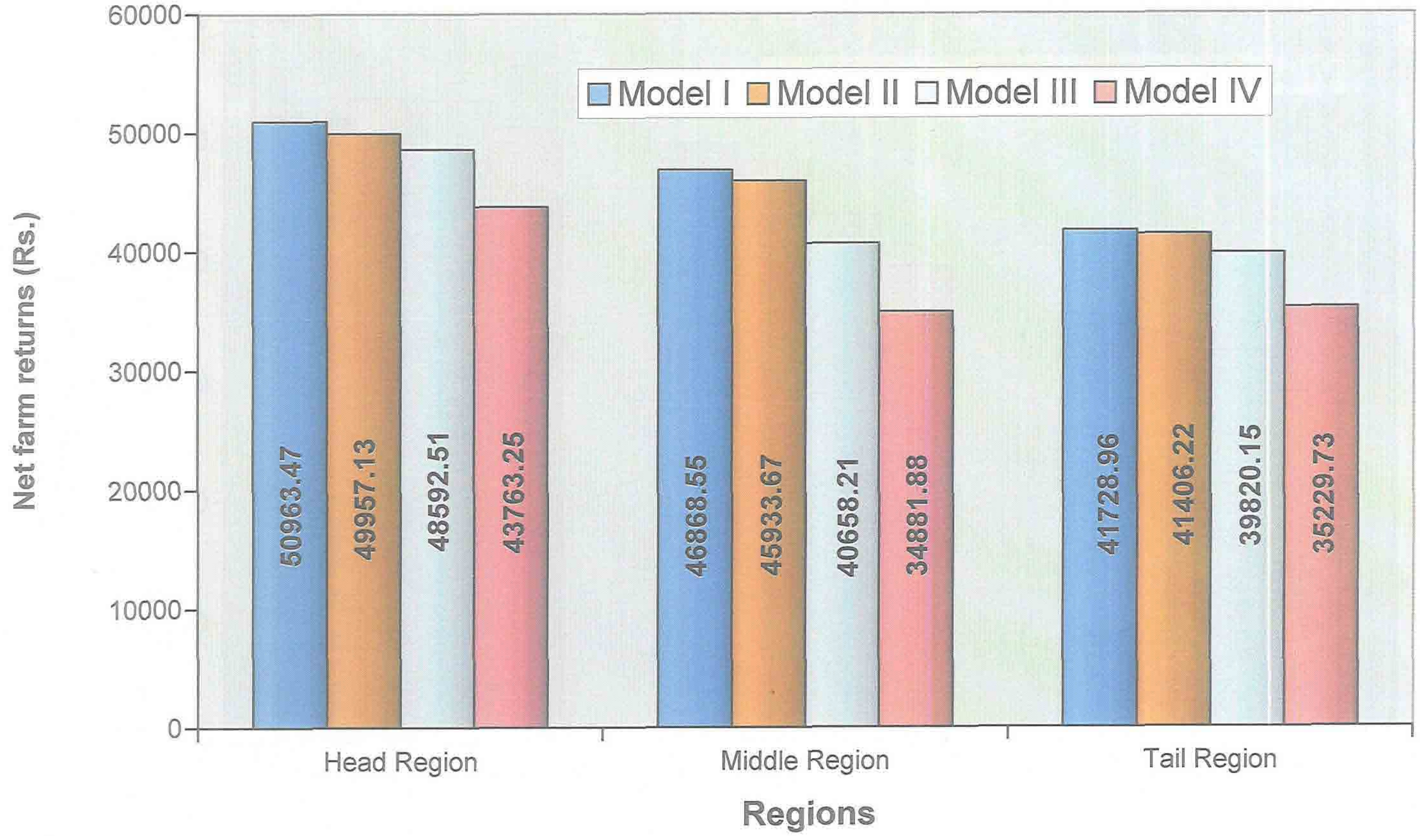


Fig 5.1: Impact of irrigation water on net farm income under different optimum plans - Small farmers

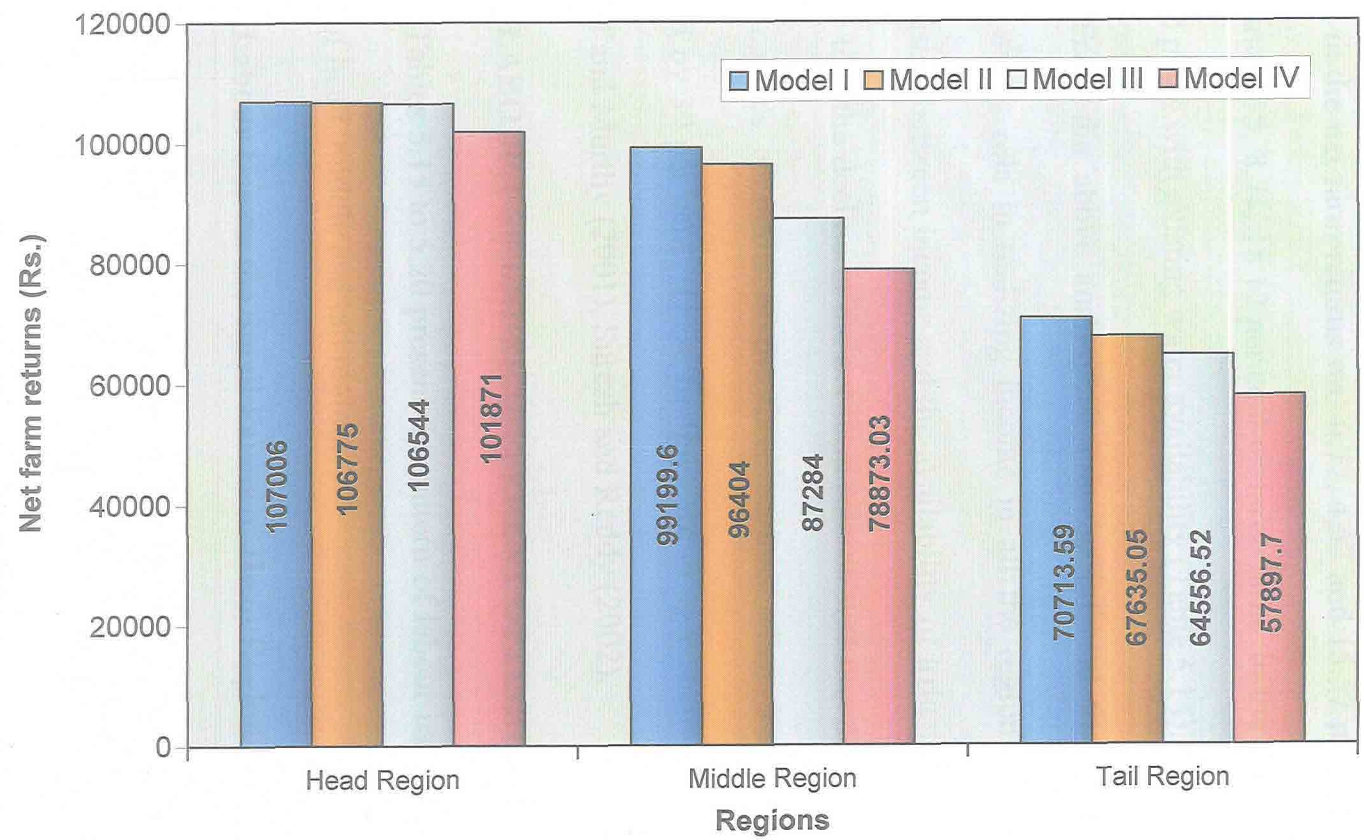


Fig 5.2: Impact of irrigation water on net farm income under different optimum plans - Large farmers

reduced by 10, 20 and 30 per cent, the small farmers were able to realize Rs.41,406.22, Rs.39,820.15 and Rs.35,229.73 while the large farmers Rs.67,635.05, Rs.64,556.52 and Rs,57,897.70 respectively. The proportionate decline in the net farm returns was 0.77, 4.57 and 15.57 per cent on the small farms and 4.35, 8.71, 18.12 per cent on large farms in the same order over the optimal plans with existing water availability (Table 5.14).

From the above analysis, it may be inferred that water availability played a key role in realizing income in all the regions. There is a direct relationship between income and the availability of irrigation water. It is also evident that the decline in the net farm returns was more pronounced on both the categories of farms of the three regions when water availability was reduced by 30 per cent. These findings are in agreement with the findings of Shareef and Murthy (2001), Suresh and Reddy (2002).

5.6 LABOUR USE UNDER DIFFERENT OPTIMUM PLANS

Tables 5.15 to 5.20 present the pattern of labour use on small and large farms of head, middle and tail regions.

5.6.1 Labour Use on the Small Farms of Head Region

The existing crop mix of small farmers of head region used 45.88 mandays, 64.77 womandays, 6.52 bullock pair days and 5.97 hours of tractor service in *kharif* season. During *rabi*, the cultivators employed 35 mandays, 64.63 womandays, 6.37 bullock pair days, and 4.49 tractor hours. The existing production programme provided an annual employment of 80.88 mandays,

Table 5.14: Impact of irrigation water on net farm returns of small and large farmers – Tail regions (in Rs.)

Category / model	Model - T_1	Model – T_2	Change over Model – T_1	Model – T_3	Change over Model – T_1	Change over Model – T_2	Model – T_4	Change over Model – T_1	Change over Model – T_2	Change over Model – T_3
Small farmers	41728.96	41406.22	-322.74 (0.77)	39820.15	-1908.81 (4.57)	-1586.07 (3.83)	35229.73	-6499.23 (15.57)	-6176.49 (14.92)	-4590.42 (11.53)
Large farmers	70713.59	67635.05	-3078.54 (4.35)	64556.52	-6157.07 (8.71)	-3078.53 (4.55)	57897.7	-12815.89 (18.12)	-9737.35 (14.39)	-6658.82 (10.31)

Figures in the parentheses indicate the percentages

129.40 womandays, 12.89 bullock pair days and 10.46 tractor hours (Table 5.15).

Model HS_1 developed with existing water availability indicated a net addition of 11.18 mandays, 10.74 womandays, 1.5 bullock pair days and 0.56 tractor hours per annum over the existing plan. The total labour required per year according to Model HS_1 was 92.06 mandays, 140.14 womandays, 14.39 bullock pair days and 11.02 tractor hours.

The results of model HS_2 indicated an increase of 3.60 mandays, 3.44 womandays, 0.80 bullock pair days and 0.05 tractor hours per annum over the existing plan. However, the increase in the labour use was marginal as compared with the optimum model HS_1. Model HS_2 used 84.48 mandays, 132.84 womandays, 13.69 bullock pair days and 10.51 tractor power interms of hours.

Model HS_3 designed at 20 per cent reduction in water availability provided an annual employment of 78.29 mandays, 117.83 womandays, 12.15 bullock pair days and 10.40 tractor power interms of hours. Men labour, women labour, bullock labour and tractor power decreased by 2.59 mandays, 11.57 womandays, 0.74 bullock pair days and 0.06 hours per annum over the existing plan.

The programming model HS_4 developed at 30 per cent reduction in the water availability helped to generate employment to 69.64 mandays, 109.70 womandays, 10.92 bullock pair days and 10.10 tractor hours. The net decline

Table 515: Labour employment on small farms under different optimum models - Head region

S.No	Items	Existing plan E-plan	Model-HS_1			Model- HS_2			Model- HS_3			Model- HS_4		
			Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan	
				(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent
Kharif season														
a.	Man days	45.88	48.70	2.82	6.15	44.43	-1.45	3.16	40.15	-5.73	12.49	35.78	-10.10	22.01
b.	Woman days	64.77	65.53	0.76	1.17	60.47	-4.3	6.64	55.40	-9.37	14.47	51.86	-12.91	19.93
c.	Bullock days	6.52	6.29	-0.23	3.52	5.95	-0.57	8.74	5.62	-0.90	13.80	5.20	-1.32	20.25
d.	Tractor hours	5.97	5.91	-0.06	1.01	5.68	-0.29	4.86	5.46	-0.51	8.54	5.08	-0.89	14.91
Rabi season														
a.	Man days	35.00	43.36	8.36	23.89	40.05	5.05	14.43	38.14	3.14	8.97	33.86	-1.14	3.26
b.	Woman days	64.63	74.61	9.98	15.44	72.37	7.74	11.98	62.43	-2.20	3.40	57.84	-6.79	10.51
c.	Bullock days	6.37	8.10	1.73	27.16	7.74	1.37	21.51	6.53	0.16	2.51	5.72	-0.65	10.20
d.	Tractor hours	4.49	5.11	0.62	13.81	4.83	0.34	7.57	4.94	0.45	10.02	5.02	0.53	11.80
Total Man days		80.88	92.06	11.18	13.82	84.48	3.60	4.45	78.29	-2.59	3.20	69.64	-11.24	13.90
Total Woman days		129.4	140.14	10.74	8.29	132.84	3.44	2.66	117.83	-11.57	8.94	109.70	-19.7	15.22
Total Bullock days		12.89	14.39	1.5	11.64	13.69	0.80	6.21	12.15	-0.74	5.74	10.92	-1.97	15.28
Total Tractor hours		10.46	11.02	0.56	5.35	10.51	0.05	0.48	10.40	-0.06	0.57	10.10	-0.36	3.44

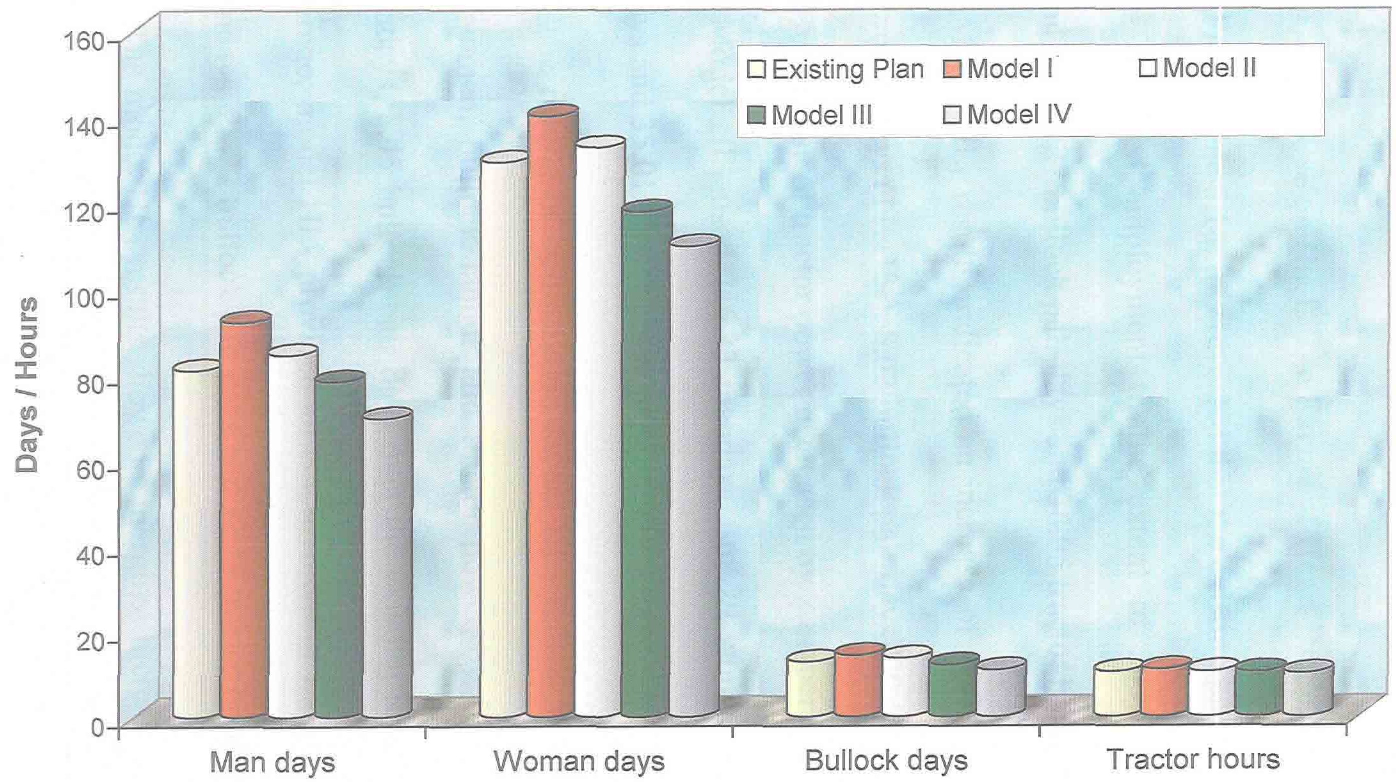


Fig. 5.3: Labour employment on small farms under different optimum models - Head region

in the employment over the existing plan was 11.24 mandays (13.90%), 19.70 womandays (15.22%), 1.97 bullock pair days (15.28%) and 0.36 tractor hours (3.44%).

5.6.2 Labour Use on the Large Farms of Head Region

From Table 5.16, it is revealed that the existing production plan of large farmers provided employment to the extent of 203.75 mandays, 330.57 womandays, 20.27 bullock pair days and 36.05 tractor hours per year.

Model HL_1 results indicated an increase of 42.58 mandays (20.89%), 37.72 womandays (11.41%), 8.02 bullock pair days (39.57%) over the existing plan. But the use of tractor power decreased by 2.88 per cent over the existing plan. Model HL_1 used 246.33 mandays, 368.29 womandays, 28.29 bullock pair days and 35.01 tractor hours per annum.

The results of optimization model HL_2 indicated an increased use of men, women, bullock labour and tractor power by 23.40 mandays, 23.05 womandays, 8.45 bullock pair days over the existing level employment. On an average, model HL_2 provided an employment of 227.15 mandays, 353.62 womandays, 28.72 bullock pair days and 32.79 tractor hours per year.

The model HL_3 results showed a marginal increase in the employment of men, women, bullock labour by 4.23 mandays, 8.36 womandays, 8.89 bullock pair days over the existing plan and the tractor power was declined by 5.48 hours per annum. On an average, the labour employment provided by

Table 5.16: Labour employment on large farms under different optimum models - Head region

S.No	Items	Existing plan E-plan	Model-HL_1			Model- HL_2			Model- HL_3			Model- HL_4		
			Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan	
				(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent
Kharif season														
a.	Man days	122.61	132.81	10.2	8.32	121.28	-1.33	1.09	109.75	-12.86	10.49	89.70	-32.91	26.84
b.	Woman days	180.82	173.98	-6.84	3.78	164.14	-16.68	9.22	154.29	-26.53	14.67	145.86	-34.96	19.33
c.	Bullock days	10.25	12.94	2.69	26.24	13.22	2.97	28.98	13.50	3.25	31.71	12.62	2.37	23.12
d.	Tractor hours	23.56	19.54	-4.02	17.06	18.42	-5.14	21.82	17.29	-6.27	26.61	17.47	-6.09	25.85
Rabi season														
a.	Man days	81.14	113.52	32.38	39.91	105.87	24.73	30.48	98.23	17.09	21.06	92.78	11.64	14.35
b.	Woman days	149.75	194.31	44.56	29.76	189.48	39.73	26.53	184.64	34.89	23.30	149.84	0.09	0.06
c.	Bullock days	10.02	15.35	5.33	53.19	15.50	5.48	54.69	15.66	5.64	56.29	9.63	-0.39	3.89
d.	Tractor hours	12.49	15.47	2.98	23.86	14.37	1.88	15.05	13.28	0.79	6.33	15.29	2.8	22.42
Total Man days		203.75	246.33	42.58	20.89	227.15	23.40	11.48	207.98	4.23	2.08	182.48	-21.27	10.44
Total Woman days		330.57	368.29	37.72	11.41	353.62	23.05	6.97	338.93	8.36	2.53	295.7	-34.87	10.55
Total Bullock days		20.27	28.29	8.02	39.57	28.72	8.45	41.69	29.16	8.89	43.86	22.25	1.98	9.77
Total Tractor hours		36.05	35.01	-1.04	2.88	32.79	-3.26	9.04	30.57	-5.48	15.20	32.76	-3.29	9.13

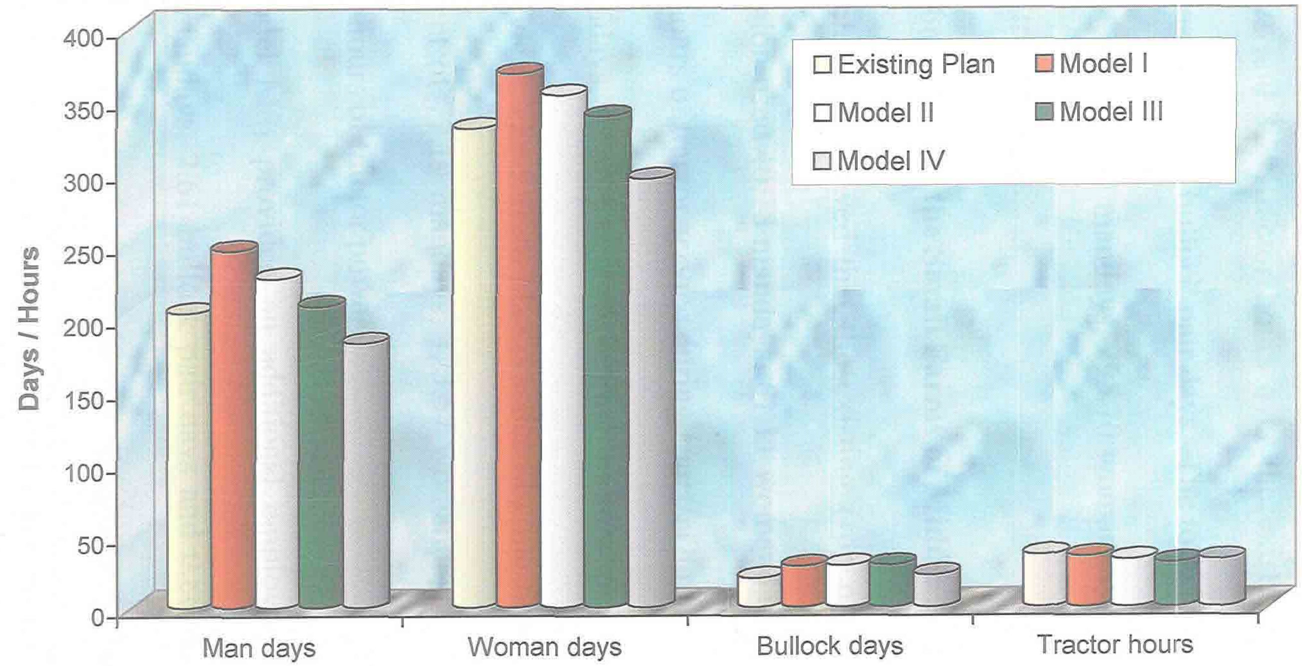


Fig. 5.4: Labour employment on large farms under different optimum models - Head region

HL_3 was 207.98 mandays, 338.93 womandays, 29.16 bullock pair days and 30.57 tractor hours per annum.

The annual labour use in HL_4 decreased by 21.27 mandays, 34.87 womandays and 3.29 tractor hours over the existing plan where as bullock days increased by 1.98 bullock pair days. The total labour use indicated by the model HL_4 was 182.48 mandays, 295.70 womandays, 22.25 bullock pair days and 32.76 tractor hours.

5.6.3 Labour Use on the Small Farms of Middle Region

Table 5.17 showed that the existing crop mix of small farms in the middle region used 40.78 mandays, 61.11 womandays, 5.63 bullock pair days and 5.99 hours of tractor service during *kharif.* During *rabi*, farmers employed 36.41 mandays, 62.46 womandays, 5.68 bullock pair days and 5.05 hours of tractor service. The current plan practiced by the farmers provided an annual employment of 77.19 mandays, 123.57 womandays, 11.31 bullock pair days and 11.04 hours of tractor power.

Model MS_1 provided an additional employment of 16.40 mandays, 24.66 womandays, 2.61 bullock pair days and 0.80 hours of tractor service. The total labour required per annum according to model MS_1 was 93.59 mandays, 148.23 womandays, 13.92 bullock pair days and 11.84 hours of tractor service.

The results of model MS_2 indicated an increase in the case of all input services in the *kharif* season and human labour alone in the *rabi* season with a

Table 5.17: Labour employment on small farms under different optimum models - Middle region

S.No	Items	Existing plan E-plan	Model-MS_1			Model- MS_2			Model- MS_3			Model- MS_4		
			Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan	
				(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent
Kharif season														
a.	Man days	40.78	51.60	10.82	26.53	46.66	5.88	14.42	40.47	-0.31	0.76	36.09	-4.69	11.50
b.	Woman days	61.11	66.48	5.37	8.79	61.54	0.43	0.70	66.50	5.39	8.82	54.07	-7.04	11.52
c.	Bullock days	5.63	5.93	0.30	5.33	5.69	0.06	1.07	5.27	-0.36	6.39	4.31	-1.32	23.45
d.	Tractor hours	5.99	6.78	0.79	13.19	6.32	0.33	5.51	6.88	0.89	14.86	5.90	-0.09	1.50
Rabi season														
a.	Man days	36.41	41.99	5.58	15.33	48.16	11.75	32.27	38.58	2.17	5.96	35.25	-1.16	3.19
b.	Woman days	62.46	81.75	19.29	30.88	72.70	10.24	16.39	65.74	3.28	5.25	64.99	2.53	4.05
c.	Bullock days	5.68	7.99	2.31	40.67	4.93	-0.75	-13.20	5.18	-0.50	8.80	5.05	-0.63	11.09
d.	Tractor hours	5.05	5.06	0.01	0.20	4.88	-0.17	-3.37	4.54	-0.51	10.10	4.07	-0.98	19.41
Total Man days		77.19	93.59	16.40	21.25	94.82	17.63	22.84	79.05	1.86	2.41	71.34	-5.85	7.58
Total Woman days		123.57	148.23	24.66	19.96	134.24	10.67	8.63	132.24	8.67	7.02	119.06	-4.51	3.65
Total Bullock days		11.31	13.92	2.61	23.08	10.62	-0.69	-6.10	10.45	-0.86	7.60	9.36	-1.95	17.24
Total Tractor hours		11.04	11.84	0.80	7.25	11.20	0.16	1.45	11.42	0.38	3.44	9.97	-1.07	9.69

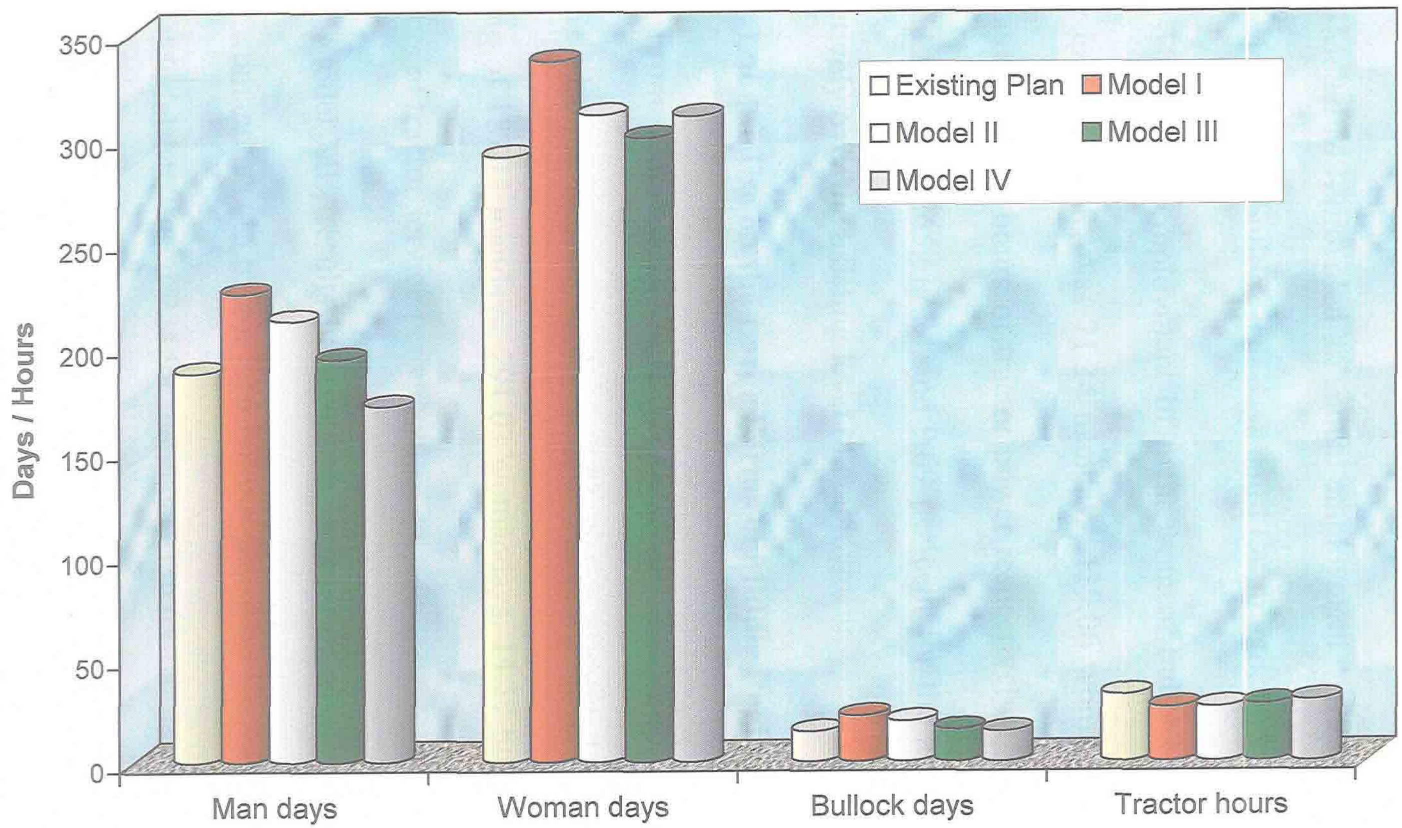


Fig. 5.6: Labour employment on large farms under different optimum models - Middle region

net addition of 17.63 mandays, 10.67 womandays, and 0.16 hours of tractor service over the existing plan. Model MS_2 used 94.82 mandays, 134.24 womandays, 10.62 bullock pair days and 11.20 hours of tractor service.

Model MS_3 provided an annual employment of 79.05 mandays, 132.24 womandays, 10.45 bullock pair days and 11.42 tractor hours.

The annual employment of men, women, bullock labour and tractor power in Model MS_4 was 71.34 mandays, 119.06 womandays, 9.36 bullock pair days and 9.97 hours of tractor power respectively. The labour use was reduced by 7.58, 3.65, 17.24 and 9.69 per cent for the above input services respectively over the existing level of employment.

5.6.4 Labour Use on the Large Farms of Middle Region

From table 5.18, it is revealed that the existing production plan practiced by the farmers in the middle region generated employment to the existing of 187.11 mandays, 291.03 womandays, 14.37 bullock pair days and 32 hours of tractor service per annum.

Model ML_1 results indicated an increase of 37.88 mandays (20.24%), 45.66 womandays (15.69%), 7.56 bullock pair days (52.61%) over the current plan. Model ML_1 used 224.99 mandays, 336.69 womandays, 21.93 bullock pair days, and 25.83 tractor hours.

The results of optimization model ML_2 indicated increased use of men, women, bullock labour by 24.8 mandays, 19.87 womandays, and 5.0 bullock pair days over the existing plan. On an average, model ML_2 provided an

Table 5.18: Labour employment on large farms under different optimum models - Middle region

S.No	Items	Existing plan E-plan	Model-ML_1			Model- ML_2			Model- ML_3			Model- ML_4		
			Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan	
				(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent
Kharif season														
a.	Man days	107.76	109.45	1.69	1.57	109.11	1.35	1.25	98.52	-9.24	8.57	88.38	-19.38	17.98
b.	Woman days	149.55	146.17	-3.38	2.26	145.89	-3.66	2.45	146.96	-2.59	1.73	153.30	3.75	2.50
c.	Bullock days	6.53	9.20	2.67	40.89	9.20	2.67	40.89	8.53	2.00	30.63	7.40	0.87	13.32
d.	Tractor hours	19.00	14.59	-4.41	23.21	14.56	-4.44	23.37	15.68	-3.32	17.47	17.84	-1.16	6.11
Rabi season														
a.	Man days	79.35	115.54	36.19	45.61	102.80	23.45	29.55	95.09	15.74	19.84	82.62	3.27	4.12
b.	Woman days	141.48	190.52	49.04	34.66	165.01	23.53	16.63	153.09	11.16	8.21	157.42	15.94	11.27
c.	Bullock days	7.84	12.73	4.89	62.37	10.17	2.33	29.72	6.81	-1.03	13.14	7.06	-0.78	9.95
d.	Tractor hours	13.00	11.24	-1.76	13.54	11.40	-1.6	-12.31	11.58	-1.42	10.92	11.38	-1.62	12.46
Total Man days		187.11	224.99	37.88	20.24	211.91	24.80	13.25	193.61	6.50	3.47	171.00	-16.11	8.61
Total Woman days		291.03	336.69	45.66	15.69	310.90	19.87	6.83	300.05	9.02	3.09	310.42	19.39	6.66
Total Bullock days		14.37	21.93	7.56	52.61	19.37	5.0	34.79	15.34	0.97	6.75	14.46	0.09	0.63
Total Tractor hours		32.00	25.83	-6.17	19.28	25.96	-6.04	18.88	27.26	-4.74	14.81	29.22	-2.78	8.69

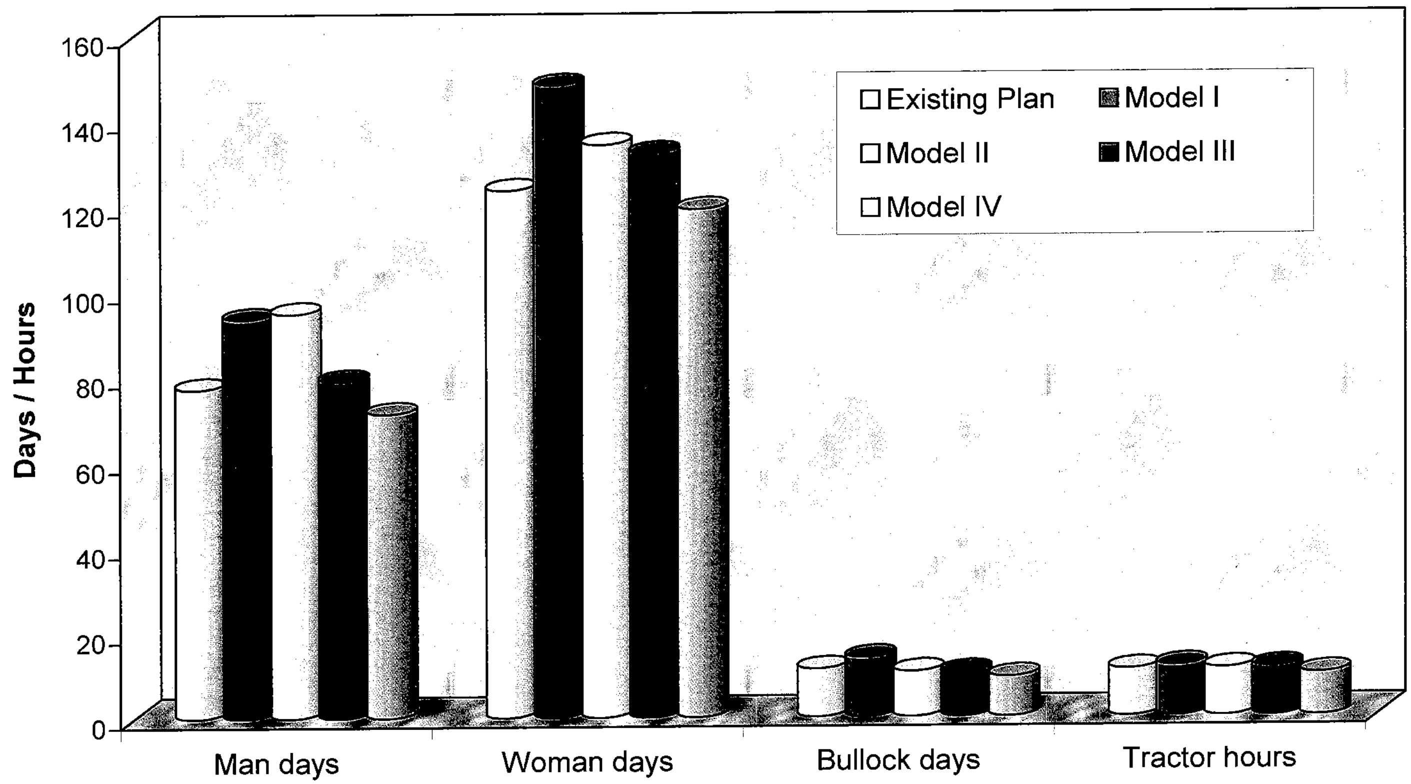


Fig. 5.5: Labour employment on small farms under different optimum models - Middle region

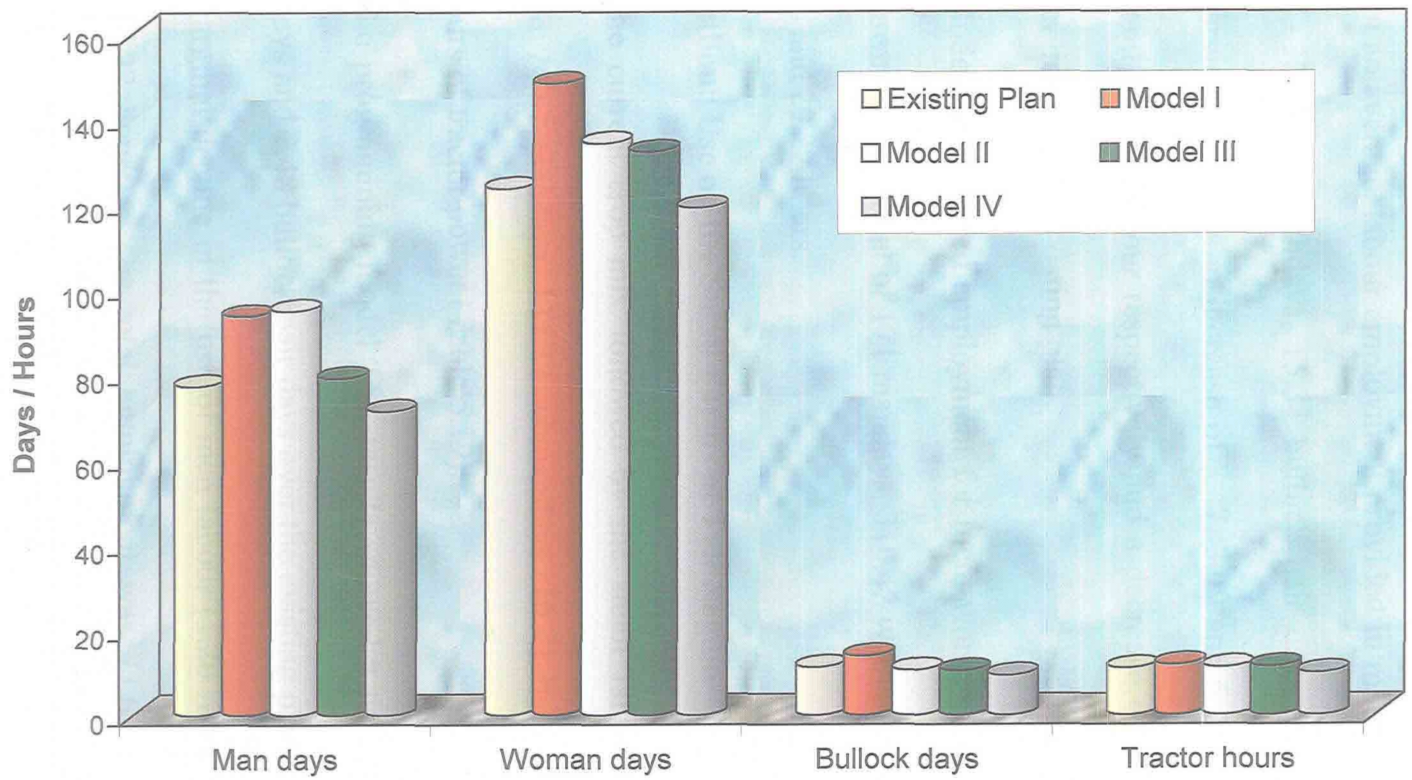


Fig. 5.5: Labour employment on small farms under different optimum models - Middle region

annual employment of 211.91 mandays, 310.90 womandays, 19.37 bullock pair days and 25.96 tractor hours.

On an average, labour employment provided in model ML_3 was 193.61 mandays, 300.05 womandays, 15.34 bullock pair days and 27.26 hours of tractor service recording an increase of 3.47, 3.09 and 6.75 per cent of men, women and bullock labour respectively and a decrease of 14.81 per cent of tractor service over the existing plan.

Model ML_4 offered employment for men, women, bullock labour and tractor power to the extent of 171 mandays, 310.42 womandays, 14.46 bullock pair days and 29.22 hours.

5.6.5 Labour Use on the Small Farms of Tail Region

The current crop mix followed by the small farmers of tail region employed 74.87 mandays, 137.12 womandays, 10.71 bullock pair days and 10.88 hours of tractor power (Table 5.19).

The programming model TS_1, results showed a net addition of 17.82 womandays and 2.48 bullock pair days over the existing plan. However, there was a marginal decline in the use of men labour (1.26 mandays) and tractor service (0.22 hours). The total employment was 73.61 mandays, 154.94 womandays, 13.19 bullock pair days and 10.66 hours of tractor service.

The model TS_2 that was developed at 10 per cent reduction in the water availability indicated the provision of about 71.88 mandays, 152.08

Table 5.19: Labour employment on small farms under different optimum models - Tail region

S.No	Items	Existing plan E-plan	Model-TS_1			Model- TS_2			Model- TS_3			Model- TS_4		
			Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan	
				(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent
Kharif season														
a.	Man days	41.56	47.24	5.68	13.67	47.91	6.35	15.28	47.33	5.77	13.88	35.20	-6.36	15.30
b.	Woman days	67.25	75.97	8.72	12.97	74.79	7.54	11.21	75.83	8.58	12.76	76.46	9.21	13.70
c.	Bullock days	5.09	5.98	0.89	17.49	5.98	0.89	17.49	5.98	0.89	17.49	4.94	-0.15	2.95
d.	Tractor hours	7.04	6.28	-0.76	10.80	6.34	-0.70	9.94	6.28	-0.76	10.80	5.95	-1.09	15.48
Rabi season-														
a.	Man days	33.31	26.37	-6.94	20.83	23.97	-9.34	28.04	24.91	-8.40	25.22	23.74	-9.57	28.73
b.	Woman days	69.87	78.97	9.10	13.02	77.29	7.42	10.62	66.21	-3.66	5.24	61.05	-8.82	12.62
c.	Bullock days	5.62	7.21	1.59	28.29	7.04	1.42	25.27	5.15	-0.47	8.36	4.34	-1.28	22.78
d.	Tractor hours	3.84	4.38	0.54	14.06	4.16	0.32	8.33	3.18	-0.66	17.19	2.68	-1.16	30.21
Total Man days		74.87	73.61	-1.26	1.68	71.88	-2.99	3.99	72.24	-2.63	3.51	58.94	-15.93	21.28
Total Woman days		137.12	154.94	17.82	13.00	152.08	14.96	10.91	142.04	4.92	3.59	137.51	0.39	0.28
Total Bullock days		10.71	13.19	2.48	23.16	13.02	2.31	21.57	11.13	0.42	3.92	9.28	-1.43	13.35
Total Tractor hours		10.88	10.66	-0.22	2.02	10.50	-0.38	3.49	9.46	-1.42	13.05	8.63	-2.25	20.68

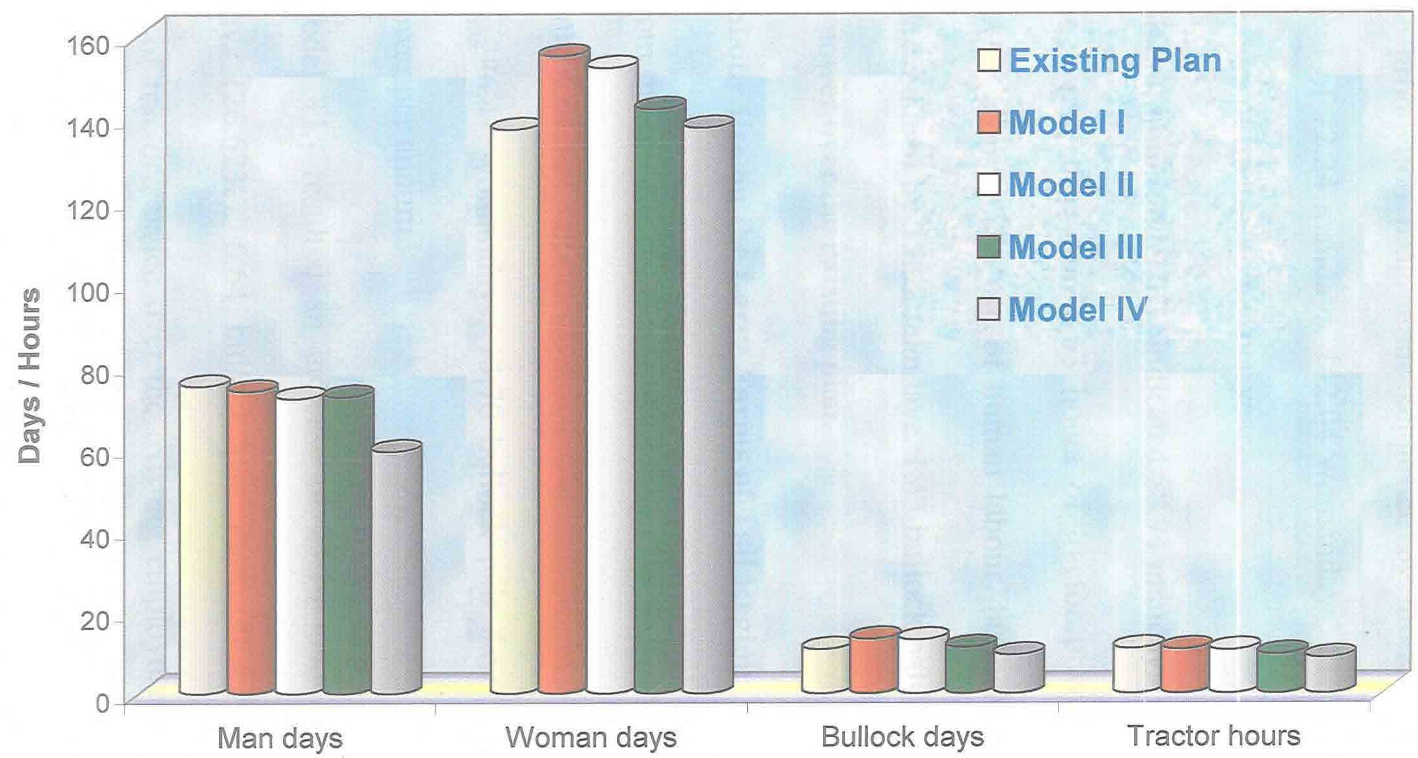


Fig. 5.7: Labour employment on small farms under different optimum models - Tail region

womandays, 13.02 bullock pair days and 10.50 hours of tractor power per annum.

The production programme suggested by model TS_3 resulted in the employment of 72.24 mandays, 142.04 womandays, 11.13 bullock pair days and 9.46 hours of tractor power per year.

The optimum model TS_4 indicated 58.94 mandays, 137.51 womandays, 9.28 bullock pair days and 8.63 hours of tractor power per year for the cultivation of crops. The use of human labour, bullock labour and tractor service was reduced by 15.93 mandays, 1.43 bullock pair days and 2.25 hours of tractor power over the existing plan.

5.6.6 Labour Use on the Large Farms of Tail Region

From the table 5.20, it is observed that the existing production plan of large farmers of tail region provided employment to the extent of 152.85 mandays, 286.41 womandays, 13.70 bullock pair days and 28.51 hours of tractor power per annum.

Model TL_1 resulted an increase of 23.16 mandays (15.15%) 76.24 womandays (26.62%), 6.64 bullock pair days (48.47%) and 3.08 hours (10.80%) of tractor service over the existing employment of input services. The crop mix suggested by TL_1 used 176.01 mandays, 362.65 womandays, 20.34 bullock pair days and 31.59 hours of tractor power per year.

Model TL_2 provided an employment of 165.35 mandays, 339.92 womandays, 18.16 bullock pair days and 30.06 hours of tractor power per

Table 5.20: Labour employment on large farms under different optimum models - Tail region

S.No	Items	Existing plan E-plan	Model-TL_1			Model- TL_2			Model- TL_3			Model- TL_4		
			Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan		Normative Employment (days/hours)	Change over E-plan	
				(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent		(days / hours)	Per cent
Kharif season														
a.	Man days	98.11	117.42	19.32	19.68	108.31	10.20	10.40	99.21	1.10	1.12	89.64	-8.47	8.63
b.	Woman days	157.09	185.40	28.31	18.02	176.98	19.89	12.66	168.56	11.47	7.30	149.48	-7.61	4.84
c.	Bullock days	6.3	8.13	1.83	29.05	8.13	1.83	29.05	8.13	1.83	29.05	7.19	0.89	14.13
d.	Tractor hours	18.67	19.39	0.72	3.86	18.48	-0.19	1.02	17.57	-1.1	5.89	15.18	-3.49	18.69
Rabi season														
a.	Man days	54.74	58.59	3.85	7.03	57.04	2.30	4.20	55.48	0.74	1.35	52.56	-2.18	3.98
b.	Woman days	129.32	177.25	47.93	37.06	162.94	33.62	26.00	148.63	19.31	14.93	131.04	1.72	1.33
c.	Bullock days	7.40	12.21	4.81	65.00	10.03	2.63	35.54	7.85	0.45	6.08	5.76	-1.64	22.16
d.	Tractor hours	9.84	12.20	2.36	23.98	11.58	1.74	17.68	10.96	1.12	11.38	10.08	0.24	2.44
Total Man days		152.85	176.01	23.16	15.15	165.35	12.50	8.18	154.69	1.84	1.20	142.20	-10.65	6.97
Total Woman days		286.41	362.65	76.24	26.62	339.92	53.51	18.68	317.19	30.78	10.75	280.52	-5.89	2.06
Total Bullock days		13.70	20.34	6.64	48.47	18.16	4.46	32.55	15.98	2.28	16.64	12.95	-0.75	5.47
Total Tractor hours		28.51	31.59	3.08	10.80	30.06	1.55	5.44	28.53	0.02	0.07	25.26	-3.25	11.40

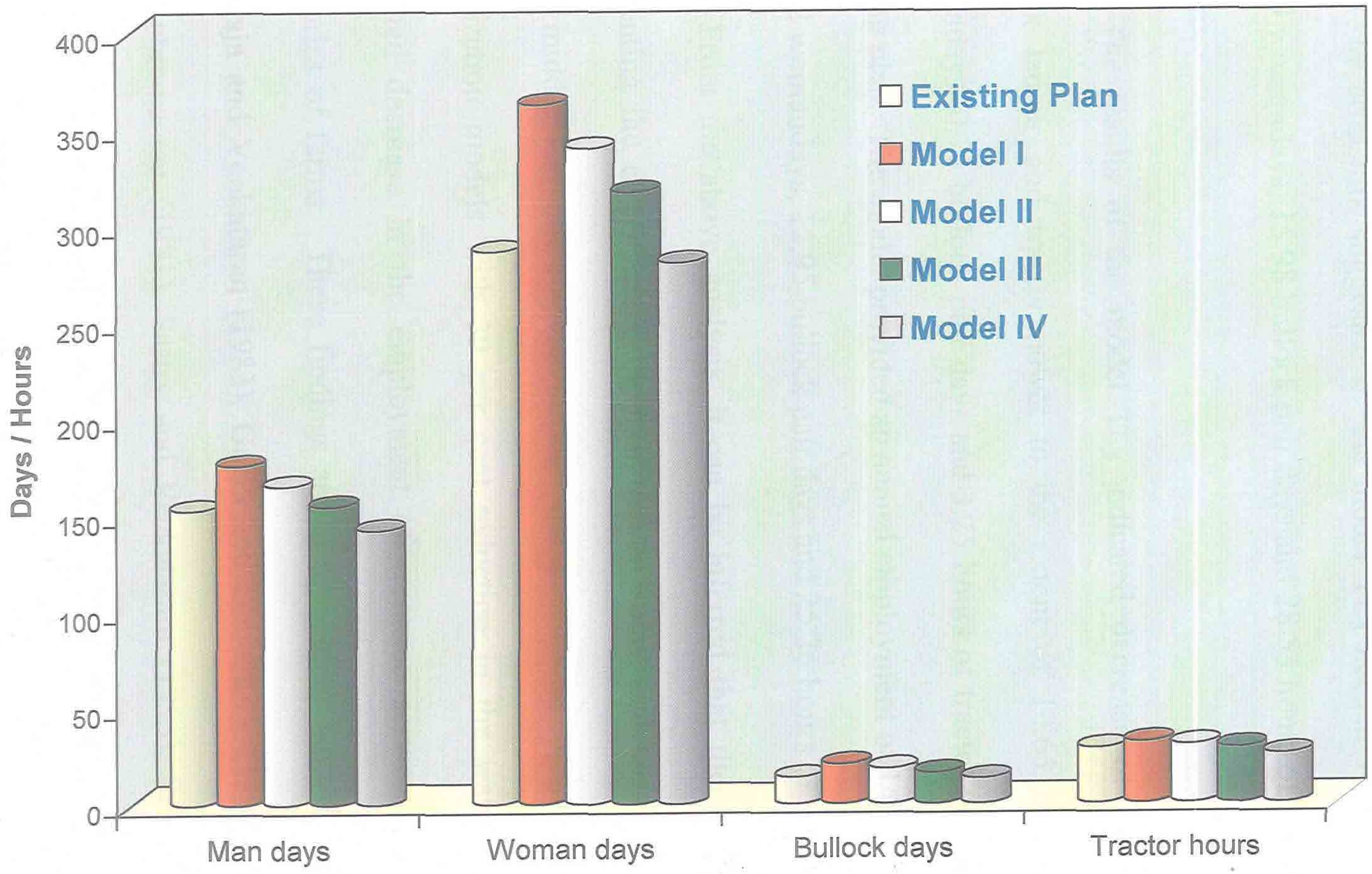


Fig. 5.8: Labour employment on large farms under different optimum models - Tail region

annum recording an increase of 12.50 mandays, 53,51 womandays, 4.46 bullock pair days and 1.55 hours of tractor power over the existing plan.

The crop mix suggested by the model TL_3 needed 154.69 mandays, 317.19 womandays, 15.98 bullock pair days and 28.53 hours of tractor service per year.

The results of the model TL_4 indicated decrease of men, women, bullock labour and tractor power to the extent of 10.65 mandays, 5.89 womandays, 0.75 bullock pair days and 3.25 hours of tractor power over the existing plan. The model provided an annual employment of 142.20 mandays, 280.52 womandays, 12.95 bullock pair days and 25.26 hours of tractor service.

From the above analysis, it can be inferred that there is scope for augmenting the employment opportunities on small and large farms in the head, middle and tail regions through the process of optimization. The optimization models with 30 per cent reduction in the water availability indicated decrease in the employment of resource services on both the categories of farms. These findings are in agreement with the findings of Nagaraja and Venkataran (1983), Gogoi and Bhowmick (1990), Selvarajan and Subramanian (1981), Sastry and Venkataram (1993), Sreelakshmi and Sastry (1995), Goswamy (1997), Deoghere (1997), Shareef and Murthy (2001), Suresh and Reddy (2002).

5.7 IMPACT OF WATER AVAILABILITY ON EMPLOYMENT

The impact of reduction in irrigation water on the employment of input services viz., men, women, bullock labour and tractor power can be examined by comparing the optimum models HS_1, HL_1, MS_1, ML_1, TS_1 and TL_1 with the optimum models designed at 10, 20 and 30 per cent reduction in irrigation water supply over the existing plan.

5.7.1 Head region

It may be observed from Table 5.21 that the use of input services declined with reduction in the water availability. In the case of small farms, the employment of men, women, bullock labour and tractor power declined from 92.06 mandays, 140.14 womandays, 14.39 bullock pair days and 11.02 hours of tractor services in optimum model HS1 developed with existing water availability to 69.64 mandays (24.35%), 109.70 woman days (21.72%), 10.92 bullock pair days (24.11%) and 10.10 hours of tractor service (8.35%) in the programming model developed with 30 per cent reduction in the water availability (HS4).

On large farms, the decline in the labour use was maximum in optimal plan HL_4. The annual employment of men, women, bullock labour and tractor service was reduced by 63.85 mandays, 72.59 woman days, 6.04 bullock pair days and 2.25 hours of tractor power in HL_4 over HL_1.

Table 5.21: Impact of irrigation water on labour employment of small and large farms – Head region

	Model-T_1	Model-T_2	Change over Model T_1	Model-T_3	Change over Model T_1	Change over Model T_2	Model-T_4	Change over Model T_1	Change over Model T_2	Change over Model T_3
Small farmers										
Total mandays	92.06	84.48	-7.58 (8.23)	78.29	-13.77 (14.87)	-6.19 (7.33)	69.64	-22.42 (24.35)	-14.84 (17.57)	-8.65 (11.05)
Total woman days	140.14	132.84	-7.30 (5.21)	117.83	-22.31 (15.92)	-15.01 (11.29)	109.70	-30.44 (21.72)	-23.14 (17.42)	-8.13 (6.89)
Total bullock days	14.39	13.69	-0.70 (4.86)	12.15	-2.24 (15.57)	-1.54 (11.25)	10.92	-3.47 (24.11)	-2.77 (20.23)	-1.23 (10.12)
Total tractor hours	11.02	10.51	-0.51 (4.63)	10.40	-0.62 (5.63)	-0.11 (1.05)	10.10	-0.92 (8.35)	-0.41 (3.90)	-0.30 (2.88)
Large farmers										
Total mandays	246.33	227.15	-19.18 (7.79)	207.98	-38.35 (15.57)	-19.17 (8.44)	182.48	-63.85 (25.92)	-44.67 (19.67)	-25.50 (12.26)
Total woman days	368.29	353.62	-14.67 (3.98)	338.93	-29.36 (7.97)	-14.69 (4.15)	295.70	-72.59 (19.71)	-57.92 (16.38)	-43.23 (12.75)
Total bullock days	28.29	28.72	0.43 (1.52)	29.16	0.87 (3.07)	0.44 (1.53)	22.25	-6.04 (21.35)	-6.47 (22.53)	-6.91 (23.69)
Total tractor hours	35.01	32.79	-2.22 (6.34)	30.57	-4.53 (12.94)	-2.22 (6.77)	32.76	-2.25 (6.41)	-0.03 (0.09)	2.19 (7.16)

Figures in the parentheses indicate the percentages

5.7.2 Middle Region

The labour use on the small farms was reduced by 22.25 mandays (23.75%), 29.17 womandays(19.68%), 4.56 bullock pair days (32.76%) and 1.87 hours of tractor service (15.79%) in MS_4 over MS_1.

On large farms, though there was reduction in the labour use in all the models M2, M3 and M4 compared with the model M1 but it was maximum in M4. Labour employment was declined to the extent of 53.99 mandays, 26.27 womandays, 7.47 bullock pair days and 3.39 hours of tractor service (Table 5.22).

5.7.3 Tail Region

Impact of irrigation water on employment of small and large farm is presented in Table 5.23.

On small farms of tail region, use of men, women, bullock labour and tractor service reduced from 73.67 mandays, 154.94 womandays, 13.19 bullock pair days and 10.66 hours of tractor service in TS_1 to 58.94 mandays, 137.51 womandays, 9.28 bullock pair days and 8.63 hours of tractor service in TS_4.

On large farms, annual employment of input services was declined by 33.81 mandays (19.21%), 82.13 womandays (22.65%), 7.39 bullock pair days (36.33%) and 6.33 (20.04%) hours of tractor service in Model TL_4 over model TL_1.

Table 5.22: Impact of irrigation water on labour employment of small and large farms – Middle Region

	Model-T_1	Model-T_2	Change over Model T_1	Model-T_3	Change over Model T_1	Change over Model T_2	Model-T_4	Change over Model T_1	Change over Model T_2	Change over Model T_3
Small farmers										
Total mandays	93.59	94.82	1.23 (1.31)	79.05	-14.54 (15.53)	-15.77 (16.63)	71.34	-22.25 (23.77)	-23.48 (24.76)	-7.71 (9.69)
Total woman days	148.23	134.24	-13.99 (9.44)	132.24	-15.99 (10.79)	-2.00 (1.49)	119.06	-29.17 (19.68)	-15.18 (11.31)	-13.18 (9.97)
Total bullock days	13.92	10.62	-3.3 (23.71)	10.45	-3.47 (24.93)	-0.17 (1.60)	9.36	-4.56 (32.76)	-1.26 (11.86)	-1.09 (10.43)
Total tractor hours	11.84	11.20	-0.64 (5.41)	11.42	-0.42 (3.55)	0.22 (1.96)	9.97	-1.87 (15.79)	-1.23 (10.98)	-1.454 (12.69)
Large farmers										
Total mandays	224.99	211.91	-13.08 (5.81)	193.61	-31.38 (13.95)	-18.30 (8.64)	171.00	-53.99 (23.99)	-40.91 (19.31)	-22.61 (11.68)
Total woman days	336.69	310.90	-25.79 (7.66)	300.05	-36.64 (10.88)	-10.85 (3.49)	310.42	-26.27 (7.80)	-0.48 (0.15)	9.92 (3.30)
Total bullock days	21.93	19.37	-2.56 (11.67)	15.34	-6.59 (30.05)	-4.03 (20.81)	14.46	-7.47 (34.06)	-4.91 (25.35)	-0.88 (5.74)
Total tractor hours	25.83	25.96	0.13 (0.50)	27.26	1.43 (5.54)	1.30 (5.00)	29.22	3.39 (13.12)	3.26 (12.56)	1.96 (7.19)

Figures in the parentheses indicate the percentages

Table 5.23: Impact of irrigation water on labour employment of small and large farms – Tail Region

	Model-T_1	Model-T_2	Change over Model T_1	Model-T_3	Change over Model T_1	Change over Model T_2	Model-T_4	Change over Model T_1	Change over Model T_2	Change over Model T_3
Small farmers										
Total mandays	73.61	71.88	-1.73 (2.35)	72.24	-1.37 (1.86)	0.36 (0.50)	58.94	-14.67 (19.92)	-12.94) (18.00	-13.30 (18.41)
Total woman days	154.94	152.08	-2.86 (1.85)	142.04	-12.90 (8.33)	-10.04 (6.60)	137.51	-17.23 (11.25)	-14.57 (9.58)	-4.53 (3.19)
Total bullock days	13.19	13.02	-0.17 (1.29)	11.13	-2.06 (15.62)	-1.89 (14.52)	9.28	-3.91 (29.64)	-3.74 (28.73)	-1.85 (16.62)
Total tractor hours	10.66	10.50	-0.16 (1.50)	9.46	-1.20 (11.26)	-1.04 (9.90)	8.63	-2.03 (19.04)	-1.87 (17.81)	-0.83 (8.77)
Large farmers										
Total mandays	176.01	165.35	-10.66 (6.06)	154.69	-21.32 (12.11)	-10.66 (6.45)	142.20	-33.81 (19.21)	-23.15 (14.00)	-12.49 (8.07)
Total woman days	362.65	339.92	-22.73 (6.27)	317.19	-45.46 (12.54)	-22.73 (6.69)	280.52	-82.13 (22.65)	-59.40 (17.47)	-36.67 (11.56)
Total bullock days	20.34	18.16	-2.18 (10.72)	15.98	-4.36 (21.44)	-2.18 (12.00)	12.95	-7.39 (36.33)	-5.21 (28.69)	-3.03 (18.96)
Total tractor hours	31.59	30.06	-1.53 (4.84)	28.53	-3.06 (9.69)	-1.53 (5.09)	25.26	-6.33 (20.04)	-4.80 (15.97)	-3.27 (11.46)

Figures in the parentheses indicate the percentages

From the above analysis it is clear that the shortage of irrigation water resulted in the reduction of employment of men, women, bullock labour and tractor power. This might be due to the allocation of large proportion of land resource for sunflower, groundnut and greengram that required less irrigation water and labour resource in the optimal plans. Further, it is observed that the labour employment was minimum in the optimum models designed at 30 per cent reduction in the water availability.

5.8 MATERIAL INPUT USE UNDER DIFFERENT OPTIMUM PLANS

Production of farm commodities not only requires input services (human labour, cattle labour, machinery) but also material inputs like seeds, fertilizers, FYM and plant protection chemicals, etc that form an important component of cost. Tables from 5.24 to 5.29 present details of material inputs use in the optimum models.

5.8.1 Material Inputs Use on the Small Farms of Head Region

It is evident from Table 5.24 that the small farmers of head region used 81.90 Quintals of FYM, 127.08 kg of N, 75.04 kg of P and 53.04 kg of K to cultivate crops in *kharif* and *rabi.*

The process of optimization with the existing water availability resulted in increased use of FYM, N, P and K nutrients by 25.63 Quintals, 13.50 kg, 12.19 kg and 7.61 kg respectively over the existing use.

Table 5.24: Material input use on small farms under different optimum models - Head region

S.No	Items	Existing plan (E-Plan)	Model-HS_1			Model- HS_2			Model- HS_3			Model- HS_4		
			Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan	
				Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent
Kharif season														
a.	FYM (Qtl.)	39.3	45.92	6.62	16.84	45.36	6.06	15.42	44.79	5.49	13.97	42.90	3.60	9.16
b.	N (Kg)	67.16	66.28	-0.88	1.31	63.24	-3.92	5.84	60.21	-6.95	10.35	53.37	-13.79	20.53
c.	P (Kg)	42.39	45.58	3.19	7.53	39.05	-3.34	7.88	32.53	-9.86	23.26	30.27	-12.12	28.59
d.	K (Kg)	31.85	34.28	2.43	7.63	33.15	1.3	4.08	32.03	0.18	0.56	28.86	-2.99	9.38
Rabi season														
a.	FYM (Qtl.)	42.6	61.16	18.56	43.57	56.84	14.24	33.43	56.07	13.47	31.62	44.00	1.4	3.28
b.	N (Kg)	59.92	74.30	14.38	23.99	70.42	10.50	17.52	63.47	3.55	5.92	55.63	-4.29	7.16
c.	P (Kg)	32.65	41.65	9.00	27.57	39.71	7.06	21.62	44.46	11.81	36.17	43.81	11.16	34.18
d.	K (Kg)	21.19	26.37	5.18	24.45	23.63	2.44	11.51	20.84	-0.35	1.65	16.27	-4.92	23.22
Total FYM (Qtl.)		81.90	107.53	25.63	31.29	102.19	20.29	24.77	100.86	18.96	23.15	86.9	5.00	6.10
Total N (Kg)		127.08	140.58	13.50	10.62	133.66	6.58	5.18	123.68	-3.4	2.68	109.0	-18.08	14.23
Total P (Kg)		75.04	87.23	12.12	16.24	78.76	3.72	4.96	76.99	1.95	2.59	74.08	-0.96	1.28
Total K (Kg)		53.04	60.65	7.61	14.35	56.78	3.74	7.05	52.87	-0.17	0.32	45.13	-7.91	14.91

Model HS2 recommended to use 102.19 Quintals of FYM, 133.66 kg of N, 78.76 kg of P and 56.78 kg of K per year.

Model HS_3 suggested to apply FYM, N, P and K to the level 100.86 Quintals, 123.68 kg, 76.99 kg, 52.87 kg to raise crops in *kharif* and *rabi*.

The use of 86.90 Quintals of FYM, 109 kg of N, 74.08 kg of P and 45.13 kg of K was recommended by model HS_4 designed at 30 per cent reduction in water availability.

5.8.2 Material Inputs Use on the Large Farms of Head Region

It is evident from Table 5.25 that the large farmers of head region used a total of 187 Quintals of FYM, 336.88 kg of N, 161.18 kg of P and 128.60 kg of K in *kharif* and *rabi* seasons.

The programming model developed with existing water availability (HL_1) indicated to apply more quantity of inputs as compared to existing use. The model suggested that the application of 246.14 Quintals of FYM, 379.56 kg of N, 210.80 kg of P and 144.03 kg of K for the given crops.

Model HL_2 developed at 10 per cent decline in water availability recommended to use 232.71 Quintals of FYM, 357.70 kg of N, 190.91 kg of P and 136.41 kg of K recording an increase of 24.44 Quintals of FYM, 6.18 kg of N, 18.46 kg of P and 6.07 kg of K.

The model HL_3 indicated higher use of FYM (32.28 Quintals), P (9.83 kg) and K (0.21 kg) as compared to existing use.

Table 5.25: Material input use on large farms under different optimum models - Head region

S.No	Items	Existing plan (E-Plan)	Model-HL_1			Model- HL_2			Model- HL_3			Model- HL_4		
			Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan	
				Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent
Kharif season														
a.	FYM (Qtl.)	109.7	111.44	1.74	1.59	105.81	-3.89	3.54	100.18	-9.52	8.68	75.13	-34.57	31.51
b.	N (Kg)	211.71	208.71	-3.00	1.42	194.65	-17.06	8.06	180.59	-31.12	14.69	165.22	-46.49	21.96
c.	P (Kg)	106.12	129.55	23.43	22.08	113.25	7.13	6.71	96.93	-9.19	8.66	65.20	-40.92	38.56
d.	K (Kg)	86.86	93.82	6.96	8.01	92.13	5.27	6.07	90.45	3.59	4.13	86.94	0.08	0.09
a.	FYM (Qtl.)	77.3	134.70	57.40	74.26	126.90	49.6	64.17	119.1	41.8	54.07	108.13	30.83	39.89
b.	N (Kg)	125.17	170.85	45.68	36.49	163.05	37.88	30.26	155.25	30.08	24.03	133.45	8.28	6.62
c.	P (Kg)	55.06	81.25	26.19	47.57	77.66	22.60	41.05	74.08	19.02	34.54	97.74	42.68	77.52
d.	K (Kg)	41.74	50.21	8.47	20.29	44.28	2.54	6.09	38.36	-3.38	8.09	31.10	-10.64	25.49
Total FYM (Qtl.)		187.00	246.14	59.14	31.63	232.71	45.71	24.44	219.28	32.28	17.26	183.26	-3.74	2.00
Total N (Kg)		336.88	379.56	42.68	12.67	357.7	20.82	6.18	335.84	-1.04	0.31	298.67	-38.21	11.34
Total P (Kg)		161.18	210.80	49.62	30.79	190.91	29.73	18.46	171.01	9.83	6.09	162.94	1.76	1.09
Total K (Kg)		128.60	144.03	15.43	11.99	136.41	7.81	6.07	128.81	0.21	0.16	118.04	-10.56	8.21

The normative plan designed at 30 per cent reduction in water availability resulted in the decreased use FYM, N and K nutrients by 3.74 Quintals, 38.21 kg, 10.56 kg respectively over the existing use.

From the above analysis, it can be inferred that the process of optimization with existing water availability led to increased use of material inputs viz., FYM, N, P and K nutrients in the case of small and large farms of head, middle and tail region. It is also observed that the optimization models with 30 per cent decrease in the water availability recommended lesser use of material inputs as compared to the existing plan.

5.8.3 Material Input Use on the Small Farms of Middle Region

The small farmers of middle region applied 81 Quintals of FYM, 142.52 kg of N, 68.30 kg of P and 59.28 kg of K to grow crops in *kharif* and *rabi* seasons (Table 5.26).

The results of optimum model MS_1 indicated to use 87.96 Quintals of FYM, 166.57 kg of N, 76.05 kg of P and 73.66 kg of K per year. The use of above said material inputs increased by 6.96 Quintals, 24.05 kg, 7.75 kg and 14.38 kg respectively over the existing plan.

Model MS_2 recommended 89.65 Quintals of FYM, 132.82 kg of N, 80.82 kg of P and 65.40 kg of K to raise crops suggested by it in *kharif* and *rabi* seasons. Except N nutrient, the use of other inputs viz., FYM, P and K was higher by 8.65 Quintals, 12.52 kg and 6.12 kg respectively over the existing use.

Table 5.26: Material input use on small farms under different optimum models - Middle region

S.No	Items	Existing plan (E-Plan)	Model-MS_1			Model- MS_2			Model- MS_3			Model- MS_4		
			Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan	
				Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent
Kharif season														
a.	FYM (Qtl.)	35.80	36.44	0.64	1.79	35.28	-0.52	1.45	39.68	3.88	10.84	32.39	-3.41	9.53
b.	N (Kg)	79.40	85.33	5.93	7.47	78.42	-0.98	1.23	73.44	-5.96	7.51	62.23	-17.17	21.62
c.	P (Kg)	37.72	49.03	11.31	29.98	42.12	4.4	11.66	33.00	-4.72	12.51	33.23	-4.49	11.90
d.	K (Kg)	37.84	49.97	12.13	32.06	46.05	8.21	21.70	43.96	6.12	16.17	38.60	0.76	2.01
Rabi season														
a.	FYM (Qtl.)	45.20	51.52	6.32	13.98	54.37	9.17	20.29	38.65	-6.55	14.49	30.00	-15.20	33.63
b.	N (Kg)	63.12	81.24	18.12	28.71	61.40	-1.72	2.72	58.60	-4.52	7.16	54.52	-8.60	13.62
c.	P (Kg)	30.58	27.02	-3.56	11.64	38.70	8.12	26.55	40.66	10.08	32.96	38.89	8.31	27.17
d.	K (Kg)	21.44	23.69	2.25	10.49	19.35	-2.09	9.75	16.34	-5.1	23.79	13.27	-8.17	38.11
Total FYM (Qtl.)		81.00	87.96	6.96	8.59	89.65	8.65	10.68	78.33	-2.67	3.30	62.39	-18.61	22.98
Total N (Kg)		142.52	166.57	24.05	16.87	139.82	-2.70	1.89	132.04	-10.48	7.35	116.75	-25.77	18.08
Total P (Kg)		68.30	76.05	7.75	11.35	80.82	12.52	18.33	73.66	5.36	7.85	72.12	3.82	5.59
Total K (Kg)		59.28	73.66	14.38	24.26	65.40	6.12	10.32	60.3	1.02	1.72	51.87	-7.41	12.50

The programming model with 20 per cent decline in irrigation water availability (MS_3) indicated to apply 78.33 Quintals of FYM, 132.04 kg of N, 73.66 of P and 60.30 kg of K per annum.

The optimum plan with 30 per cent decrease in water availability (MS_4) resulted in lesser use of FYM, nitrogen and potash compared to the existing use. On an average, crop mix suggested by the model used 62.39 Quintals of FYM, 116.75 kg of N, 72.12 kg of P and 51.87 kg of K.

5.8.4 Material Inputs Use on the Large Farms of Middle Region

Large farmers of middle region applied FYM, N, P and K to the extent of 181.65 Quintals, 343.48 kg, 149.47 kg and 146.62 kg respectively to cultivate crops in *kharif* and *rabi* seasons.

Model ML_1 indicated to apply more quantity of FYM (29.35 Quintals) nitrogen (3.04 kg), phosphorus (18.03kg) and potash (5.14kg) than of existing use (Table 5.27).

Model ML_2 suggested to use 171.47 Quintals of FYM, 338.33 kg of N, 185.10 kg of P and 148.kg of K per year.

Model ML_3 recommended the use of FYM, N, P and K to the extent of 219.16 Quintals, 309.83 kg, 178.82 kg and 136.47 kg respectively to raise crops in both the seasons.

The optimum plan with 30 per cent reduction in water availability indicated to reduce FYM, N and K by 8.11 Quintals, 52.24 kg, 20.82 kg respectively over the existing plan.

Table 5.27: Material input use on large farms under different optimum models - Middle region

S.No	Items	Existing plan (E-Plan)	Model-ML_1			Model- ML_2			Model- ML_3			Model- ML_4		
			Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan	
				Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent
Kharif season														
a.	FYM (Qtl.)	93.4	80.50	-12.9	13.81	80.49	-12.91	13.82	100.36	6.96	7.45	105.65	12.25	13.12
b.	N (Kg)	204.21	183.03	-21.18	10.37	182.53	-21.68	10.62	169.59	-34.62	16.95	158.88	-45.33	22.20
c.	P (Kg)	93.66	103.74	10.08	10.76	103.31	9.65	10.30	83.62	-10.04	10.72	61.65	-32.01	34.18
d.	K (Kg)	103.14	105.99	2.85	2.76	105.79	2.65	2.57	102.39	-0.75	0.73	100.75	-2.39	2.32
Rabi season														
a.	FYM (Qtl.)	88.25	130.50	42.25	47.88	90.98	2.73	3.09	118.80	30.55	34.62	67.89	-20.36	23.07
b.	N (Kg)	139.27	163.49	24.22	17.39	155.80	16.53	11.87	140.24	0.97	0.70	132.36	-6.91	4.96
c.	P (Kg)	55.81	63.76	7.95	14.24	81.79	25.98	46.55	95.20	39.39	70.58	91.81	36.00	64.50
d.	K (Kg)	43.48	45.77	2.29	5.27	42.21	-1.27	2.92	34.08	-9.4	21.62	25.05	-18.43	42.39
Total FYM (Qtl.)		181.65	211.00	29.35	16.16	171.47	-10.18	5.60	219.16	37.51	20.65	173.54	-8.11	4.46
Total N (Kg)		343.48	346.52	3.04	0.89	338.33	-5.15	1.50	309.83	-33.65	9.80	291.24	-52.24	15.21
Total P (Kg)		149.47	167.50	18.03	12.06	185.10	35.63	23.84	178.82	29.35	19.64	153.46	3.99	2.67
Total K (Kg)		146.62	151.76	5.14	3.51	148.00	1.38	1.38	136.47	-10.15	6.92	125.80	-20.82	14.20

5.8.5 Material Inputs Use on the Small Farms of Tail Region

It is evident from Table 5.28 the small farmers of tail region used a total of 69.30 Quintals of FYM, 162.79 kg of N, 79.76 kg of P and 70.55 kg of K nutrients in the existing plan.

The optimum model TS_1 suggested to use FYM, N, P and K nutrients to the extent of 61.15 Quintals, 134.21 kg, 100.60 kg and 66.68 kg respectively. The use of FYM, N and K nutrients declined by 8.15 Quintals, 28.58 kg and 3.87 kg respectively over the existing plan.

The normative plan designed at 10 per cent decrease in the irrigation water availability (TS_2) indicated to use 58.06 Quintals of FYM, 133.36 kg of N, 100.11 kg of P and 64.72 kg of K nutrients recording a decline of 11.24 Quintals, 29.43 kg, 20.35 kg and 5.83 kg of the above inputs respectively over the existing level.

The optimum model TS_3 recommended to reduce FYM, N and K nutrients by 8.52 Quintals, 45.34 kg and 10.24 kg respectively and to increase the application of P nutrient by 14.06 kg over the existing use.

The programming model developed at 30 per cent reduction in water availability TS_4 indicated to apply 50.42 Quintals of FYM, 106.87 kg of N, 77.40 kg of P and 50.32 kg of K nutrients. The use of FYM, N, P and K declined by 18.88 Quintals (27.24%), 55.92 kg (34.35%), 2.36 (2.96%) and 20.23 kg (28.67%) respectively over the existing use.

Table 5.28: Material input use on small farms under different optimum models - Tail region

S.No	Items	Existing plan (E-Plan)	Model-TS_1			Model- TS_2			Model- TS_3			Model- TS_4		
			Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan	
				Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent
Kharif season														
a.	FYM (Qtl.)	42.30	49.65	7.35	17.38	49.36	7.06	16.69	49.62	7.32	17.30	40.12	-2.18	5.15
b.	N (Kg)	90.30	61.38	-28.92	32.03	64.79	-25.51	28.85	61.79	-28.51	31.57	58.67	-31.63	35.03
c.	P (Kg)	43.14	53.79	10.65	24.69	54.52	11.38	26.38	53.88	10.74	24.90	40.32	-2.82	6.54
d.	K (Kg)	48.83	49.54	0.71	1.45	49.71	0.88	1.80	49.56	0.73	1.49	42.49	-6.34	12.98
Rabi season														
a.	FYM (Qtl.)	27.00	11.50	-15.50	57.41	8.70	-18.30	67.78	11.16	-15.84	58.67	10.30	-16.70	61.85
b.	N (Kg)	72.49	72.83	0.34	0.47	68.57	-3.92	5.41	55.66	-16.83	23.22	48.20	-24.29	33.51
c.	P (Kg)	36.62	46.81	10.19	27.83	45.59	8.97	24.49	39.94	3.32	9.07	37.08	0.46	1.26
d.	K (Kg)	21.72	17.14	-4.58	21.09	15.01	-6.71	30.89	10.75	-10.97	50.51	7.83	-13.89	63.95
Total FYM (Qtl.)		69.30	61.15	-8.15	11.76	58.06	-11.24	16.22	60.78	-8.52	12.29	50.42	-18.88	27.24
Total N (Kg)		162.79	134.21	-28.58	17.56	133.36	-.29.43	18.08	117.45	-45.34	27.85	106.87	-55.92	34.35
Total P (Kg)		79.76	100.60	20.84	26.13	100.11	20.35	25.51	93.82	14.06	17.63	77.40	-2.36	2.96
Total K (Kg)		70.55	66.68	-3.87	5.49	64.72	-5.83	8.26	60.31	-10.24	14.51	50.32	-20.23	28.67

5.8.6 Material Input Use on the Large Farms of Tail Region

It was found from Table 5.29 that existing plan used 145.55 Quintals of FYM, 339.84 kg of nitrogen, 176.02 kg of P and 167.11 kg of K in both seasons.

The programming model with existing water availability (TL_1) recommended to apply 140.03 Quintals of FYM, 356.51 kg of N, 240.59 kg of P and 170.96 kg of K. The use of N, P and K nutrients increased by 16.67 kg, 64.57 kg and 3.85 kg respectively.

Model TL_2 indicated to reduce the application of 6.66 Quintals of FYM, 12.22 kg of N and 10.21 kg of K over the existing level. The total quantity of FYM, N, P and K use was 138.89 Quintals, 327.62 kg, 215.15 kg and 156.90 kg respectively.

The results of model TL_3 suggested to use a total quantity of 137.76 Quintals of FYM, 298.75 kg of N, 189.71 kg of K and 142.87 kg of P.

The crop mix suggested by TL_4 required 121.89 Quintals of FYM, 250.70 kg of N, 176.20 kg of P and 120.69 kg of K. The resource use decreased by 23.66 Quintals of FYM, 89.14 kg of nitrogen and 46.42 kg of potash over the existing plan.

5.9 SHADOW PRICES

This section presents the shadow prices of selected resources in optimum solution of different models. Shadow prices refer to the marginal value products of the resources. They indicate quantum of change in the net

Table 5.29: Material input use on large farms under different optimum models - Tail region

S.No	Items	Existing plan (E-Plan)	Model-TL_1			Model- TL_2			Model- TL_3			Model- TL_4		
			Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan		Normative use	Change over E-plan	
				Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent		Kg/Qtl	Per cent
Kharif season														
a.	FYM (Qtl.)	106.45	118.03	11.58	10.88	116.89	10.44	9.81	115.76	9.31	8.75	99.89	-6.56	6.16
b.	N (Kg)	216.15	202.61	-13.54	6.26	191.46	-24.69	11.42	180.32	-35.83	16.58	150.30	-65.85	30.46
c.	P (Kg)	111.48	139.04	27.56	24.72	121.07	9.59	8.60	103.09	-8.39	7.53	99.00	-12.48	11.19
d.	K (Kg)	133.88	137.21	3.33	2.49	129.69	-4.19	3.13	122.19	-11.69	8.73	105.49	-28.39	21.21
Rabi season														
a.	FYM (Qtl.)	39.1	22.00	-17.10	43.73	22.00	-17.10	43.73	22.00	-17.10	43.73	22.00	-17.10	43.73
b.	N (Kg)	123.69	153.90	30.21	24.42	136.16	12.47	10.08	118.43	-5.26	4.25	100.40	-23.29	18.83
c.	P (Kg)	64.54	101.55	37.01	57.34	94.08	29.54	45.77	86.62	22.08	34.21	77.20	12.66	19.62
d.	K (Kg)	33.23	33.75	0.52	1.56	27.21	-6.02	18.12	20.68	-12.55	37.77	15.20	-18.03	54.26
Total FYM (Qtl.)		145.55	140.03	-5.52	-3.79	138.89	-6.66	4.58	137.76	-7.79	5.35	121.89	-23.66	16.26
Total N (Kg)		339.84	356.51	16.67	4.91	327.62	-12.22	3.60	298.75	-41.09	12.09	250.70	-89.14	26.23
Total P (Kg)		176.02	240.69	64.57	36.68	215.15	39.13	22.23	189.71	13.69	7.78	176.20	0.18	0.10
Total K (Kg)		167.11	170.96	3.85	2.30	156.90	-10.21	6.11	142.87	-24.24	14.51	120.69	-46.42	27.78

farm returns due to a unit change of that particular resource *ceteris paribus*. They are of interest to the decision makers and planners because they indicate the most profitable resources to alter and also the maximum amount of each resource that can be used in a particular production process. The shadow prices with positive sign mean that a unit increase in the quantity of resource used would increase the objective function by the amount shown.

Shadow prices would be zero when a resource is not completely utilized because there is no return added for the marginal use of resource, all other conditions remaining the same. However, the marginal value product of resource change if one or more of other conditions change. The shadow prices of selected resources on the small and large farms of head, middle and tail regions are presented in Tables from 5.30 to 5.35.

5.9.1 Head Region

The optimization models of small and large farms (except HS_4) showed shadow prices for both *kharif* and *rabi* irrigated land. This reflected complete use of land resource.

The results of optimal plans designed at 30 per cent reduction in water availability indicated lower shadow prices for *kharif* and *rabi* irrigated land as compared to the shadow prices in other optimal plans. This clearly reveals that the profitability of farm business could be increased if the farmers are provided with adequate irrigation of water (Tables 5.30 and 5.31).

Table 5.30: Shadow prices of selected resources on small farms under different optimum models - Head Region (in Rs.)

Land Resource	Model – HS_1	Model – HS_2	Model – HS_3	Model – HS_4
Kharif irrigated land	12064.12	12064.12	10231.18	-
Rabi irrigated land	14366.20	14366.20	13560.22	10686.21
Kharif input services and inputs				
Man	-	-	-	-
Woman	26.00	26.00	-	-
Bullock	-	-	-	-
Tractor	260.00	260.00	260.00	260.00
FYM	26.00	26.00	26.00	26.00
N	11.44	11.44	11.44	11.44
P	15.60	15.60	15.60	15.60
K	9.36	9.36	9.36	9.36
Irrigation water	79.14	79.14	144.14	371.50
Rabi input services and inputs				
Man	-	-	-	-
Woman	25.00	25.00	25.00	-
Bullock	-	-	-	-
Tractor	250.00	250.00	250.00	250.00
FYM	25.00	25.00	25.00	25.00
N	11.00	11.00	11.00	11.00
P	15.00	15.00	15.00	15.00
K	9.00	9.00	9.00	9.00
Irrigation water	32.67	32.67	64.91	227.87

Table 5.31: Shadow prices of selected resources on large farms under different optimum models - Head Region (in Rs.)

Land Resource	**Model – HL_1**	**Model – HL_2**	**Model – HL_3**	**Model – HL_4**
Kharif irrigated land	19131.12	19131.12	19131.12	4875.38
Rabi irrigated land	13588.00	13588.00	13588.00	8519.29
Kharif input services and inputs				
Man	46.80	46.80	46.80	46.80
Woman	26.00	26.00	26.00	26.00
Bullock	124.00	124.80	124.00	124.00
Tractor	260.00	260.00	260.00	260.00
FYM	26.00	26.00	26.00	26.00
N	11.44	11.44	11.44	11.44
P	15.60	15.60	15.60	15.60
K	10.40	10.40	10.40	10.40
Irrigation water	8.98	8.98	8.98	325.78
Rabi input services and inputs				
Man	45.00	45.00	45.00	45.00
Woman	25.00	25.00	25.00	25.00
Bullock	120.00	120.00	120.00	120.00
Tractor	250.00	250.00	250.00	250.00
FYM	25.00	25.00	25.00	25.00
N	11.00	11.00	11.00	11.00
P	15.00	15.00	15.00	15.00
K	10.00	10.00	10.00	10.00
Irrigation water	1.48	1.48	1.48	204.23

The programming models designed at existing water availability and 10, 20 and 30 per cent shortage of water supply indicated shadow prices for resource services (men, women, bullock labour and tractor service) material inputs (FYM, N, P and K) and irrigation water on both the categories of farms in *kharif* and *rabi* (except men and bullock labour in all the normative plans of small farms).

The marginal value productivity of irrigation water was higher during *kharif* compared to *rabi* season. The shadow prices of irrigation water in *kharif* and *rabi* were the highest in the optimum plan developed with 30 per cent decrease in water availability. The shadow price of irrigation water was higher on small farms compared to large farms and thus reflected higher profitability among small farms for each additional hectare centimeter of irrigation water if it could be made available. It can be inferred that the scarcity of irrigation water was more on the small farms.

5.9.2 Middle Region

All the optimum models of large farms indicated shadow prices for male labour, female labour, bullock labour, tractor services, FYM, N, P and K nutrients in both the seasons. On the contrary, the shadow prices of male labour, bullock labour in *kharif* and *rabi* seasons and FYM in *kharif* season on the small farms were zero. This indicates that an additional employment of these resources would not add any more to the net farm returns. Except MS_4, all other programming models indicated shadow prices for land resource. The normative plan MS_4 showed zero shadow price for *kharif* irrigated land. The plausible reason for the under utilization of *kharif* land was shortage irrigation water.The profitability of irrigation water in *kharif* and *rabi* was indicated by all the optimal plans.(Tables 5.32 and 5.33)

5.9.3 Tail Region

From the tables 5.34 and 5.35 it is observed that the shadow prices were indicated by all the optimum models for resources services like male labour, female labour, bullock labour, tractor services and material inputs viz., FYM, N, P and K nutrients on small and large farms in both the seasons except male labour, and bullock labour on the small farms. Bullock labour and male labour were considered to be surplus in both the seasons on the small farms as reflected by zero shadow prices in the optimum models. The profitability of additional unit of irrigation was indicated by all the models (except TS_1 and TS_2). These findings are in agreement with the findings of Shareef and Murthy (2001), Suresh and Reddy (2002).

5.10 POLICY MEASURES

There is a divergence between the actually realised incomes on the farms and those, which would have been realized if the given resources were allocated optimally. This proves the contention that there is always sub optimal use of resources in agriculture. The existing land use pattern in the Somasila Project command area is sub - optimal.

Table 5.32: Shadow prices of selected resources on small farms under different optimum models - Middle Region (in Rs.)

Land Resource	**Model – MS_1**	**Model – MS_2**	**Model – MS_3**	**Model – MS_4**
Kharif irrigated land	16345.93	5261.12	1193.29	--
Rabi irrigated land	16498.88	8068.33	6621.99	5910.21
Kharif input services and inputs				
Man	-	-	-	-
Woman	31.20	31.20	31.20	31.20
Bullock	-	-	-	-
Tractor	260.00	260.00	260.00	260.00
FYM	-	-	-	-
N	10.40	10.40	10.40	10.40
P	15.60	15.60	15.60	15.60
K	9.36	9.36	9.36	9.36
Irrigation water	33.10	279.43	369.83	396.34
Rabi input services and inputs				
Man	-	-	-	-
Woman	30.00	30.00	30.00	30.00
Bullock	-	-	-	-
Tractor	250.00	250.00	250.00	250.00
FYM	25.00	25.00	25.00	1.04
N	10.00	10.00	10.00	10.00
P	15.00	15.00	15.00	15.00
K	9.00	9.00	9.00	9.00
Irrigation water	1.09	188.66	246.52	274.99

Table 5.33: Shadow prices of selected resources on large farms under different optimum models - Middle Region (in Rs.)

Land Resource	Model – ML_1	Model – ML_2	Model – ML_3	Model – ML_4
Kharif irrigated land	17674.96	9969.32	4106.40	4106.40
Rabi irrigated land	8972.49	5322.44	3237.85	3237.85
Kharif input services and inputs				
Man	46.80	46.80	46.80	46.80
Woman	31.20	31.20	31.20	31.20
Bullock	156.00	156.00	156.00	156.00
Tractor	260.00	260.00	260.00	260.00
FYM	26.00	26.00	26.00	26.00
N	11.44	11.44	11.44	11.44
P	15.60	15.60	15.60	15.60
K	9.36	9.36	9.36	9.36
Irrigation water	-	171.23	301.52	301.52
Rabi input services and inputs				
Man	45.00	45.00	45.00	45.00
Woman	30.00	30.00	30.00	30.00
Bullock	150.00	150.00	150.00	150.00
Tractor	250.00	250.00	250.00	250.00
FYM	25.00	25.00	25.00	25.00
N	11.00	11.00	11.00	11.00
P	15.00	15.00	15.00	15.00
K	9.00	9.00	9.00	9.00
Irrigation water	74.76	190.42	273.81	273.81

Table 5.34: Shadow prices of selected resources on small farms under different optimum models - Tail Region (in Rs.)

Land Resource	**Model – TS_1**	**Model – TS_2**	**Model – TS_3**	**Model – TS_4**
Kharif irrigated land	20950.64	20950.64	14190.81	--
Rabi irrigated land	13907.38	13907.38	11503.89	6458.26
Kharif input services and inputs				
Man	-	-	-	-
Woman	31.20	31.20	31.20	31.20
Bullock	-	-	-	-
Tractor	312.00	312.00	312.00	312.00
FYM	26.00	26.00	26.00	26.00
N	10.40	10.40	10.40	10.40
P	15.60	15.60	15.60	15.60
K	9.36	9.36	9.36	9.36
Irrigation water	-	-	150.22	465.57
Rabi input services and inputs				
Man	-	-	-	-
Woman	30.00	30.00	30.00	30.00
Bullock	-	-	-	-
Tractor	300.00	300.00	300.00	300.00
FYM	-	-	-	-
N	10.00	10.00	10.00	10.00
P	15.00	15.00	15.00	15.00
K	9.00	9.00	9.00	9.00
Irrigation water	46.10	46.10	142.24	344.07

Table 5.35: Shadow prices of selected resources on large farms under different optimum models - Tail Region

Land Resource	Model – TL_1	Model – TL_2	Model – TL_3	Model – TL_4
Kharif irrigated land	8559.61	8559.61	8559.61	--
Rabi irrigated land	10086.67	10086.67	10086.67	--
Kharif input services and inputs				
Man	52.00	52.00	52.00	52.00
Woman	31.20	31.20	31.20	31.20
Bullock	156.00	156.00	156.00	156.00
Tractor	312.00	312.00	312.00	312.00
FYM	26.00	26.00	26.00	26.00
N	10.40	10.40	10.40	10.40
P	15.60	15.60	15.60	15.60
K	9.36	9.36	9.36	9.36
Irrigation water	37.51	37.51	37.51	227.12
Rabi input services and inputs				
Man	50.00	50.00	50.00	50.00
Woman	30.00	30.00	30.00	30.00
Bullock	150.00	150.00	150.00	150.00
Tractor	300.00	300.00	300.00	300.00
FYM	-	-	-	-
N	10.00	10.00	10.00	10.00
P	15.00	15.00	15.00	15.00
K	9.00	9.00	9.00	9.00
Irrigation water	171.13	171.13	171.13	574.60

Examined in terms of size categories, the increase in income level in the optimum situation over the existing level, subject to physical constraints and availability of inputs is the maximum on the small farms and the minimum on the large holdings. This would seem to support the generally held notion that the small farmers may be the least efficient resource allocators in changing agriculture. In view of the findings that the small farmers are the least efficient allocators of resources, state agencies should go in for two-pronged action viz., strengthening the revenue position of small farmers and helping them in rationally allocating their resources.

The optimum resource use, in addition to increasing farm incomes was also more labour intensive. The development efforts, which will encourage needed adjustments in the cropping pattern, should be taken up.

The optimum cropping pattern involved fewer crops, thereby indicating the trend towards specialization. This is in conflict with the current emphasis on diversification of agriculture. Hence, incentives should be devised for the relatively less paying minor crops especially grams and other pulses.

The problem of surplus non land fixed resources (farm labour and animal labour) on the small farms as indicated by zero shadow prices do suggested the need of introducing subsidiary enterprises viz., sheep rearing, small dairy unit, small poultry unit etc which can absorb the surplus labour, there by bringing additional income.

The evidence of project preparation cell, Somasila Project division, Nellore is that in a period of 5 years, there is a year of shortfall in the water inflows to the Somasila Project to the extent of 30 per cent. This prompted to undertake sensitivity analysis at rates varying from 10 to 30 per cent of shortfall in water supply. The results obtained through this analysis are quite revealing. The reduction of 10 and 20 per cent water supplies resulted in negligible decline in the net farm income over the optimum plan at existing water availability. However, 30 per cent reduction in water supply is a cause of concern as the net income had gone down by a maximum of 25.58 per cent on the small farms of middle region and a minimum of 4.59 per cent on the large farms of head region. This was due to displacement of high valued crops by low valued crops. During those periods of shortage of water supply, all that the farmers can do as suggested by the optimum plans is simply to settle down with crops of lesser water requirement which evidently bringing in lower returns. Given the compelling situation, the farmers may be extended needed technology for improving the productivity of the lesser remunerative crops by the department of agriculture. Though there is linkage between department of irrigation and department of agriculture during these periods, the role to be played by the department of agriculture is more significant. This in essence is that farmers should be prepared for this eventuality by the extension wing of the state department of agriculture.

Relatively higher shadow prices for land on the small farms in all the three regions amply demonstrated that the true potential that exists for further use of irrigation input. Though in theory, the lands located either at head or middle or tail end region have equal access to the available irrigation at the corresponding points. The reality is that the small farmers did not enjoy the same privilege of large farmers in providing required water from the available supplies. This has more to do with economic and social factors. Large farmers should be more rational in sharing the available supplies to their counter parts of small category. After all, every farmer has equal right on natural resource.

SUMMARY AND CONCLUSIONS

CHAPTER - VI

SUMMARY AND CONCLUSIONS

Water resource, as an input to agriculture, has become vital for economic growth and sustainable development. Its catalytic role in enhancing the productivity and growth to meet the food and income needs of the Indian economy is well established. With looming crisis in water sector, water policies and water plans will have to be vision oriented for ensuring equity and efficiency in their multiple uses and various sources of water.

Recognizing the importance of irrigation as a crucial input in India's agricultural development, harnessing of water resources for irrigation has been given an important place in our successive Five Year Plans. India has the world's largest irrigated area, which was increased from 22.6 M Ha in 1951 to 96.90 M Ha at the end of the Eighth Five Year Plan (1997). Water management becomes more relevant in the coming century in view of the fact that about 85 per cent of the usable water is diverted for agriculture at present. This will be reduced to 71 per cent in the next 15-20 years. In order to feed the growing population, productivity from irrigated area must be increased to at least two to three times.

The present study entitled **"A strategy for optimal allocation of irrigation water under Somasila Project in Andhra Pradesh"** intended to examine the possibilities and prospects of increasing net farm returns and employment by better resource allocation through optimum crop enterprise system.

6.1 OBJECTIVES OF THE STUDY

1. To study the existing resource use pattern of selected farmers under three regions in the command area of Somasila Project.
2. To develop optimal enterprise mix for the sampled farmers and compare the same with existing situation.
3. To examine the income and employment opportunities through optimal reorganization of resources
4. To suggest policy measures for efficient water use in the command area of Somasila Project.

The Somasila Project command area of Andhra Pradesh was purposively selected for the present study. The entire command area is divided into three regions *viz.,* head, middle and tail region. From each region, the first two mandals with maximum command area were purposively selected. From each mandal, two villages were selected for detailed study and the sample farmers were stratified into two size groups i.e. small (upto 2 hectares of dry land) and large (more than 2 hectares of dry land). From the list of farmers in each village, five each from small and large farmers were selected at random. Thus the number of farmers selected from each village was ten and the total number of farmers selected for the purpose of present study was 120. The required data were collected in the structured schedule developed for the purpose through personal interviews from the respondents. The input output data pertains to the agricultural year 2003-04.

Linear programming technique was used to develop optimum plans. A total of twenty four normative farm plans were developed for small and large farmers of head, middle and tail regions of Somasila Project command area. These, plans were used to compare and asses whether the farmers were using resources optimally or not.

An assessment of impact of irrigation water at varying levels of availability on income and employment was also made.

To accomplish the objectives of the study, a few variations in the basic model were incorporated. The model was run with existing water supply level (optimum model 1). Later, with 10 per cent decrease in water supply (optimum model 2), 20 per cent decrease in water supply (optimum model 3) and 30 per cent decrease in water supply (Optimum model 4) were assumed and corresponding models were solved to study the effect of irrigation water on cropping pattern, income, employment and resources use pattern.

6.2 MAJOR FINDINGS OF THE STUDY

The average size of the family of small farmers was 9.06, 8.63 and 7.73 members as against 6.57, 5.72 and 7.23 members in the case of large farmers under head, middle and tail regions respectively. The average size of irrigated land of large farmers varied from 2.43 ha in head region to 2.01 ha in the tail region. The selected large farmers of middle region owned 2.09 ha. On an average the small farmers of head, middle and tail regions owned 0.98, 0.94 and 0.93 ha of irrigated land respectively.

The existing crop mix of farmers in the head, middle and tail regions consisted of food crops *viz.,* paddy and bajra, oil seeds crops like sunflower and groundnut, commercial crop sugarcane and vegetable crop brinjal on *kharif* irrigated land and paddy, cotton, chillies, cowpea, gingelly and greengream on *rabi* irrigated land.

The cropping intensity was 185.71, and 170.37, 185.11 and 177.51 and 192.47 and 176.12 per cent on the small and large farms of head, middle and tail regions respectively.

The present plan provided a net farm income of Rs.33,187.79, Rs.31,716.76 and Rs.28,054.68 on the small farms of head, middle and tail regions respectively. While the same was Rs.74,307.16, Rs.71,489.29 and Rs.49,526.29 on large farms of the above said regions in the same order.

On *kharif* irrigated land, all the crops except bajra, which were in the existing plan, entered the optimum plan with changes in the acreage. The optimum model HS_1, suggested to increase the area under paddy (1009), groundnut, sugarcane and brinjal from 0.21, 0.10, 0.11 and 0.02 ha in the existing plan to 0.42, 0.20, 0.20 and 0.10 ha respectively. But the area under sunflower declined from 0.12 ha in existing plan to 0.06 ha in the optimum plan. Paddy and bajra, which occupied 0.34 and 0.08 ha in the existing plan, were eliminated. In *rabi*, the results of the optimal model indicated to increase the area under the production of cotton, chillies and greengram. The allocation of land for cotton, chillies and greengram was 0.25, 0.10 and 0.14 ha respectively. There was no perceptible change in the allocation of land for the production of paddy. Sugarcane occupied the same area as in *kharif.* The plan did not favour the inclusion of cowpea and gingelly.

The resource optimization lead to increase in the intensity of cropping from 185.71 per cent in the existing plan to 200 per cent in the optimal plan HS_1. The net farm returns and the net farm returns per hectare of cultivated area were higher by Rs.17,775.68 (53.56 per cent) and Rs.18,138.45 (34.88 per cent) respectively over the existing plan.

The optimum model HS_2 developed by decreasing 10 per cent of water supply resulted in different cropping pattern to that of model HS_1. On *kharif*-irrigated land, the area under groundnut, sugarcane and brinjal remained the same as in optimum model HS_1. However, it recommended to increase the area for sunflower from 0.06 ha (6.12 per cent) in model HS_1 to 0.17 ha (17.35 per cent) in model HS_2. The model also suggested to reduce the area for paddy (1009) from 0.42 ha in HS_1 to 0.31 ha in model HS_2 due to reduction in the water availability. During *rabi*, sugarcane continued to occupy the same area as in *kharif.* The area under cotton and chillies remained the same as in model HS_1. The area under paddy declined from 0.29 ha in model HS_1 to 0.21 ha in model HS_2. Consequently, the area under less water consuming greengram crop increased from 0.14 ha in model HS_1 to 0.22 ha in model HS_2. The cropping intensity remained the same as in model HS_1.

The cropping pattern suggested by model HS_2 resulted in the realization of Rs.49,957.13 as net farm returns. The net farm returns were increased by 16,769.34 over the existing plan.

The impact of 20 per cent decrease in the water supply was analyzed through model HS_3. On *kharif* irrigated land, groundnut, sugarcane and brinjal occupied the same area as in the previous optimal models. Due to less availability of irrigation water, the area under paddy (1009) decreased by 0.11 ha over model HS_2. However, the plan suggested to increase the area from 0.17 ha in model HS_2 to 0.28 ha for the production of sunflower.Paddy occupied 20.41 per cent of the *rabi* irrigated land. There was no change in the allocation of area for chillies (0.10 ha). The plan suggested to decrease the area under cotton from 0.25 ha in model HS_2 to 0.09 ha in model HS_3. The area under greengram increased from 0.22 ha in model HS_2 to 0.39 ha. Sugarcane continued in the *rabi* season with the same extent of land as in *kharif.* Cowpea and gingelly did not enter this plan also.

There was no change in the cropping intensity (200 per cent) though the irrigation water availability reduced by 20 per cent. The farmers were able to realize Rs.48,592.51 as net farm returns.

The programming model with 30 percent decrease in water supply (Model HS_4) resulted in different cropping pattern from that of previous models. This model suggested to allocate minimum area (0.20 ha) for the production of paddy in each season. Groundnut and brinjal occupied the same area on *kharif* irrigated land as in the previous models. The plan indicated to double the area under the production of sunflower compared to the existing situation. Due to shortage of irrigation water, the model suggested to reduce the area for sugarcane from the 0.20 ha in the previous optimal models to 0.13 ha, leaving 0.12 ha of *kharif* irrigated land to be uncultivated. More than half of the *rabi* cultivated area was occupied by greengram. Chillies entered the plan with the same acreage as in the previous models. Cotton, which was in model HS1, HS2 and HS3 was completely eliminated in this model.

The cropping intensity declined from 200 per cent in model HS_3 to 187.76 per cent in model HS_4. The cropping pattern suggested by the model HS_4 helped small farmers of head region to realize Rs.43,763.25 as net farm returns.

Model HL_1, which was designed with currently available water suggested to increase the area for the production of paddy (1009), groundnut, sugarcane and brinjal from 0.61, 0.24, 0.18 and 0.06 ha in the existing plan to 1.08, 0.40, 0.50 and 0.20 ha in the optimal plan respectively during *kharif*, eliminating less remunerative enterprises *viz.,* paddy (1001), sunflower (morden variety) and bajra. Also, this plan showed marginal decrease in the area of sunflower (hybrid) from 0.30 ha in the existing plan to 0.25 ha in optimal plan HL_1.On irrigated land in *rabi*, the plan indicated to increase the area of commercial crops like cotton and chillies and pulse crop namely greengram from the current level and thus occupied 0.60 ha, 0.30 ha and 0.56 ha respectively by the above mentioned crops. However, the area of paddy declined from 0.68 ha in the current plan to 0.47 ha. The model did not favour the inclusion of cowpea and gingelly. Sugarcane continued to occupy the same area as in *kharif*.

The cropping intensity increased from 170.37 per cent in the existing plan to 200 per cent in the model HL_1 due to complete utilization of land resource. The net farm returns were higher by Rs.32,698.84 over the existing plan.

The optimum model HL_2 (10 per cent decrease in water availability) suggested same crops with changes in the acreage as in model HL_1. During *kharif*, groundnut, sugarcane and brinjal occupied the same area as in model HL_1. The model indicated to double the area under the production of sunflower (Hybrid) and to reduce the area from 1.08 ha in model HL_1 to 0.80 ha in model HL_2 for the production of paddy.Due to inadequate water availability, paddy enters the plan with the reduction in the acreage by 0.15 ha over the optimum model HL_1, during *rabi* season. As a result, the area under the production of greengram, which requires less water increased to 0.71 ha. Cotton and chilies occupied the same area as in the previous model. Sugarcane continued to occupy the same area as in *kharif* season.

The cropping intensity remains the same as in the optimum model HL_1, though there was less water availability. The net farm returns and net farm returns per hectare of cultivated area were Rs.1,06,775 and Rs.43,940.33 respectively.

The resource optimization model with 20 per cent decrease in the water availability (HL_3) recommended the same acerage for the production of groundnut (0.40ha), sugarcane (0.50 ha) and brinjal (0.20 ha) as in the previous models during *kharif.* However, it indicated drastic reduction in the area for paddy production from 1.08 ha in HL_1, and 0.80 ha in HL_2 to 0.51 ha on account of less water availability. Sunflower, which requires less irrigation water, appeared with more acreage in this plan. Its area increased from 0.25 ha in HL_1 to 0.82 ha in HL_3.During *rabi*, the model suggested to reduce the area for paddy by 50 per cent over the previous model. Consequently, the area for green gram increased from 0.71 ha in HL_2 to 0.87 ha to HL_3. There was no change in the allocation of land for the production of cotton and chillies.

The cropping intensity remained the same as in the previous optimum models. The crop mix suggested by HL_3 enabled the farmers realize a net farm returns of Rs.1,06,544.

The results of optimum model HL_4 designed with 30 per cent decrease in the availability of irrigation water suggested to grow fewer crops compared to the previous plans. Sunflower (hybrid) emerged as the most significant enterprise with acreage of 1.30 ha occupying 53.50 per cent of the *kharif-*

irrigated land due to shortage of irrigation water availability. The remaining 46.50 per cent of *kharif*-irrigated land was allocated for the production of paddy (13.17 per cent), groundnut (16.46 per cent) and sugarcane (16.87 per cent). During *rabi*, 59.26 per cent of the land was occupied by greengram followed by chillies (12.35 per cent) and paddy (11.52 per cent). Sugarcane continued to occupy the same area as in *kharif.* Brinjal and cotton found in the existing as well as in the previous optimum plans were completely eliminated.

The cropping intensity was 200 per cent due to complete land use both in *kharif* and *rabi* season inspite of decline in the water availability by 30 per cent. The results of optimum model ML_4 revealed that it was possible for the large farmers in the head region to get a net farm income of Rs.1, 01,871.

The reorganization of resources with the existing irrigation water availability (MS_1) suggested to increase the area for paddy, groundnut and sugarcane from 0.18, 0.08 and 0.15 ha in the current plan to 0.48, 0.20 and 0.20 ha in optimum model MS_1 during *kharif.* As a result, the area under sunflower (morden) declined from 0.12 ha in the existing plan to 0.06 ha. Also, bajra and paddy (1001) found in the existing plan were eliminated.

The model recommended to allocate more land for cotton and chilies by eliminating cowpea, greengram and gingelly which were grown in the existing production programme. Consequently, the area under the production of cotton and chillies during *rabi* increased from 0.15 and 0.05 ha in the existing plan to 0.41 and 0.15 ha respectively. But the area for paddy declined from 0.32 ha in the existing plan to 0.18 ha. Sugarcane continued to occupy the same area as in *kharif* season.

The cropping intensity increased from 185.11 per cent in the existing plan to 200 per cent in model MS_1. The crop mix suggested by Model MS_1 helped in realization of Rs.46,868.55 as net farm returns.

The optimum model developed by decreasing 10 per cent of water supply resulted in the same cropping pattern as that of optimum plan MS_1 except decrease in the area of paddy from 0.48 ha in MS_1 to 0.37 ha and increase in the area of sunflower from 0.06 ha in MS_1 to 0.17 ha. There was no change in the area of groundnut (0.20 ha) and sugarcane (0.20) during *kharif* season. Cotton which occupied 0.41 ha in model MS_1 was completely eliminated from the plan, yielding its area to cowpea (0.26 ha) and greengram (0.10). There was a marginal increase in the area of paddy from 0.18 ha in MS_1 to 0.23 ha. However, chillies occupied the same acreage as in MS_1.

The cropping intensity remained the same as in model MS_1. The cropping pattern suggested by model MS_2 resulted in the realization of Rs.45,933.67 as net farm returns. The net farm returns were increased by Rs.14,216.91 over the existing plan.

The impact of 20 per cent decline in the water supply was anlaysed through model MS_3. This plan suggested to reduce the area of paddy and sugarcane from 0.37 and 0.20 ha in model MS_2 to 0.34 and 0.08 ha respectively during the *kharif* season due to scarcity of irrigation water. As a result, the area of sunflower almost doubled. The area under the production of groundnut remained the same as in the previous optimum plans. During *rabi*, the plan suggested to increase the area of greengram from 0.10 ha in MS_2 to 0.44 ha by completely eliminating cowpea, Which found in MS_2 with 0.26 ha. There was a slight increase in the area of paddy over MS_2. Chillies continued to occupy the same area as in the previous models.

The crop mix recommended by the model MS_3 enabled the small farmers of middle region to realize Rs.40,658.25 as net farm returns.

The optimum plan developed with 30 per cent decrease in the water availability (Model MS_4) included the same crops as in the previous model with changes in the allocation of land resource. The area for the production of sunflower was declined drastically from 0.32 ha in MS_3 to 0.09 ha, keeping 0.23 ha of *kharif* irrigated land fallow due to paucity of irrigation water. Also, the area of sugarcane was declined from 0.08 ha in MS_3 to 0.04 ha. The proportionate area under paddy increased from 36.17 per cent in MS_3 to 40.43 per cent in MS_4.About 56 per cent of the *rabi* irrigated land was occupied by greengram followed by paddy (23.40 per cent) and chillies (15.96 per cent).

The cropping intensity dropped from 200 per cent in the previous optimum plans to 175.53 per cent in MS_4 due to under use of 0.23 ha of *kharif* land. The net farm returns were higher by Rs.3,165.12 over the existing plan.

The optimum farm plan ML_1 developed for the large farmers of middle region suggested to increase the area under paddy (1009), groundnut and sugarcane from 0.53, 0.19 and 0.26 ha in the existing plan to 0.67, 0.60 and 0.60 ha respectively. The process of reallocation of land resource resulted in the decline of land use for sunflower (Hybrid) from 0.28 ha in the existing plan to 0.22 ha and the elimination of paddy (1001) and sunflower (morden variety).During *rabi*, the plan recommended to increase the area of cotton, chillies and cowpea from the present level of 0.58, 0.12 and 0.09 ha to 0.60, 0.40and 0.36 ha by eliminating greengram and gingelly and by drastically reducing area of paddy from 0.53 ha in the current plan to 0.13 ha. Sugarcane continued to occupy the same area as in *kharif.*

The cropping intensity increased from 177.51 per cent in the existing plan to 200 per cent due to complete utilization of land in both the season. The present income of Rs.71,489.29 had increased to Rs.99,199.60 indicating an increase of 38.76 per cent over the existing plan.

The optimum model ML_2 (10 per cent decrease in water availability) suggested almost the same cropping pattern as that model ML_1 during *kharif.* During *rabi*, paddy was favoured in 0.14 ha, maintaining the same area for chillies as in optimum plan ML_4. The plan indicated to reduce the area of cotton by 0.26 ha over the model ML_1 and completely eliminated cowpea. Consequently, greengram which did not enter the previous optimal plan appeared in this plan with 0.61 ha.

There is no change in the intensity of cropping between ML_1 and ML_2 but net farm returns declined from Rs.99,199.60 in optimum plan ML_1 to Rs.96,404 in optimum model ML_2.

The optimum model ML_3 recommended to reduce the area of paddy and sugarcane from 0.66 and 0.60 ha in model ML_2 to 0.55 and 0.40 ha due to decrease in the water availability by 20 per cent. As a result, the area under the production of sunflower increased from 0.23 ha in the optimum plan ML_2 to 0.54 ha. Groundnut maintained the same area as in previous optimum models.During *rabi,* the plan recommended the expansion of area from 0.61 ha in ML_2 to 1.04 ha for greengram. This plan did not favour the inclusion of cotton. The area under paddy showed an increase from 0.14 ha in the previous optimum plan to 0.25 ha. The plan also favoured the same area as in the previous optimum plans for chillies.The intensity of cropping was 200 per cent. This normative plan helped the large farmers of middle region to realize Rs.87,284.00 as net farm returns.

The optimum model ML_4 favoured the extension of area under sunflower from 0.54 ha in ML_3 to 0.88 ha, by reducing area of sugarcane to the extent of 0.29 ha over the ML_2. There was no change in the allocation of land for groundnut production and it remained the same as in the previous models. Half a hectare of land was allotted for paddy production during *kharif.* Sixty one per cent of the *rabi* irrigated land was occupied by greengram followed by chillies (19.4 per cent) and paddy (14.35 per cent) sugarcane occupied the same area as in *kharif.*

The reduction in the water availability by 30 per cent over the existing level did not result in under utilization of land resource either in *kharif* or *rabi.* Hence, the intensity of cropping remained the same as in the previous normative plans. The optimization plan resulted in the realization of Rs.36,873.03 as net farm income.

Model TS_1 included fewer activities compared to the existing plan. The plan suggested to increase the area of groundnut and brinjal from 0.12 and 0.05 ha in the existing plan to 0.36 and 0.40 ha in optimal plan TS_1 respectively during *kharif* season. As a result, land allotted for paddy declined from 0.58ha in the existing plan to 0.17 ha in the model TS_1. Also, sunflower was eliminated from the plan.

On *rabi* irrigated land, paddy, cotton and greengram occupied 0.23, 0.40 and 0.30 ha respectively. The area under cotton and greengram increased by 0.29 and 0.12 ha while that of paddy decreased by 0.19 ha respectively over the existing plan. The plan did not favour the inclusion of gingelly.

Due to complete utilization of land in both the seasons, the cropping intensity increased from 192.47 per cent in the existing plan to the maximum attainable level of 200 per cent in the model TS_1. The net farm returns were higher by Rs.13,674.28 over the existing plan.

Model TS_2 was designed at 10 per cent decrease in the water availability in both the seasons. In this plan, there was a marginal decline in the area for groundnut production, which was offset by increase in the area of paddy to the same extent. Paddy and groundnut occupied 0.23 and 0.30 ha respectively. Brinjal maintained the same area as in Model TS_1 on *kharif*-irrigated land. The allocation of land for *rabi* paddy declined from 0.23 and 0.17 ha while that of greengram increased from 0.30 and0.36 ha between models TS_1 and TS_2. Cotton occupied one acre of *rabi* irrigated land.The intensity of cropping remained the same as in model TS_1. The net farm returns increased from Rs.28,054.68 in the existing plan to Rs.41,406.22.

The optimum model TS_3 suggested crop activities similar to that of model TS_2 with slight decrease (0.05 ha) in the area for paddy and by the same extent of increase for the production of groundnut over the model TS_2 during *kharif*. Greengram, a predominant pulse crop of the study area occupied about 65 per cent of *rabi* irrigated area followed by paddy (23.66 per cent) and cotton (11.83 per cent). It is important to note that cotton area declined by 72.50 per cent over the previous optimum models. The plan did not exhibit any change in the intensity of cropping. The net farm returns were increased from Rs.28,054.68 in the existing plan to Rs.39,820.15.

The results of normative plan TS_4 recommended for the complete elimination of brinjal during *kharif* and cotton during *rabi* which were found not only in the existing plan but also in all the previous optimum plans. This might be due to scarcity of irrigation water. There was no much variation in the allotment of land resource for other crop activities except a significant increase in the area of groundnut from 0.35 ha in model TS_3 to 0.63 ha during *kharif* and an increase of 0.12 ha for the production of greengram during *rabi* over the model TS_3.The cropping intensity declined from 200 per cent in the previous optimum model to 188.17 per cent due to under utilization of *kharif* irrigated land 0.11 ha. However, the small farmers of tail region realized Rs.35,229.73 as net farm returns.

The optimum model TL_1 recommended to increase the area under paddy (1009), groundnut and brinjal from 0.52, 0.28 and 0.11 ha in the current production programme to 1.11, 0.60 and 0.30 ha respectively by eliminating paddy (1001) and sunflower during *kharif* season. On *rabi* irrigated land, paddy, cotton and greengram occupied 0.40 and 0.88 and 0.73 ha respectively indicating a decrease of 0.10 ha in the case of paddy and an increase of 0.52 and 0.35 ha under cotton and greengram respectively over the existing plan. The plan did not favour the inclusion of less remunerative gingelly crop. The process of optimization led to complete utilization of land in both the seasons and this resulted in the increase of cropping intensity from the 176.12 and 200 per cent. The production programme indicated by the model ML_1 helped the large farmers of tail region to realize Rs.70,713.59 as net farm returns exhibiting an increase of Rs.21,187.30 over the existing plan.

Model TL_2 suggested a different crop mix from that of model TL_1 by including sunflower (Hybrid) on 0.23 ha. As a result, the area under paddy declined by 20.72 per cent over the model TL_1. Groundnut and brinjal occupied the same area as in model TL_1 during the *kharif.* Greengram occupied more than 50 percent of *rabi* land followed by cotton (28.36 %) and paddy (19.90 %).The cropping intensity remained the same as in model ML_1. The net farm returns were increased by 36.56 per cent over the existing plan.

The normative plan TL_3 suggested to allocate the same extent of land resource as in the previous optimal plans for the production of groundnut and brinjal during *kharif* and paddy during *rabi*. However, it recommended increase in the area of sunflower (hybrid) by 0.23 ha while reducing the area of paddy by the same extent over the model TL_2 during *kharif.* Similarly during *rabi*, the area under cotton declined by 0.31 ha leading to increase in the area of greengram by the same magnitude over model TL_2.The cropping intensity was 200 per cent. The net farm returns increased from Rs.49,526.29 in the current plan to Rs.64,556.52 an increase of Rs.15,030.23.

The optimum model TL_4 indicated to keep 0.31 ha of *kharif* land and 0.09 ha of*rabi* land as fallow and this resulted in decline in the cropping intensity by 20 per cent over models ML_1, ML_2 and ML_3. This was due to shortage of water supply to the extent of 30 per cent over the existing water availability.

The model did not favour any alteration in the level of production of groundnut and brinjal during *kharif* and paddy during *rabi*. The area under paddy and sunflower declined from 0.65 ha and 0.46 ha in model TL_3 to 0.60 ha and 0.20 ha in model TL_4 respectively during *kharif*. Due to paucity of irrigation water, greengram a less water consuming crop occupied 75 per cent of the *rabi* land. The crop mix suggested by the model enabled the large farmers of tail region to realize Rs.57,897.70 as net farm returns.

A rational use of presently available resources would enable to realize a net farm income of Rs.50,963.47 and Rs.1,07,006 for small and large farmers respectively in the head region, Rs.46,868.55 and Rs.99,199.60 for small and large farmers respectively in the middle region and Rs.41,728.96 and Rs.70,713.59 for the above said categories of farmers in the tail region. This showed that the farmers were using their resources at sub optimality and there is scope for reorganizing the resources in order to enhance the net farm returns to the extent of 53.56 and 44.00, 47.77 and 38.76 and 48.74 and 42.78 among small and large farmers of head, middle and tail regions respectively.

Ten per cent decrease in the water supply facilitated for realization of Rs.49,957.13 and Rs.1,06,775.00, Rs.45,933.67 and Rs.96,404.00 and Rs.41, 406.22 and Rs.67,635.05 by the small and large farmers in the head, middle and tail regions respectively.

Twenty per cent decrease in water supply resulted in improvement in the net farm income by 46.42 and 43.38 per cent on the small and large farms of head region, 28.19 and 22.09 per cent on the small and large farms of middle region and 41.94 and 30.35 per cent on the small and large farms of tail regions respectively over the existing income.

Thirty per cent decrease in water supply helped to realize Rs.43,763.25 and Rs.1,01,871.00 by the small and large farms in the head region, Rs.34,881.88 and Rs 76,873.03 by the small and large farms of middle region and Rs.35,229.73 and Rs.57,897.70 on the small and large farmers in the tail region respectively.

The optimum plans of small and large farms of head, middle and tail regions with existing water availability indicated additional employment of male, female and bullock labour to the extent of 11.18 mandays, 10.74 womandays, 10.60 bullock pair days and Rs.42.58 mandays, 37.72 womandays, 8.02 bullock pair days, 16.40 mandays, 24.66 womandays, 2.61 bullock pair days and 37.88 mandays, 45.66 womandays and 7.56 bullock pair days and –1.26 mandays, 17.82 womandays and 2.48 bullock pair days and 23.16 mandays, 76.24 womandays and 6.62 bullock pair days respectively.

The net farm income was declined by 14.13 and 4.79 per cent in the optimum model developed at 30 per cent reduction in water supply on the small and large farms of head region over the net farm income realized in the optimum plan at existing water availability. The same was 25.58 and 22.51 per cent on small and large farms of middle region and 15.57 and 18.12 per cent on the aforesaid categories of farms of tail region respectively.

The normative plan designed at 30 per cent reduction in the water supply indicated decline in the labour use to the extent of 22.42 mandays, 30.44 womandays, 3.47 bullock pair days and 63.85 mandays, 72.59 womandays and 6.04 bullock pair days on the small and large farms respectively in the head region, 22.25 mandays, 29.17 womandays and 4.56 bullock pair days and 53.99 mandays, 26.27 womandays and 7.47 bullock pair days on the small and large farms respectively in the middle region and 14.67 mandays, 17.43 womandays and 3.91 bullock pair days and 33.81 mandays, 82.13 womandays and 7.39 bullock pair days on the above groups of farms in the tail region over the optimum plan with existing water availability.

The optimization models of small and large farms (except HS_4, MS_4, TS_4, TL_4) showed shadow prices for both *kharif* and *rabi* irrigated land indicating complete use of land resource.

The results of optimal plans indicated positive shadow prices for male, female, bullock labour, tractor service, FYM, N, P and K nutrients (Except male and bullock labour on small farms of the three regions).

All the normative plans also indicated positive shadow prices for irrigation water (except models TS_1, TS_2 and ML_1).

6.3 CONCLUSIONS

1. The present study revealed that farmers were operating their farms under conditions of sub-optimality. But the extent of mal-allocation of resources was relatively higher on the small farms compared to the large farms.

2. The optimum cropping patter involved fewer crops, thereby indicating the trend towards specialization. The process of optimization led to increase in the area under high valued crops and thus reducing the number of crops.

3. There is greater scope for increasing the net farm returns and the use of resource services and resources through systematic farm planning under the existing water supply and resource base on the farms of the three regions.

4. The sensitivity analysis with reduced availability of water by 10, 20 and 30 per cent level revealed that the farmers income could be increased over the existing plan if the normative plans are adopted.

5. The optimum plans developed at 30 per cent reduction in water availability indicated substantial decrease in net farm income, labour employment and material input use.

6. The scope for water resource development and use is encouraging as revealed through the MVP for irrigation water.

7. Farm planning as an extension tool could be popularized by the extension agencies to convince the farmers on the need for changing the crop mix in the command area.

8. Cash requirement decreased with the reduction in the water availability.

9. The shadow price of irrigation water was higher on small farms compared to large farms. This implies that additional hectare centimeter of irrigation water for small farmers would be more remunerative.

6.4 POLICY SUGGESTIONS

- The existing land use pattern in the Somasila Project command area is sub-optimal. In all the regions net income had increased in the optimal plans considerably over the existing plans. This suggests the need for popularization of optimum plans by extension agencies.
- In view of the findings that the small farmers are the least efficient allocators of resources. Thus the Department of Agricultural Personnel should orient towards educating the farmers in farm planning for efficient use of farm resources.
- Banks and Cooperative should take initiation in providing financial assistance to small farmers to absorb the surplus farm labour and animal labour to run subsidiary enterprises viz., sheep rearing, small dairy unit, small poultry unit which will augment the net farm income.

- SRI method of paddy cultivation may be suggested in the command area which could over take the problem of water scarcity.
- Warabhandi system of water allocation may be suggested with in the command area so that tail-ender will get equal irrigation water.
- Water user Association's have to be strengthened in the study area in order to have equal right on irrigation water irrespective of their size groups.

LITERATURE CITED

LITERATURE CITED[#]

Arora V P S and Prasad B 1978 Impact of optimal allocation of supervised production of credit on different farm size groups in agriculturally progressive area of Western Uttar Pradesh. Agricultural Situation in India 33(6): 369-371.

Bhatia H C and Gangwar A C 1980 Prospects of increasing income and employment through dairying on small farms. Indian Journal of Agricultural Economics 35(4):16.

Dangat S B and Patil R G 1985 Potential for increasing farm income, in dry farming areas through diversification. Indian Journal of Agricultural Economics 40(3):331

Deoghare P R, Sharma B N and Goel S K 1997 Impact of credit and technology on income and employment on small farms under different farming systems in Karnal district, Haryana. Agricultural Situation in India 46 (2): 65-70.

Desai D K 1960 Linear programming applied to problems of Indian agriculture. Indian Journal of Agricultural Economics 15(2): 59-65.

Desai D K 1962 Budgeting and programming in Management. Indian Journal of Agricultural Economics 17(1): 196 –205.

Dhawan K C, Khattra P S and Brar S S 1997 Impact of fruit cultivation on general crops and milk production in Punjab. Indian Journal of Agricultural Economics 52(3):650.

Elumalai G 1982 A strategy for irrigation Water Management Under Major Irrigation system. A Micro-level study. Wamana 2(2): 1-7.

Eswaramoorthy 1980 Allocation of Irrigation water among various periods and crop areas in Lower Bhavani Project command area, Tamil Nadu, M.Sc. Thesis, Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi.

Gajanana T M and Sharma B M 1990 Income and employment prospects of drought prone farmers - Role of credit and technology. Agricultural Situation in India 45 (5): 307-312.

[#] **As per the guidelines of Acharya N.G.Ranga Agricultural University thesis writing manual**

Ganesan K R 1982 Use of irrigation water in Parambikulam. M.Sc (Ag.) Thesis, Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore.

Gangwar A C and Ghakar R K 1975 Can small farmers yield more income. Indian Journal of Agricultural Economics 30(3) :172-181.

Gogoi J K and Bhowmick B C 1990 A study of resource allocation in farms of flood-prone and flood-free areas in Sibsagar sub-division of Assam. Assam Agricultural University, Jorhat. Agricultural Economics Research Review 3(1 & 2) :68.

Goswamy S N 1997 Economic appraisal of indigenous farming systems of West Garo hills district of Meghalaya. Indian Journal of Agricultural Economics 52 (2): 252-259.

Goswamy S N and Meenakshi Sundaram V 1992 Prospects of increasing farm income in traditional hill farms of West Garo hills district Meghalaya. Indian Journal of Agricultural Economics 47(2): 247-254.

Gracy C P 1987 Optimum cropping pattern for farmers in Bangalore north taluk of Karnataka – An application of parametric linear programming. Ph.D. thesis, University of Agricultural Sciences, Bangalore.

Hiremath K C and Sirohi A S 1980 Temporal and Spatial Allocation of Irrigation Water in the Krishnaraja Sagar Project (Mysore State). Studies in Economics in Irrigation, Division of Agricultural Economics. Indian Agricultural Research Institute, Research Bulletin No.32, pp: 31-57.

Jahagirdar S. W. Marawar S. S and Kakde S. J. 1997 Demand for credit in agriculture-A parametric linear programming approach. Financing Agriculture 29 (3) :17-19.

Jain S K and Ikbal Singh 1993 Prospects of increasing income and employment through edible oil seeds production in Gurgaon district of Haryana. Indian Journal of Agricultural Economics 68(3) : 418.

Johl S S and Kahlon A S 1963 Economics of cropping pattern – An analytical case study. Indian Journal of Agricultural Economics. 18(1) :132-142.

Kahlon A S and Johl S S 1962 Application of budgeting and linear programming in farm management analysis. Indian Journal of Agricultural Economics 17 (1): 235-241.

Kanade D B, Suryawanshi S N and Dangat S B 1989 Optimisation of irrigation water in Mula command area. Indian Journal of Agricultural Economics 44(3): 268.

* Kausik C R and Gangwar A G 1980 Optimum Utilisation of Irrigation Water on farms of Jui Lift canal area of Haryana State. Department of Agricultural Economics, Haryana Agricultural University. Research Bulletin No.6 pp: 1-10.

Kesava Reddy T R 1979 Optimum crop and dairy mix for farmers in Bangalore district Karnataka M. Sc (Ag) Thesis, University of Agricultural Sciences, Bangalore.

Kiresur VR, Gaddi G M, Gummagolnath KC, Wadear R R and Kulkarni V S (2004) Optimum plans for sustainable farming systems in Northern Eastern Dry zone in Karnataka. A linear programming approach. The Bihar Journal of Agricultural Marketing 12(1): 16-27.

* Lakshminarayana V and Rajagopalan S P 1977 Optimal Cropping Pattern for Bari Basin. Indian Journal of Irrigation and Drainage Division 103 (IRI) pp: 53-70.

Lathar R K, Pandey R N and Goyal S K1996 Diversification of enhancing the income on marginal and small farms in Haryana. Indian Journal of Agricultural Economics 54 (4): 697.

Meenakshi Malya 1962 Linear programming and farm planning. Indian Journal of Agricultural Economics 17 (1): 206 –211.

Mruthyanjaya and Sirohi A S 1979 Enterprise systems for stability and growth on drought prone farms – An application of parametric linear programming. Indian Journal of Agricultural Economics 34 (1): 27–42.

Nadda A L, Sharma L R, Bhadauria V S and Swarna R 1978 Optimizing Crop Production patterns in different agro- climatic zones of Himachal Pradesh. Indian Journal of Agricultural Economics 33 (4): 23–28.

Nagaraja G N and Venkataram J V 1983 An optimum cropping pattern and its impact of net farm returns in Daddaballapur taluk, Bangalore district of Karnataka – An application of linear programming technique. Agricultural Banker 6 (2): 16 – 18.

Nanja Reddy C 1980 Income and employment potential of small farmers in Channapatna block, Bangalore district of Karnataka. Ph.D. Thesis, University of Agricultural Sciences, Bangalore.

Palanisami K 1980 Pattern of allocation use and management of irrigation water in Lower Bhavani Project, Coimbatore district, Tamil Nadu. Ph.D. Dissertation, Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore pp: 97-99.

Parasurama Reddy G, Venkatram J V and Nagaraja G N 1989 An optimum resource use pattern and credit requirement for the beneficiaries of Upper Krishna Project Command Area of Karnataka. Financing Agriculture 21(4): 25.

Prasad D S 2004 Optimum herd size, income and employment potential of common buffalo breeds in Ranga Reddy district of Andhra Pradesh. Indian Journal of Agricultural Economics 59(2): 268-276.

Radhey Shyam, Chauhan HS and Sharma J S 1994 Optimal operation scheduling model for a canal system. Agricultural Water Management. 26(3): 213-225.

Ramakrishnaiah and Sastry T V N 1998 An optimum crop and livestock pattern for farmers in Nandyal mandal of Kurnool district, Andhra Pradesh. M.Sc(Ag)Thesis, Acharya N.G.Ranga Agricultural University, Hyderabad .

Ramanna R 1996 Productivity of resources and income potential on subsistence and commercially oriented farms in Bangalore district. Ph.D Thesis, Post Graduate School, IARI, New Delhi.

Randhawa N S and Heady E O 1966 Spatial programming of production for agricultural development in India. Indian Journal of Agricultural Economics 21(3): 14-22.

Rao D S 1997 Optimal management of land, water and nutrient resources in rainfed agriculture: Some technological options. Journal of Agricultural Economics 52(3):559.

Saini A S, Sharma K D, Pant K P and Thakur D R 1998 Energy management for sustainable Hill Agriculture : A case of Himachal Pradesh, Indian Journal of Agricultural Economics 53(3):223-240.

Saini A S, Sharma K D and Binaykanth Singh 1996 Impact of diversification on small farms economy in Himachal Pradesh. Indian Journal of Agricultural Economics 51(4): 697.

Sastry T V N and Venkataram J V 1993 Optimum enterprise system for farmers in Chittoor district of Andhra Pradesh, Ph.D Thesis, University of Agricultural Sciences, Bangalore.

* Satpue T B 1988 Irrigation Management in Common Area A study of Jayakwadi Irrigation Project, Mittal Publication New Delhi.

Selvarajan S 1986 Water use planning in Amaravathi Rivar Basin, Ph.D Thesis, Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore.

Selvarajan S and Subramanian S R 1981 Economic impact of resource use optimization and water augmentation in farms of Parambikulam Aliyar Project region, Indian Journal of Agricultural Economics 36(1): 89-101.

Shareef S M and Krishna Murthy S 2001 Optimum plans for increasing income, employment and water use at farm level in three regions of K.C Canal Irrigation system in Andhra Pradesh. Agricultural Situation in India 57 (11) : 603-610.

Sharma B M, Puranchand and Vasisht A K 1996 Role of diversification in eradication of farm poverty; A case study of Alwar district of Rajasthan State. Indian Journal of Agricultural Economics 57 (4):707–708.

Singh A K and Sharma J S 1988 Income and Employment increasing possibilities under different farming systems on all farms in Mid-Western Region of Uttar Pradesh. Agricultural Situation in India 43(1): 17-24.

Singh and Chaurasia S P R 1990 Possibilities of Increasing Income and employment through progressive farming practices on vegetable farms in Deoria, Uttar Pradesh. Indian Journal of Agricultural Economics 23(3): 1-14.

Singh Ikbal and Subbarayan M 1986 Optimal use of energy inputs on different size groups of farms in Meerut district of Uttar Pradesh. Indian Journal of Agricultural Economics 41 (1): 86-92.

Singh R and Saini A S 1988 Integration of improved technology of crops and milk production for income and employment. Agricultural Situation in India 43 (9) : 751-755.

Singh R D, Varma R K and Singh L R 1972 Production possibilities and resources use pattern on small farmers – A comprehensive study in three regions of Uttar Pradesh. Indian Journal of Agricultural Economics 27 (4): 126-136.

Singh R I, Singh G N and Singh R K 1977 Economics of milk production farms in Aligarh district of Uttar Pradesh - A case study. Indian Journal of Agricultural Economics, 30 (3): 148-149

Singh R K 1970 Optimal resource allocation among crop and dairy enterprises on farms of Eathah district of Uttar Pradesh. Ph.D Thesis, IARI, New Delhi.

Sirohi A S and Gangawar A C 1968 Economic Optima in resource allocation for the cultivators of Kenjawala block. Indian Journal of Agricultural Economics 23(3):1-14.

Sirohi A S, Sharma B M, Ikbal Singh and Rajeswar Dayal 1980 Role of Dairy enterprise and poultry enterprises for increasing income and employment on farms in the Union Territory of Delhi. Indian Journal of Agricultural Economics 35 (4) 112-119.

Sree Lakshimi K and Sastry T V N 1995 Optimum Enterprise system for farmers in Chandragiri Mandal of Chittoor (unpublished) Andhra Pradesh Agricultural University, Hyderabad

Subbarayan M and Singh I 1989 Optimal use of irrigation water resource in the eastern Yamuna canal command in western Uttar Pradesh. Indian Journal of Agricultural Economics 44(3): 267.

Suresh N and Subbareddy S 2002 An economic study of efficient use of irrigation water under Tambaraparani command area of Tamil Nadu. M.SC (Ag) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Thorve P V and Galgalikar V D 1985 Economics of diversification of farming with dairy enterprise. Indian Journal of Agricultural Economics 40(3): 317-323.

Tilekar S N and Nimbalkar CA 2000 Optimization of farm income in and outside Mula Irrigation command area; use of Linear Programming Technique, Journal of Maharashtra Agricultural University 25(3): 284-288.

Tilekar S N and Nimbalkar CA 2000 Potential for increasing the farm income in Mula Command area (Ahmednagar); An application of Linear programming technique. Journal of Maharashtra Agricultural Universities 25(2): 191-195.

Ushasri D, Seetharaman S and Raghuram P 1994 Maximisation of farm income and employment resource use plan for an integrated rice-based farming system in rural areas of Krishna district of coastal Andhra. Land Bank Journal 32(4): 11-17.

Venkatram J V 1975 Effects of external finance on farm returns in Mandya district of Karnataka. Financing Agriculture 7(1): 110-113.

Vijaya Kumar H S 1976 Credit requirements and its impact on irrigated and unirrigated farms in Bangalore south taluk. M.Sc Thesis, University of Agricultural Sciences, Bangalore.

---

* original not seen

APPENDICES

Notations used in the Initial Tableau
(Input-Output Matrix)

Row Symbols

KILD	:	*Kharif* Irrigated Land
RILD	:	*Rabi* Irrigated Land
MLRK	:	Men Labour Required In *Kharif*
WLRK	:	Women Labour Required In *Kharif*
BLRK	:	Bullock Labour Required In *Kharif*
TPRK	:	Tractor Power Required In *Kharif*
NFRK	:	Nitrogen Fertilizer Required In *Kharif*
PFRK	:	Phosphatic Fertilizer Required In *Kharif*
KFRK	:	Potassic Fertilizer Required In *Kharif*
FYMK	:	Farm Yard Mannure Required in *Kharif*
IWRK	:	Irrigation Water Requirement in *Kharif*
MLRR	:	Men Labour Required In *Rabi*
WLRR	:	Women Labour Required In *Rabi*
BLRR	:	Bullock Labour Required In *Rabi*
TPRR	:	Tractor Power Required In *Rabi*
NFRK	:	Nitrogen Fertilizer Required In *Rabi*
PFRK	:	Phosphatic Fertilizer Required In *Rabi*
KFRK	:	Potassic Fertilizer Required In *Rabi*
FYMK	:	Farm Yard Mannure Required in *Rabi*
IWRK	:	Irrigation Water Requirement in *Rabi*
KPA_1Y	:	*Kharif* Paddy Yield (1001)
KPA_9Y	:	*Kharif* Paddy Yield (1009)
KSMY	:	Kharif Sunflower (Morden) Yield

KSHY	:	Kharif Sunflower (Hybrid) Yield
KGJY	:	*Kharif* Groundnut (JL-24) Yield
KBJY	:	*Kharif* Bajra Yield
KSCY	:	*Kharif* Sugarcane (092) Yield
KBRY	:	*Kharif* Brinjal Yield
RPAY	:	*Rabi* Paddy Yield
RCOY	:	*Rabi* Cotton Yield
RCHY	:	*Rabi* Chilli Yield
RCPY	:	*Rabi* Cowpea Yield
RGGY	:	*Rabi* Greengram Yield
RGIY	:	*Rabi* Gingelly Yield
CASK	:	Cash Availability In *Kharif*
CASR	:	Cash Availability In *Rabi*
BORK	:	Borrowing In *Kharif*
DEMK	:	Debt Management In *Kharif*
DEMR	:	Debt Management In *Rabi*
MIPA	:	Minimum Land Under Paddy
MSUC	:	Maximum Land Under Sugarcane
MGNT	:	Maximum Land Under Groundnut
MBRI	:	Maximum Land Under Brinjal
MCHI	:	Maximum Land Under Chillies
MCOT	:	Maximum Land Under Cotton
Z	:	Objective Function

Column Symbols

KPA_1D	:	*Kharif* Paddy (1001)
KPA_9D	:	*Kharif* Paddy (1009)
KSFM	:	Kharif Sunflower (Morden)
KSFH	:	Kharif Sunflower (Hybrid)
KGNJ	:	*Kharif* Groundnut (JL-24)
KBAJ	:	*Kharif* Bajra
KSUC	:	*Kharif* Sugarcane (092)
KBRI	:	*Kharif* Brinjal
RPAD	:	*Rabi* Paddy
RCOT	:	*Rabi* Cotton
RCHI	:	*Rabi* Chilli
RCOW	:	*Rabi* Cowpea
RGRG	:	*Rabi* Greengram
RGIN	:	*Rabi* Gingelly
HMLK	:	Hired Men Labour In *Kharif*
HWLK	:	Hired Women Labour In *Kharif*
HBLK	:	Hired Bullock Labour In *Kharif*
HTPK	:	Hired Tractor Labour In *Kharif*
PNFK	:	Purchase of Nitrogen Fertilizer In *Kharif*
PPFK	:	Purchase of Phosphatic Fertilizer In *Kharif*
PKFK	:	Purchase of Potassic Fertilizer In *Kharif*
PFMK	:	Purchase of Farm Yard Manure In *Kharif*
HMLR	:	Hired Men Labour In *Rabi*
HWLR	:	Hired Women Labour In *Rabi*
HBLR	:	Hired Bullock Labour In *Rabi*

HTPR	:	Hired Tractor Labour In *Rabi*
PNFR	:	Purchase of Nitrogen Fertilizer In *Rabi*
PPFR	:	Purchase of Phosphatic Fertilizer In *Rabi*
PKFR	:	Purchase of Potassic Fertilizer In *Rabi*
PFMR	:	Purchase of Farm Yard Manure In *Rabi*
SKP_1A	:	Sale of *Kharif* Paddy
SKP_9A	:	Sale of *Kharif* Paddy
SKSM	:	Sale of Kharif Sunflower (Morden)
SKSH	:	Sale of Kharif Sunflower (Hybrid)
SKGN	:	Sale of *Kharif* Groundnut (JL-24)
SKBJ	:	Sale of *Kharif* Bajra
SKSC	:	Sale of *Kharif* Sugarcane (092)
SKBR	:	Sale of *Kharif* Brinjal
SRPS	:	Sale of *Rabi* Paddy
SRCO	:	Sale of *Rabi* Cotton
SRCH	:	Sale of *Rabi* Chilli
SRCP	:	Sale of *Rabi* Cowpea
SRGG	:	Sale of *Rabi* Greengram
SRGI	:	Sale of *Rabi* Gingelly
BORK	:	Borrowing of Credit in *Kharif*
RKLR	:	Repayment of *Kharif* loan in *Rabi*
RKLZ	:	Repayment of *Khairf* loan at end
KCTR	:	Kharif Cash Transfer to *Rabi*
RCTZ	:	*Rabi* Cash Transfer to Objective Function

INPUT-OUTPUT MATRIX OF SMALL FARMERS - HEAD REGION (Page 1 of 6)

	KPA1D	KPA9D	KSFM	KGNJ	KBAJ	KSUC	KBRI	RPAD
KILD	1	1	1	1	1	1	1	
RILD						1		1
MLRK	55	58	20	35	30	50	60	
WLRK	80	87	42	80	35	20	63	
BLRK	8	7	4	9	6	3	7	
TPRK	7	9	7	6	2		5	
FYMK	45	40	35	60	30		150	
NFRK	80	80	53	52	45	60	70	
PFRK	58	58	0	40	18	35	60	
KFRK	38	38	28	42	0	25	32	
IWRK	125	125	45	45	40	100	55	
MLRR						63		56
WLRR						42		79
BLRR						7		9
TPRR						4		8
FYMR						180		60
NFRR						100		86
PFRR						80		58
KFRR						50		38
IWRR						100		150
KPA_1Y	-56							
KPA_9Y		-58						
KSMY			-14					
KGNY				-23				
KBJY					-25			
KSCY						-100		
KBRY							-100	
RPAY								-54
RCOY								
RCHY								
RCPY								
RGGY								
RGIY								
CASK	2800	2880	1600	7300	1000	4000	4500	
CASR						8000		2800
BORK								
DEMK								
DEMR								
MIPA	1	1						1
MSUC						1		
MCHI								
MBRI							1	
MCOT								
MGNT				1				
Z								

INPUT-OUTPUT MATRIX OF SMALL FARMERS - HEAD REGION (Page 2 of 6)

	RCOT	RCHI	RCOW	RGRG	RGIN	HMLK	HWLK	HBLK	HTPK
KILD									
RILD	1	1	1	1	1				
MLRK						-1			
WLRK							-1		
BLRK								-1	
TPRK									-1
FYMK									
NFRK									
PFRK									
KFRK									
IWRK									
MLRR	18	88	37	10	24				
WLRR	106	102	82	48	69				
BLRR	11	8	3	4	2				
TPRR	3	7	3	4	5				
FYMR	0	80	0	0	40				
NFRR	70	76	28	32	58				
PFRR	0	46	21	31	0				
KFRR	14	20	0	0	15				
IWRR	70	60	40	25	25				
KPA$_1$Y									
KPA$_9$Y									
KSMY									
KGNY									
KBJY									
KSCY									
KBRY									
RPAY									
RCOY	-13								
RCHY		-18							
RCPY			-13						
RGGY				-12					
RGIY					-8				
CASK						45	25	120	250
CASR	1000	9000	1200	1000	1000				
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MCHI		1							
MBRI									
MCOT	1								
MGNT									
Z									

INPUT-OUTPUT MATRIX OF SMALL FARMERS - HEAD REGION (Page 3 of 6)

	PFMK	PNFK	PPFK	PKFK	HMLR	HWLR	HBLR	HTPR	PFMR
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK	-1								
NFRK		-1							
PFRK			-1						
KFRK				-1					
IWRK									
MLRR					-1				
WLRR						-1			
BLRR							-1		
TPRR								-1	
FYMR									-1
NFRR									
PFRR									
KFRR									
IWRR									
KPA_1Y									
KPA_9Y									
KSMY									
KGNY									
KBJY									
KSCY									
KBRY									
RPAY									
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK	25	11	15	9					
CASR					45	25	120	250	25
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MCHI									
MBRI									
MCOT									
MGNT									
Z									

INPUT-OUTPUT MATRIX OF SMALL FARMERS - HEAD REGION (Page 4 of 6)

	PNFR	PPFR	PKFR	SKP1A	SKP9A	SKSM	SKGN	SKBJ	SKSC
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK									
NFRK									
PFRK									
KFRK									
IWRK									
MLRR									
WLRR									
BLRR									
TPRR									
FYMR									
NFRR	-1								
PFRR		-1							
KFRR			-1						
IWRR									
KPA_1Y				1					
KPA_9Y					1				
KSMY						1			
KGNY							1		
KBJY								1	
KSCY									1
KBRY									
RPAY									
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK									
CASR	11	15	9	-540	-565	-1570	-1816	-600	
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MCHI									
MBRI									
MCOT									
MGNT									
Z									925

INPUT-OUTPUT MATRIX OF SMALL FARMERS - HEAD REGION (Page 5 of 6)

	SKBR	SRPS	SRCO	SRCH	SRCP	SRGG	SRGI	BORK	RKLR
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK									
NFRK									
PFRK									
KFRK									
IWRK									
MLRR									
WLRR									
BLRR									
TPRR									
FYMR									
NFRR									
PFRR									
KFRR									
IWRR									
KPA_1Y									
KPA_9Y									
KSMY									
KGNY									
KBJY									
KSCY									
KBRY	1								
RPAY		1							
RCOY			1						
RCHY				1					
RCPY					1				
RGGY						1			
RGIY							1		
CASK								-1	
CASR	-350								1.04
BORK								1	
DEMK								-1	1
DEMR								-1	1
MIPA									
MSUC									
MCHI									
MBRI									
MCOT									
MGNT									
Z		550	1800	2300	1400	1600	2400		

INPUT-OUTPUT MATRIX OF SMALL FARMERS - HEAD REGION (Page 6 of 6)

	RKLZ	KCTR	RCTZ	SIGN	COEF
KILD				<=	0.98
RILD				<=	0.98
MLRK				<=	50
WLRK				<=	60
BLRK				<=	30
TPRK				<=	0
FYMK				<=	30
NFRK				<=	0
PFRK				<=	0
KFRK				<=	0
IWRK				<=	90
MLRR				<=	50
WLRR				<=	60
BLRR				<=	30
TPRR				<=	0
FYMR				<=	30
NFRR				<=	0
PFRR				<=	0
KFRR				<=	0
IWRR				<=	90
KPA_1Y				<=	0
KPA_9Y				<=	0
KSMY				<=	0
KGNY				<=	0
KBJY				<=	0
KSCY				<=	0
KBRY				<=	0
RPAY				<=	0
RCOY				<=	0
RCHY				<=	0
RCPY				<=	0
RGGY				<=	0
RGIY				<=	0
CASK		1		<=	2500
CASR		-1	1	=	0
BORK				>=	0
DEMK				=	0
DEMR	1			=	0
MIPA				>=	0.4
MSUC				<=	0.2
MCHI				<=	0.1
MBRI				<=	0.1
MCOT				<=	0.25
MGNT				<=	0.2
Z	-1.08		1		

SMALL FARMERS - HEAD REGION - (HS_1)

```
MAX   925 X35 + 550 X37 + 1800 X38 + 2300 X39 + 1400 X40 + 1600 X41+ 2400 X42 - 1.08 X45
        + X47
SUBJECT TO
  2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 <=  .98
  3)  X6 + X8 + X9 + X10 + X11 + X12 + X13 <=  .98
  4)  55 X1 + 58 X2 + 20 X3 + 35 X4 + 30 X5 + 50 X6 + 60 X7 - X14 <=  50
  5)  80 X1 + 87 X2 + 42 X3 + 80 X4 + 35 X5 + 20 X6 + 63 X7 - X15  <=  60
  6)  8 X1 + 7 X2 + 4 X3 + 9 X4 + 6 X5 + 3 X6 + 7 X7 - X16 <=  30
  7)  7 X1 + 9 X2 + 7 X3 + 6 X4 + 2 X5 + 5 X7 - X17 <=  0
  8)  45 X1 + 40 X2 + 35 X3 + 60 X4 + 30 X5 + 150 X7 - X18 <=  30
  9)  80 X1 + 80 X2 + 53 X3 + 52 X4 + 45 X5 + 60 X6 + 70 X7 - X19  <=  0
 10)  58 X1 + 58 X2 + 40 X4 + 18 X5 + 35 X6 + 60 X7 - X20 <=  0
11)  38 X1 + 38 X2 + 28 X3 + 42 X4 + 25 X6 + 32 X7 - X21 <=  0
12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 + 55 X7   <=  90
13)  63 X6 + 56 X8 + 18 X9 + 88 X10 + 37 X11 + 10 X12 + 24 X13 -  X22 <=  50
14)  42 X6 + 79 X8 + 106 X9 + 102 X10 + 82 X11 + 48 X12 + 69 X13 - X23 <=  60
15)  7 X6 + 9 X8 + 11 X9 + 8 X10 + 3 X11 + 4 X12 + 2 X13 - X24 <=  30
16)  4 X6 + 8 X8 + 3 X9 + 7 X10 + 3 X11 + 4 X12 + 5 X13 - X25 <=  0
17)  180 X6 + 60 X8 + 80 X10 + 40 X13 - X26 <=  30
18)  100 X6 + 86 X8 + 70 X9 + 76 X10 + 28 X11 + 32 X12 + 58 X13 -     X27<=  0
19)  80 X6 + 58 X8 + 46 X10 + 21 X11 + 31 X12 - X28 <=  0
20)  50 X6 + 38 X8 + 14 X9 + 20 X10 + 15 X13 - X29 <=  0
21)  100 X6 + 150 X8 + 70 X9 + 60 X10 + 40 X11 + 25 X12 + 25 X13   <=  90
   22) - 56 X1 + X30 <=  0
   23) - 58 X2 + X31 <=  0
   24) - 14 X3 + X32 <=  0
   25) - 23 X4 + X33 <=  0
   26) - 25 X5 + X34 <=  0
   27)  X35 - 100 X6 <=  0
   28) - 100 X7 + X36 <=  0
   29)  X37 - 54 X8 <=  0
   30)  X38 - 13 X9 <=  0
   31)  X39 - 18 X10 <=  0
   32)  X40 - 13 X11 <=  0
   33)  X41 - 12 X12 <=  0
   34)  X42 - 8 X13 <=  0
   35)  2800 X1 + 2880 X2 + 1600 X3 + 7300 X4 + 1000 X5 + 4000 X6 + 4500 X7 + 45 X14 + 25
        X15 + 120 X16 + 250 X17 + 25 X18 + 11 X19+ 15 X20 + 9 X21 - X43 + X46 <=  2500
   36)  X47 + 8000 X6 + 2800 X8 + 1000 X9 + 9000 X10 + 1200 X11 + 1000 X12 + 1000 X13  +
        45 X22 + 25 X23 + 120 X24 + 250 X25 +25 X26+ 11 X27 + 15 X28 + 9 X29 - 540 X30 -
        565 X31 - 1570 X32- 1816 X33- 600 X34 - 350 X36 - X46 + 1.04 X44 = 0
   37)  X43 >=  0
   38) - X43 + X44 =   0
   39)  X45 - X43 + X44 =   0
   40)  X1 + X2 + X8 >=  .4
   41)  X6 <=  .2
   42)  X10 <=  .1
   43)  X7 <=  .1
   44)  X9 <=  .25
   45)  X4 <=  .2
END
```

SMALL FARMERS - HEAD REGION - (HS_2)

```
MAX   925 X35 + 550 X37 + 1800 X38 + 2300 X39 + 1400 X40 + 1600 X41+ 2400 X42 - 1.08 X45
       + X47
SUBJECT TO
     2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 <=   .98
     3)  X6 + X8 + X9 + X10 + X11 + X12 + X13 <=   .98
     4)  55 X1 + 58 X2 + 20 X3 + 35 X4 + 30 X5 + 50 X6 + 60 X7 - X14 <=   50
     5)  80 X1 + 87 X2 + 42 X3 + 80 X4 + 35 X5 + 20 X6 + 63 X7 - X15 <=   60
     6)  8 X1 + 7 X2 + 4 X3 + 9 X4 + 6 X5 + 3 X6 + 7 X7 - X16 <=   30
     7)  7 X1 + 9 X2 + 7 X3 + 6 X4 + 2 X5 + 5 X7 - X17 <=   0
     8)  45 X1 + 40 X2 + 35 X3 + 60 X4 + 30 X5 + 150 X7 - X18 <=   30
     9)  80 X1 + 80 X2 + 53 X3 + 52 X4 + 45 X5 + 60 X6 + 70 X7 - X19 <=   0
    10)  58 X1 + 58 X2 + 40 X4 + 18 X5 + 35 X6 + 60 X7 - X20 <=   0
    11)  38 X1 + 38 X2 + 28 X3 + 42 X4 + 25 X6 + 32 X7 - X21 <=   0
    12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 + 55 X7 <=   81
    13)  63 X6 + 56 X8 + 18 X9 + 88 X10 + 37 X11 + 10 X12 + 24 X13 - X22 <=   50
    14)  42 X6 + 79 X8 + 106 X9 + 102 X10 + 82 X11 + 48 X12 + 69 X13- X23 <=   60
    15)  7 X6 + 9 X8 + 11 X9 + 8 X10 + 3 X11 + 4 X12 + 2 X13 - X24 <=   30
    16)  4 X6 + 8 X8 + 3 X9 + 7 X10 + 3 X11 + 4 X12 + 5 X13 - X25  <=   0
    17)  180 X6 + 60 X8 + 80 X10 + 40 X13 - X26 <=   30
    18)  100 X6 + 86 X8 + 70 X9 + 76 X10 + 28 X11 + 32 X12 + 58 X13 - X27 <=   0
    19)  80 X6 + 58 X8 + 46 X10 + 21 X11 + 31 X12 - X28 <=   0
    20)  50 X6 + 38 X8 + 14 X9 + 20 X10 + 15 X13 - X29 <=   0
    21)  100 X6 + 150 X8 + 70 X9 + 60 X10 + 40 X11 + 25 X12 + 25 X13 <=   81
    22) - 56 X1 + X30 <=   0
    23) - 58 X2 + X31 <=   0
    24) - 14 X3 + X32 <=   0
    25) - 23 X4 + X33 <=   0
    26) - 25 X5 + X34 <=   0
    27)  X35 - 100 X6 <=   0
    28) - 100 X7 + X36 <=   0
    29)  X37 - 54 X8 <=   0
    30)  X38 - 13 X9 <=   0
    31)  X39 - 18 X10 <=   0
    32)  X40 - 13 X11 <=   0
    33)  X41 - 12 X12 <=   0
    34)  X42 - 8 X13 <=   0
    35)  2800 X1 + 2880 X2 + 1600 X3 + 7300 X4 + 1000 X5 + 4000 X6 + 4500 X7 + 45 X14 + 25
         X15 + 120 X16 + 250 X17 + 25 X18 + 11 X19 + 15 X20 + 9 X21 - X43 + X46 <=   2500
    36)  X47 + 8000 X6 + 2800 X8 + 1000 X9 + 9000 X10 + 1200 X11 + 1000 X12 + 1000 X13 + 45
         X22 + 25 X23 + 120 X24 + 250 X25 + 25 X26 + 11 X27 + 15 X28 + 9 X29 - 540 X30 - 565
         X31 - 1570 X32 - 1816 X33 - 600 X34 - 350 X36 - X46 + 1.04 X44        =    0
    37)  X43 >=   0
    38) - X43 + X44 =    0
    39)  X45 - X43 + X44 =    0
    40)  X1 + X2 + X8 >=   .4
    41)  X6 <=   .2
    42)  X10 <=   .1
    43)  X7 <=   .1
    44)  X9 <=   .25
    45)  X4 <=   .2
  END
```

SMALL FARMERS - HEAD REGION - (HS_3)

```
MAX  925 X35 + 550 X37 + 1800 X38 + 2300 X39 + 1400 X40 + 1600 X41 + 2400 X42 - 1.08 X45
      + X47
SUBJECT TO
   2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 <=  .98
   3)  X6 + X8 + X9 + X10 + X11 + X12 + X13 <=  .98
   4)  55 X1 + 58 X2 + 20 X3 + 35 X4 + 30 X5 + 50 X6 + 60 X7 - X14 <=  50
   5)  80 X1 + 87 X2 + 42 X3 + 80 X4 + 35 X5 + 20 X6 + 63 X7 - X15 <=  60
   6)  8 X1 + 7 X2 + 4 X3 + 9 X4 + 6 X5 + 3 X6 + 7 X7 - X16 <=  30
   7)  7 X1 + 9 X2 + 7 X3 + 6 X4 + 2 X5 + 5 X7 - X17 <=  0
   8)  45 X1 + 40 X2 + 35 X3 + 60 X4 + 30 X5 + 150 X7 - X18 <=  30
   9)  80 X1 + 80 X2 + 53 X3 + 52 X4 + 45 X5 + 60 X6 + 70 X7 - X19 <=  0
  10)  58 X1 + 58 X2 + 40 X4 + 18 X5 + 35 X6 + 60 X7 - X20 <=  0
  11)  38 X1 + 38 X2 + 28 X3 + 42 X4 + 25 X6 + 32 X7 - X21 <=  0
  12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 + 55 X7 <=  72
  13)  63 X6 + 56 X8 + 18 X9 + 88 X10 + 37 X11 + 10 X12 + 24 X13 - X22 <=  50
  14)  42 X6 + 79 X8 + 106 X9 + 102 X10 + 82 X11 + 48 X12 + 69 X13- X23 <=  60
  15)  7 X6 + 9 X8 + 11 X9 + 8 X10 + 3 X11 + 4 X12 + 2 X13 - X24 <=  30
  16)  4 X6 + 8 X8 + 3 X9 + 7 X10 + 3 X11 + 4 X12 + 5 X13 - X25 <=  0
  17)  180 X6 + 60 X8 + 80 X10 + 40 X13 - X26 <=  30
  18)  100 X6 + 86 X8 + 70 X9 + 76 X10 + 28 X11 + 32 X12 + 58 X13-  X27 <=  0
  19)  80 X6 + 58 X8 + 46 X10 + 21 X11 + 31 X12 - X28 <=  0
  20)  50 X6 + 38 X8 + 14 X9 + 20 X10 + 15 X13 - X29 <=  0
  21)  100 X6 + 150 X8 + 70 X9 + 60 X10 + 40 X11 + 25 X12 + 25 X13  <=  72
 22) - 56 X1 + X30 <=  0
 23) - 58 X2 + X31 <=  0
 24) - 14 X3 + X32 <=  0
 25) - 23 X4 + X33 <=  0
 26) - 25 X5 + X34 <=  0
 27)  X35 - 100 X6 <=  0
 28) - 100 X7 + X36 <=  0
 29)  X37 - 54 X8 <=  0
 30)  X38 - 13 X9 <=  0
 31)  X39 - 18 X10 <=  0
 32)  X40 - 13 X11 <=  0
 33)  X41 - 12 X12 <=  0
 34)  X42 - 8 X13 <=  0
 35)  2800 X1 + 2880 X2 + 1600 X3 + 7300 X4 + 1000 X5 + 4000 X6 + 4500 X7 + 45 X14 + 25
      X15 + 120 X16 + 250 X17 + 25 X18 + 11 X19 + 15 X20 + 9 X21 - X43 + X46 <=  2500
 36)  X47 + 8000 X6 + 2800 X8 + 1000 X9 + 9000 X10 + 1200 X11+ 1000 X12 + 1000 X13 + 45
      X22 + 25 X23 + 120 X24 + 250 X25 + 25 X26 + 11 X27 + 15 X28 + 9 X29 - 540 X30 - 565
      X31- 1570 X32 -1816 X33-600 X34 - 350 X36 - X46 + 1.04 X44 = 0
  37)  X43 >=  0
  38) - X43 + X44 =   0
  39)  X45 - X43 + X44 =   0
  40)  X1 + X2 + X8 >=  .4
  41)  X6 <=  .2
  42)  X10 <=  .1
  43)  X7 <=  .1
  44)  X9 <=  .25
  45)  X4 <=  .2
END
```

SMALL FARMERS - HEAD REGION - (HS$_4$)

MAX 925 X35 + 550 X37 + 1800 X38 + 2300 X39 + 1400 X40 + 1600 X41 + 2400 X42 - 1.08 X45
+ X47

SUBJECT TO

2) X1 + X2 + X3 + X4 + X5 + X6 + X7 <= .98
3) X6 + X8 + X9 + X10 + X11 + X12 + X13 <= .98
4) 55 X1 + 58 X2 + 20 X3 + 35 X4 + 30 X5 + 50 X6 + 60 X7 - X14 <= 50
5) 80 X1 + 87 X2 + 42 X3 + 80 X4 + 35 X5 + 20 X6 + 63 X7 - X15 <= 60
6) 8 X1 + 7 X2 + 4 X3 + 9 X4 + 6 X5 + 3 X6 + 7 X7 - X16 <= 30
7) 7 X1 + 9 X2 + 7 X3 + 6 X4 + 2 X5 + 5 X7 - X17 <= 0
8) 45 X1 + 40 X2 + 35 X3 + 60 X4 + 30 X5 + 150 X7 - X18 <= 30
9) 80 X1 + 80 X2 + 53 X3 + 52 X4 + 45 X5 + 60 X6 + 70 X7 - X19 <= 0
10) 58 X1 + 58 X2 + 40 X4 + 18 X5 + 35 X6 + 60 X7 - X20 <= 0
11) 38 X1 + 38 X2 + 28 X3 + 42 X4 + 25 X6 + 32 X7 - X21 <= 0
12) 125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 + 55 X7 <= 63
13) 63 X6 + 56 X8 + 18 X9 + 88 X10 + 37 X11 + 10 X12 + 24 X13- X22 <= 50
14) 42 X6 + 79 X8 + 106 X9 + 102 X10 + 82 X11 + 48 X12 + 69 X13 - X23 <= 60
15) 7 X6 + 9 X8 + 11 X9 + 8 X10 + 3 X11 + 4 X12 + 2 X13 - X24 <= 30
16) 4 X6 + 8 X8 + 3 X9 + 7 X10 + 3 X11 + 4 X12 + 5 X13 - X25 <= 0
17) 180 X6 + 60 X8 + 80 X10 + 40 X13 - X26 <= 30
18) 100 X6 + 86 X8 + 70 X9 + 76 X10 + 28 X11 + 32 X12 + 58 X13- X27 <= 0
19) 80 X6 + 58 X8 + 46 X10 + 21 X11 + 31 X12 - X28 <= 0
20) 50 X6 + 38 X8 + 14 X9 + 20 X10 + 15 X13 - X29 <= 0
21) 100 X6 + 150 X8 + 70 X9 + 60 X10 + 40 X11 + 25 X12 + 25 X13<= 63
22) - 56 X1 + X30 <= 0
23) - 58 X2 + X31 <= 0
24) - 14 X3 + X32 <= 0
25) - 23 X4 + X33 <= 0
26) - 25 X5 + X34 <= 0
27) X35 - 100 X6 <= 0
28) - 100 X7 + X36 <= 0
29) X37 - 54 X8 <= 0
30) X38 - 13 X9 <= 0
31) X39 - 18 X10 <= 0
32) X40 - 13 X11 <= 0
33) X41 - 12 X12 <= 0
34) X42 - 8 X13 <= 0
35) 2800 X1 + 2880 X2 + 1600 X3 + 7300 X4 + 1000 X5 + 4000 X6+ 4500 X7 + 45 X14 + 25
X15 + 120 X16 + 250 X17 + 25 X18 + 11 X19+ 15 X20 + 9 X21 - X43 + X46 <=2500
36) X47 + 8000 X6 + 2800 X8 + 1000 X9 + 9000 X10 + 1200 X11+ 1000 X12 + 1000 X13 + 45
X22 + 25 X23 + 120 X24 + 250 X25 + 25 X26 + 11 X27 + 15 X28 + 9 X29 - 540 X30 - 565
X31 - 1570 X32 - 1816 X33- 600 X34-350 X36 - X46 +1.04 X44 = 0
37) X43 >= 0
38) - X43 + X44 = 0
39) X45 - X43 + X44 = 0
40) X1 + X2 + X8 >= .4
41) X6 <= .2
42) X10 <= .1
43) X7 <= .1
44) X9 <= .25
45) X4 <= .2

END

INPUT-OUTPUT MATRIX OF LARGE FARMERS - HEAD REGION (Page 1 of 6)

	KPA1D	KPA9D	KSFM	KSFH	KGNJ	KBAJ	KSUC	KBRI	RPAD
KILD	1	1	1	1	1	1	1	1	
RILD							1		1
MLRK	62	63	22	22	45	32	56	67	
WLRK	90	88	47	53	97	40	24	75	
BLRK	3	3	3	4	9	5	7	8	
TPRK	11	12	8	8	8	3		7	
NFRK	109	109	59	59	52	45	80	78	
PFRK	58	58	0	0	40	18	75	68	
KFRK	38	38	32	32	42	0	40	40	
FYMK	55	50	30	30	50	30		150	
IWRK	125	125	45	45	45	40	100	55	
MLRR							68		62
WLRR							41		85
BLRR							3		3
TPRR							5		12
NFRR							80		85
PFRR							35		58
KFRR							35		38
FYMR							180		50
IWRR							100		150
KPA_1Y	-58								
KPA_9Y		-64							
KSMY			-15						
KSHY				-17					
KGNY					-25				
KBJY						-20			
KSCY							-105		
KBRY								-120	
RPAY									-53
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK	3000	3200	1800	2000	7300	1000	4000	5000	
CASR							8000		3100
BORK									
DEMK									
DEMR									
MIPA	1	1							1
MSUC							1		
MGNT					1				
MBRI								1	
MCHI									
MCOT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - HEAD REGION (Page 2 of 6)

	RCOT	RCHI	RCOW	RGRG	RGIN	HMLK	HWLK	HBLK	HTPK
KILD									
RILD	1	1	1	1	1				
MLRK						-1			
WLRK							-1		
BLRK								-1	
TPRK									-1
NFRK									
PFRK									
KFRK									
FYMK									
IWRK									
MLRR	23	97	40	13	27				
WLRR	120	105	90	54	72				
BLRR	14	6	4	4	2				
TPRR	3	9	3	5	5				
NFRR	74	89	32	35	58				
PFRR	0	56	20	35	0				
KFRR	14	21	0	0	15				
FYMR	0	70	0	0	40				
IWRR	70	60	40	25	25				
KPA_1Y									
KPA_9Y									
KSMY									
KSHY									
KGNY									
KBJY									
KSCY									
KBRY									
RPAY									
RCOY	-13								
RCHY		-20							
RCPY			-12						
RGGY				-12					
RGIY					-8				
CASK						45	25	120	250
CASR	950	9300	1200	1000	1000				
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MGNT									
MBRI									
MCHI		1							
MCOT	1								
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - HEAD REGION (Page 3 of 6)

	PNFK	PPFK	PKFK	PFMK	HMLR	HWLR	HBLR	HTPR	PNFR
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
NFRK	-1								
PFRK		-1							
KFRK			-1						
FYMK				-1					
IWRK									
MLRR					-1				
WLRR						-1			
BLRR							-1		
TPRR								-1	
NFRR									-1
PFRR									
KFRR									
FYMR									
IWRR									
KPA_1Y									
KPA_9Y									
KSMY									
KSHY									
KGNY									
KBJY									
KSCY									
KBRY									
RPAY									
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK	11	15	10	25					
CASR					45	25	120	250	11
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MGNT									
MBRI									
MCHI									
MCOT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - HEAD REGION (Page 4 of 6)

	PPFR	PKFR	PFMR	SKP1A	SKP9A	SKSM	SKSH	SKGN	SKBJ
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
NFRK									
PFRK									
KFRK									
FYMK									
IWRK									
MLRR									
WLRR									
BLRR									
TPRR									
NFRR									
PFRR	-1								
KFRR		-1							
FYMR			-1						
IWRR									
KPA_1Y				1					
KPA_9Y					1				
KSMY						1			
KSHY							1		
KGNY								1	
KBJY									1
KSCY									
KBRY									
RPAY									
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK									
CASR	15	10	25	-540	-565	-1600	-1670	-1750	-600
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MGNT									
MBRI									
MCHI									
MCOT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - HEAD REGION (Page 5 of 6)

	SKSC	SKBR	SRPS	SRCO	SRCH	SRCP	SRGG	SRGI	BORK
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
NFRK									
PFRK									
KFRK									
FYMK									
IWRK									
MLRR									
WLRR									
BLRR									
TPRR									
NFRR									
PFRR									
KFRR									
FYMR									
IWRR									
KPA_1Y									
KPA_9Y									
KSMY									
KSHY									
KGNY									
KBJY									
KSCY	1								
KBRY		1							
RPAY			1						
RCOY				1					
RCHY					1				
RCPY						1			
RGGY							1		
RGIY								1	
CASK									-1
CASR		-350							
BORK									1
DEMK									-1
DEMR									-1
MIPA									
MSUC									
MGNT									
MBRI									
MCHI									
MCOT									
Z	925		540	1800	2200	1400	1600	2400	

INPUT-OUTPUT MATRIX OF LARGE FARMERS - HEAD REGION (Page 6 of 6)

	RKLR	RKLZ	KCTR	RCTZ	SIGN	COEF
KILD					<=	2.43
RILD					<=	2.43
MLRK					<=	0
WLRK					<=	0
BLRK					<=	0
TPRK					<=	0
NFRK					<=	0
PFRK					<=	0
KFRK					<=	0
FYMK					<=	50
IWRK					<=	225
MLRR					<=	0
WLRR					<=	0
BLRR					<=	0
TPRR					<=	0
NFRR					<=	0
PFRR					<=	0
KFRR					<=	0
FYMR					<=	50
IWRR					<=	195
KPA$_1$Y					<=	0
KPA$_9$Y					<=	0
KSMY					<=	0
KSHY					<=	0
KGNY					<=	0
KBJY					<=	0
KSCY					<=	0
KBRY					<=	0
RPAY					<=	0
RCOY					<=	0
RCHY					<=	0
RCPY					<=	0
RGGY					<=	0
RGIY					<=	0
CASK			1		<=	10000
CASR	1.04		-1	1	=	0
BORK					>=	0
DEMK	1				=	0
DEMR	1	1			=	0
MIPA					>=	0.6
MSUC					<=	0.5
MGNT					<=	0.4
MBRI					<=	0.2
MCHI					<=	0.3
MCOT					<=	0.6
Z		-1.08		1		

LARGE FARMERS - HEAD REGION (HL_1)

```
MAX   925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08  X47
      + X49
SUBJECT TO
   2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 <=   2.43
   3)  X7 + X9 + X10 + X11 + X12 + X13 + X14 <=   2.43
   4)  62 X1 + 63 X2 + 22 X3 + 22 X4 + 45 X5 + 32 X6 + 56 X7 + 67 X8 - X15 <=   0
   5)  90 X1 + 88 X2 + 47 X3 + 53 X4 + 97 X5 + 40 X6 + 24 X7 + 75 X8 - X16 <=   0
   6)  3 X1 + 3 X2 + 3 X3 + 4 X4 + 9 X5 + 5 X6 + 7 X7 + 8 X8 - X17   <=   0
   7)  11 X1 + 12 X2 + 8 X3 + 8 X4 + 8 X5 + 3 X6 + 7 X8 - X18 <=   0
   8)  109 X1 + 109 X2 + 59 X3 + 59 X4 + 52 X5 + 45 X6 + 80 X7 + 78 X8 - X19 <=   0
   9)  58 X1 + 58 X2 + 40 X5 + 18 X6 + 75 X7 + 68 X8 - X20 <=   0
  10)  38 X1 + 38 X2 + 32 X3 + 32 X4 + 42 X5 + 40 X7 + 40 X8 - X21  <=   0
  11)  55 X1 + 50 X2 + 30 X3 + 30 X4 + 50 X5 + 30 X6 + 150 X8 - X22 <=   50
  12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 40 X6 + 100 X7 + 55 X8  <=   225
  13)  68 X7 + 62 X9 + 23 X10 + 97 X11 + 40 X12 + 13 X13 + 27 X14 - X23  <=   0
  14)  41 X7 + 85 X9 + 120 X10 + 105 X11 + 90 X12 + 54 X13 + 72 X14  - X24 <=   0
  15)  3 X7 + 3 X9 + 14 X10 + 6 X11 + 4 X12 + 4 X13 + 2 X14 - X25  <=   0
  16)  5 X7 + 12 X9 + 3 X10 + 9 X11 + 3 X12 + 5 X13 + 5 X14 - X26   <=   0
  17)  80 X7 + 85 X9 + 74 X10 + 89 X11 + 32 X12 + 35 X13 + 58 X14 - X27   <=   0
  18)  35 X7 + 58 X9 + 56 X11 + 20 X12 + 35 X13 - X28 <=   0
  19)  35 X7 + 38 X9 + 14 X10 + 21 X11 + 15 X14 - X29 <=   0
  20)  180 X7 + 50 X9 + 70 X11 + 40 X14 - X30 <=   50
  21)  100 X7 + 150 X9 + 70 X10 + 60 X11 + 40 X12 + 25 X13 + 25 X14  <=   195
  22) - 58 X1 + X31 <=   0
  23) - 64 X2 + X32 <=   0
  24) - 15 X3 + X33 <=   0
  25) - 17 X4 + X34 <=   0
  26) - 25 X5 + X35 <=   0
  27) - 20 X6 + X36 <=   0
  28)  X37 - 105 X7 <=   0
  29) - 120 X8 + X38 <=   0
  30)  X39 - 53 X9 <=   0
  31)  X40 - 13 X10 <=   0
  32)  X41 - 20 X11 <=   0
  33)  X42 - 12 X12 <=   0
  34)  X43 - 12 X13 <=   0
  35)  X44 - 8 X14 <=   0
  36) 3000 X1 + 3200 X2 + 1800 X3 + 2000 X4 + 7300 X5 + 1000 X6 + 4000 X7 + 5000 X8    +
      45 X15 + 25 X16 + 120 X17 + 250 X18 + 11 X19 + 15 X20 + 10 X21 + 25 X22 - X45 + X48
      <=   10000
  37)  X49 + 8000 X7 + 3100 X9 + 950 X10 + 9300 X11 + 1200 X12 + 1000 X13 + 1000 X14  +
      45 X23 + 25 X24 + 120 X25 + 250 X26 + 11 X27 + 15 X28 + 10 X29 + 25 X30 - 540     X31
      - 565 X32 - 1600 X33 - 1670 X34 - 1750 X35 - 600 X36 - 350 X38 - X48 + 1.04 X46 =   0
  38)  X45 >=   0
  39) - X45 + X46 =    0
  40)  X47 - X45 + X46 =    0
  41)  X1 + X2 + X9 >=   .6
  42)  X7 <=   .5
  43)  X5 <=   .4
  44)  X8 <=   .2
  45)  X11 <=   .3
  46)  X10 <=   .6
END
```

LARGE FARMERS - HEAD REGION (HL_2)

```
MAX   925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47
      + X49
SUBJECT TO
     2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 <=  2.43
     3)  X7 + X9 + X10 + X11 + X12 + X13 + X14 <=  2.43
     4)  62 X1 + 63 X2 + 22 X3 + 22 X4 + 45 X5 + 32 X6 + 56 X7 + 67 X8  - X15 <=  0
     5)  90 X1 + 88 X2 + 47 X3 + 53 X4 + 97 X5 + 40 X6 + 24 X7 + 75 X8  - X16 <=  0
     6)  3 X1 + 3 X2 + 3 X3 + 4 X4 + 9 X5 + 5 X6 + 7 X7 + 8 X8 - X17   <=  0
     7)  11 X1 + 12 X2 + 8 X3 + 8 X4 + 8 X5 + 3 X6 + 7 X8 - X18 <=  0
     8)  109 X1 + 109 X2 + 59 X3 + 59 X4 + 52 X5 + 45 X6 + 80 X7 + 78 X8  - X19 <=  0
     9)  58 X1 + 58 X2 + 40 X5 + 18 X6 + 75 X7 + 68 X8 - X20 <=  0
    10)  38 X1 + 38 X2 + 32 X3 + 32 X4 + 42 X5 + 40 X7 + 40 X8 - X21   <=  0
    11)  55 X1 + 50 X2 + 30 X3 + 30 X4 + 50 X5 + 30 X6 + 150 X8 - X22    <=  50
    12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 40 X6 + 100 X7 + 55 X8  <= 202.5
    13)  68 X7 + 62 X9 + 23 X10 + 97 X11 + 40 X12 + 13 X13 + 27 X14 - X23    <=  0
    14)  41 X7 + 85 X9 + 120 X10 + 105 X11 + 90 X12 + 54 X13 + 72 X14 - X24 <=  0
    15)  3 X7 + 3 X9 + 14 X10 + 6 X11 + 4 X12 + 4 X13 + 2 X14 - X25   <=  0
    16)  5 X7 + 12 X9 + 3 X10 + 9 X11 + 3 X12 + 5 X13 + 5 X14 - X26   <=  0
    17)  80 X7 + 85 X9 + 74 X10 + 89 X11 + 32 X12 + 35 X13 + 58 X14 - X27  <=  0
    18)  35 X7 + 58 X9 + 56 X11 + 20 X12 + 35 X13 - X28 <=  0
    19)  35 X7 + 38 X9 + 14 X10 + 21 X11 + 15 X14 - X29 <=  0
    20)  180 X7 + 50 X9 + 70 X11 + 40 X14 - X30 <=  50
    21)  100 X7 + 150 X9 + 70 X10 + 60 X11 + 40 X12 + 25 X13 + 25 X14  <=  175.5
    22) - 58 X1 + X31 <=  0
    23) - 64 X2 + X32 <=  0
    24) - 15 X3 + X33 <=  0
    25) - 17 X4 + X34 <=  0
    26) - 25 X5 + X35 <=  0
    27) - 20 X6 + X36 <=  0
    28)  X37 - 105 X7 <=  0
    29) - 120 X8 + X38 <=  0
    30)  X39 - 53 X9 <=  0
    31)  X40 - 13 X10 <=  0
    32)  X41 - 20 X11 <=  0
    33)  X42 - 12 X12 <=  0
    34)  X43 - 12 X13 <=  0
    35)  X44 - 8 X14 <=  0
    36)  3000 X1 + 3200 X2 + 1800 X3 + 2000 X4 + 7300 X5 + 1000 X6 + 4000 X7 + 5000 X8  +
         45 X15 + 25 X16 + 120 X17 + 250 X18 + 11 X19 + 15 X20 + 10 X21 + 25 X22  - X45 +
         X48 <=  10000
    37)  X49 + 8000 X7 + 3100 X9 + 950 X10 + 9300 X11 + 1200 X12 + 1000 X13 + 1000 X14 + 45
         X23 + 25 X24 + 120 X25 + 250 X26 + 11 X27 + 15 X28 + 10 X29 + 25  X30 - 540 X31 -
         565 X32 - 1600 X33 - 1670 X34 - 1750 X35 - 600 X36 - 350 X38 - X48 + 1.04 X46 =   0
    38)  X45 >=  0
    39) - X45 + X46 =   0
    40)  X47 - X45 + X46 =   0
    41)  X1 + X2 + X9 >=  .6
    42)  X7 <=  .5
    43)  X5 <=  .4
    44)  X8 <=  .2
    45)  X11 <=  .3
    46)  X10 <=  .6
END
```

LARGE FARMERS - HEAD REGION (HL_3)

```
MAX  925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47
     + X49
SUBJECT TO
    2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 <=  2.43
    3)  X7 + X9 + X10 + X11 + X12 + X13 + X14 <=  2.43
    4)  62 X1 + 63 X2 + 22 X3 + 22 X4 + 45 X5 + 32 X6 + 56 X7 + 67 X8 - X15 <=  0
    5)  90 X1 + 88 X2 + 47 X3 + 53 X4 + 97 X5 + 40 X6 + 24 X7 + 75 X8 - X16 <=  0
    6)  3 X1 + 3 X2 + 3 X3 + 4 X4 + 9 X5 + 5 X6 + 7 X7 + 8 X8 - X17  <=  0
    7)  11 X1 + 12 X2 + 8 X3 + 8 X4 + 8 X5 + 3 X6 + 7 X8 - X18 <=  0
    8)  109 X1 + 109 X2 + 59 X3 + 59 X4 + 52 X5 + 45 X6 + 80 X7 + 78 X8 - X19 <=  0
    9)  58 X1 + 58 X2 + 40 X5 + 18 X6 + 75 X7 + 68 X8 - X20 <=  0
   10)  38 X1 + 38 X2 + 32 X3 + 32 X4 + 42 X5 + 40 X7 + 40 X8 - X21  <=  0
   11)  55 X1 + 50 X2 + 30 X3 + 30 X4 + 50 X5 + 30 X6 + 150 X8 - X22 <=  50
   12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 40 X6 + 100 X7 + 55 X8 <=  180
   13)  68 X7 + 62 X9 + 23 X10 + 97 X11 + 40 X12 + 13 X13 + 27 X14 - X23 <=  0
   14)  41 X7 + 85 X9 + 120 X10 + 105 X11 + 90 X12 + 54 X13 + 72 X14- X24 <=  0
   15)  3 X7 + 3 X9 + 14 X10 + 6 X11 + 4 X12 + 4 X13 + 2 X14 - X25 <=  0
   16)  5 X7 + 12 X9 + 3 X10 + 9 X11 + 3 X12 + 5 X13 + 5 X14 - X26<=  0
   17)  80 X7 + 85 X9 + 74 X10 + 89 X11 + 32 X12 + 35 X13 + 58 X14 - X27 <=  0
   18)  35 X7 + 58 X9 + 56 X11 + 20 X12 + 35 X13 - X28 <=  0
   19)  35 X7 + 38 X9 + 14 X10 + 21 X11 + 15 X14 - X29 <=  0
   20)  180 X7 + 50 X9 + 70 X11 + 40 X14 - X30 <=  50
   21)  100 X7 + 150 X9 + 70 X10 + 60 X11 + 40 X12 + 25 X13 + 25 X14 <=  156
   22) - 58 X1 + X31 <=  0
   23) - 64 X2 + X32 <=  0
   24) - 15 X3 + X33 <=  0
   25) - 17 X4 + X34 <=  0
   26) - 25 X5 + X35 <=  0
   27) - 20 X6 + X36 <=  0
   28)  X37 - 105 X7 <=  0
   29) - 120 X8 + X38 <=  0
   30)  X39 - 53 X9 <=  0
   31)  X40 - 13 X10 <=  0
   32)  X41 - 20 X11 <=  0
   33)  X42 - 12 X12 <=  0
   34)  X43 - 12 X13 <=  0
   35)  X44 - 8 X14 <=  0
   36) 3000 X1 + 3200 X2 + 1800 X3 + 2000 X4 + 7300 X5 + 1000 X6 + 4000 X7 + 5000 X8  +
       45 X15 + 25 X16 + 120 X17 + 250 X18 + 11 X19 + 15 X20 + 10 X21 + 25 X22  - X45 +
       X48 <=  10000
   37) X49 + 8000 X7 + 3100 X9 + 950 X10 + 9300 X11 + 1200 X12 + 1000 X13 + 1000 X14 + 45
       X23 + 25 X24 + 120 X25 + 250 X26 + 11 X27 + 15 X28 + 10 X29 + 25  X30 - 540 X31 -
       565 X32 - 1600 X33 - 1670 X34 - 1750 X35 - 600 X36 - 350 X38 - X48 + 1.04 X46 = 0
   38)  X45 >=  0
   39) - X45 + X46 =   0
   40)  X47 - X45 + X46 =   0
   41)  X1 + X2 + X9 >=  .6
   42)  X7 <=  .5
   43)  X5 <=  .4
   44)  X8 <=  .2
   45)  X11 <=  .3
   46)  X10 <=  .6
END
```

LARGE FARMERS - HEAD REGION (HL_4)

```
MAX   925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47
      + X49
SUBJECT TO
   2)  X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 <=  2.43
   3)  X7 + X9 + X10 + X11 + X12 + X13 + X14 <=  2.43
   4)  62 X1 + 63 X2 + 22 X3 + 22 X4 + 45 X5 + 32 X6 + 56 X7 + 67 X8 - X15 <=  0
   5)  90 X1 + 88 X2 + 47 X3 + 53 X4 + 97 X5 + 40 X6 + 24 X7 + 75 X8 - X16 <=  0
   6)  3 X1 + 3 X2 + 3 X3 + 4 X4 + 9 X5 + 5 X6 + 7 X7 + 8 X8 - X17 <=  0
   7)  11 X1 + 12 X2 + 8 X3 + 8 X4 + 8 X5 + 3 X6 + 7 X8 - X18 <=  0
   8)  109 X1 + 109 X2 + 59 X3 + 59 X4 + 52 X5 + 45 X6 + 80 X7 + 78 X8 - X19 <=  0
   9)  58 X1 + 58 X2 + 40 X5 + 18 X6 + 75 X7 + 68 X8 - X20 <=  0
   10)  38 X1 + 38 X2 + 32 X3 + 32 X4 + 42 X5 + 40 X7 + 40 X8 - X21  <=  0
   11)  55 X1 + 50 X2 + 30 X3 + 30 X4 + 50 X5 + 30 X6 + 150 X8 - X22  <=  50
   12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 40 X6 + 100 X7 + 55 X8  <=  157.5
   13)  68 X7 + 62 X9 + 23 X10 + 97 X11 + 40 X12 + 13 X13 + 27 X14 - X23  <=  0
   14)  41 X7 + 85 X9 + 120 X10 + 105 X11 + 90 X12 + 54 X13 + 72 X14- X24 <=  0
   15)  3 X7 + 3 X9 + 14 X10 + 6 X11 + 4 X12 + 4 X13 + 2 X14 - X25  <=  0
   16)  5 X7 + 12 X9 + 3 X10 + 9 X11 + 3 X12 + 5 X13 + 5 X14 - X26  <=  0
   17)  80 X7 + 85 X9 + 74 X10 + 89 X11 + 32 X12 + 35 X13 + 58 X14 - X27 <=  0
   18)  35 X7 + 58 X9 + 56 X11 + 20 X12 + 35 X13 - X28 <=  0
   19)  35 X7 + 38 X9 + 14 X10 + 21 X11 + 15 X14 - X29 <=  0
   20)  180 X7 + 50 X9 + 70 X11 + 40 X14 - X30 <=  50
   21)  100 X7 + 150 X9 + 70 X10 + 60 X11 + 40 X12 + 25 X13 + 25 X14 <=  136.5
   22) - 58 X1 + X31 <=  0
   23) - 64 X2 + X32 <=  0
   24) - 15 X3 + X33 <=  0
   25) - 17 X4 + X34 <=  0
   26) - 25 X5 + X35 <=  0
   27) - 20 X6 + X36 <=  0
   28)  X37 - 105 X7 <=  0
   29) - 120 X8 + X38 <=  0
   30)  X39 - 53 X9 <=  0
   31)  X40 - 13 X10 <=  0
   32)  X41 - 20 X11 <=  0
   33)  X42 - 12 X12 <=  0
   34)  X43 - 12 X13 <=  0
   35)  X44 - 8 X14 <=  0
   36)  3000 X1 + 3200 X2 + 1800 X3 + 2000 X4 + 7300 X5 + 1000 X6 + 4000 X7 + 5000 X8  +
        45 X15 + 25 X16 + 120 X17 + 250 X18 + 11 X19+ 15 X20 + 10 X21 + 25 X22  - X45 +
        X48 <=  10000
   37)  X49 + 8000 X7 + 3100 X9 + 950 X10 + 9300 X11 + 1200 X12+ 1000 X13 + 1000 X14 + 45
        X23 + 25 X24 + 120 X25 + 250 X26 + 11 X27+ 15 X28 + 10 X29 + 25  X30 - 540 X31 -
        565 X32 - 1600 X33 - 1670 X34 - 1750 X35 - 600 X36 - 350 X38 - X48 + 1.04 X46 =  0
   38)  X45 >=  0
   39) - X45 + X46 =  0
   40)  X47 - X45 + X46 =  0
   41)  X1 + X2 + X9 >=  .6
   42)  X7 <=  .5
   43)  X5 <=  .4
   44)  X8 <=  .2
   45)  X11 <=  .3
   46)  X10 <=  .6
 END
```

INPUT-OUTPUT MATRIX OF SMALL FARMERS- MIDDLE REGION (Page 1 of 5)

	KPA1D	KPA9D	KSFM	KGNJ	KBAJ	KSUC	RPAD	RCOT	RCHI
KILD	1	1	1	1	1	1			
RILD							1	1	1
MLRK	52	63	20	40	30	60			
WLRK	80	85	42	85	43	30			
BLRK	6	6	4	7	6	7			
TPRK	8	10	6	8	3				
FYMK	45	50	40	50	40				
NFRK	98	115	55	53	50	80			
PFRK	46	60	0	40	0	60			
KFRK	42	62	28	56	0	36			
IWRK	125	125	45	45	40	100			
MLRR						48	57	20	92
WLRR						40	82	102	115
BLRR						3	8	12	7
TPRR						5	10	4	4
FYMR						150	60	0	70
NFRR						80	87	88	90
PFRR						55	57	0	37
KFRR						36	37	15	24
IWRR						100	150	70	60
KPA_1Y	-50								
KPA_9Y		-56							
KSMY			-14						
KGNY				-22					
KBJY					-19				
KSCY						-102			
RPAY							-52		
RCOY								-13	
RCHY									-19
RCPY									
RGGY									
RGIY									
CASK	2600	2800	1500	6000	900	4000			
CASR						7000	2900	1100	7200
BORK									
DEMK									
DEMR									
MIPA	1	1					1		
MSUC						1			
MCHI									1
MGNT				1					
Z									

INPUT-OUTPUT MATRIX OF SMALL FARMERS- MIDDLE REGION (Page 2 of 5)

	RCOW	RGRG	RGIN	HMLK	HWLK	HBLK	HTPK	PFMK	PNFK
KILD									
RILD	1	1	1						
MLRK				-1					
WLRK					-1				
BLRK						-1			
TPRK							-1		
FYMK								-1	
NFRK									-1
PFRK									
KFRK									
IWRK									
MLRR	40	13	25						
WLRR	90	53	69						
BLRR	4	4	4						
TPRR	3	2	2						
FYMR	0	0	0						
NFRR	32	35	58						
PFRR	21	35	0						
KFRR	0	0	15						
IWRR	40	25	25						
KPA$_1$Y									
KPA$_9$Y									
KSMY									
KGNY									
KBJY									
KSCY									
RPAY									
RCOY									
RCHY									
RCPY	-15								
RGGY		-11							
RGIY			-6						
CASK				45	30	150	250	25	10
CASR	1600	1300	1100						
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MCHI									
MGNT									
Z									

INPUT-OUTPUT MATRIX OF SMALL FARMERS- MIDDLE REGION (Page 3 of 5)

	PPFK	PKFK	HMLR	HWLR	HBLR	HTPR	PFMR	PNFR	PPFR
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK									
NFRK									
PFRK	-1								
KFRK		-1							
IWRK									
MLRR			-1						
WLRR				-1					
BLRR					-1				
TPRR						-1			
FYMR							-1		
NFRR								-1	
PFRR									-1
KFRR									
IWRR									
KPA_1Y									
KPA_9Y									
KSMY									
KGNY									
KBJY									
KSCY									
RPAY									
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK	15	9							
CASR			45	30	150	250	25	10	15
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MCHI									
MGNT									
Z									

INPUT-OUTPUT MATRIX OF SMALL FARMERS- MIDDLE REGION (Page 4 of 5)

	PKFR	SKP1A	SKP9A	SKSM	SKGN	SKBJ	SKSC	SRPS	SRCO	SRCH
KILD										
RILD										
MLRK										
WLRK										
BLRK										
TPRK										
FYMK										
NFRK										
PFRK										
KFRK										
IWRK										
MLRR										
WLRR										
BLRR										
TPRR										
FYMR										
NFRR										
PFRR										
KFRR	-1									
IWRR										
KPA$_1$Y		1								
KPA$_9$Y			1							
KSMY				1						
KGNY					1					
KBJY						1				
KSCY							1			
RPAY								1		
RCOY									1	
RCHY										1
RCPY										
RGGY										
RGIY										
CASK										
CASR	9	-570	-560	-1650	-1690	-550				
BORK										
DEMK										
DEMR										
MIPA										
MSUC										
MCHI										
MGNT										
Z							900	540	1750	2000

INPUT-OUTPUT MATRIX OF SMALL FARMERS- MIDDLE REGION (Page 5 of 5)

	SRCP	SRGG	SRGI	BORK	RKLR	RKLZ	KCTR	RCTZ	SIGN	COEF
KILD									<=	0.94
RILD									<=	0.94
MLRK									<=	60
WLRK									<=	50
BLRK									<=	20
TPRK									<=	0
FYMK									<=	40
NFRK									<=	0
PFRK									<=	0
KFRK									<=	0
IWRK									<=	92
MLRR									<=	60
WLRR									<=	50
BLRR									<=	20
TPRR									<=	0
FYMR									<=	30
NFRR									<=	0
PFRR									<=	0
KFRR									<=	0
IWRR									<=	85
KPA_1Y									<=	0
KPA_9Y									<=	0
KSMY									<=	0
KGNY									<=	0
KBJY									<=	0
KSCY									<=	0
RPAY									<=	0
RCOY									<=	0
RCHY									<=	0
RCPY	1								<=	0
RGGY		1							<=	0
RGIY			1						<=	0
CASK				-1			1		<=	3000
CASR					1.04		-1	1	=	0
BORK				1					>=	0
DEMK				-1	1				=	0
DEMR				-1	1	1			=	0
MIPA									>=	0.6
MSUC									<=	0.2
MCHI									<=	0.15
MGNT									<=	0.2
Z	1420	1550	2200			-1.08		1		

SMALL FARMERS - MIDDLE REGION (MS_I)

```
MAX   900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39 + 2200 X40 -
      1.08 X43 + X45
SUBJECT TO
     2)  X1 + X2 + X3 + X4 + X5 + X6 <=  .94
     3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=  .94
     4)  52 X1 + 63 X2 + 20 X3 + 40 X4 + 30 X5 + 60 X6 - X13 <=  60
     5)  80 X1 + 85 X2 + 42 X3 + 85 X4 + 43 X5 + 30 X6 - X14 <=  50
     6)  6 X1 + 6 X2 + 4 X3 + 7 X4 + 6 X5 + 7 X6 - X15 <=  20
     7)  8 X1 + 10 X2 + 6 X3 + 8 X4 + 3 X5 - X16 <=  0
     8)  45 X1 + 50 X2 + 40 X3 + 50 X4 + 40 X5 - X17 <=  40
     9)  98 X1 + 115 X2 + 55 X3 + 53 X4 + 50 X5 + 80 X6 - X18 <=  0
    10)  46 X1 + 60 X2 + 40 X4 + 60 X6 - X19 <=  0
    11)  42 X1 + 62 X2 + 28 X3 + 56 X4 + 36 X6 - X20 <=  0
    12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 <=  92
    13)  48 X6 + 57 X7 + 20 X8 + 92 X9 + 40 X10 + 13 X11 + 25 X12 - X21  <=  60
    14)  40 X6 + 82 X7 + 102 X8 + 115 X9 + 90 X10 + 53 X11 + 69 X12 - X22    <=  50
    15)  3 X6 + 8 X7 + 12 X8 + 7 X9 + 4 X10 + 4 X11 + 4 X12 - X23    <=  20
    16)  5 X6 + 10 X7 + 4 X8 + 4 X9 + 3 X10 + 2 X11 + 2 X12 - X24 <=  0
    17)  150 X6 + 60 X7 + 70 X9 - X25 <=  30
    18)  80 X6 + 87 X7 + 88 X8 + 90 X9 + 32 X10 + 35 X11 + 58 X12 - X26    <=  0
    19)  55 X6 + 57 X7 + 37 X9 + 21 X10 + 35 X11 - X27 <=  0
    20)  36 X6 + 37 X7 + 15 X8 + 24 X9 + 15 X12 - X28 <=  0
    21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12    <=  85
    22) - 50 X1 + X29 <=  0
    23) - 56 X2 + X30 <=  0
    24) - 14 X3 + X31 <=  0
    25) - 22 X4 + X32 <=  0
    26) - 19 X5 + X33 <=  0
    27)  X34 - 102 X6 <=  0
    28)  X35 - 52 X7 <=  0
    29)  X36 - 13 X8 <=  0
    30)  X37 - 19 X9 <=  0
    31)  X38 - 15 X10 <=  0
    32)  X39 - 11 X11 <=  0
    33)  X40 - 6 X12 <=  0
    34)  2600 X1 + 2800 X2 + 1500 X3 + 6000 X4 + 900 X5 + 4000 X6 + 45 X13 + 30 X14
         + 150 X15 + 250 X16 + 25 X17 + 10 X18 + 15 X19   + 9 X20 - X41 + X44 <=  3000
    35)  X45 + 7000 X6 + 2900 X7 + 1100 X8 + 7200 X9 + 1600 X10 + 1300 X11 + 1100
         X12 + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 10 X26 + 15 X27 + 9 X28
         - 570 X29 - 560 X30 - 1650 X31 - 1690 X32 - 550 X33 - X44 + 1.04 X42 =   0
    36)  X41 >=  0
    37) - X41 + X42 =   0
    38)  X43 - X41 + X42 =   0
    39)  X1 + X2 + X7 >=  .6
    40)  X4 <=  .2
    41)  X6 <=  .2
    42)  X9 <=  .15
END
```

SMALL FARMERS - MIDDLE REGION (MS_2)

```
MAX    900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39
       + 2200 X40 - 1.08 X43 + X45
SUBJECT TO
    2)  X1 + X2 + X3 + X4 + X5 + X6 <=  .94
    3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=  .94
    4)  52 X1 + 63 X2 + 20 X3 + 40 X4 + 30 X5 + 60 X6 - X13 <=  60
    5)  80 X1 + 85 X2 + 42 X3 + 85 X4 + 43 X5 + 30 X6 - X14 <=  50
    6)  6 X1 + 6 X2 + 4 X3 + 7 X4 + 6 X5 + 7 X6 - X15 <=  20
    7)  8 X1 + 10 X2 + 6 X3 + 8 X4 + 3 X5 - X16 <=  0
    8)  45 X1 + 50 X2 + 40 X3 + 50 X4 + 40 X5 - X17 <=  40
    9)  98 X1 + 115 X2 + 55 X3 + 53 X4 + 50 X5 + 80 X6 - X18 <=  0
   10)  46 X1 + 60 X2 + 40 X4 + 60 X6 - X19 <=  0
   11)  42 X1 + 62 X2 + 28 X3 + 56 X4 + 36 X6 - X20 <=  0
   12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 <=  82.8
   13)  48 X6 + 57 X7 + 20 X8 + 92 X9 + 40 X10 + 13 X11 + 25 X12 - X21   <=  60
   14)  40 X6 + 82 X7 + 102 X8 + 115 X9 + 90 X10 + 53 X11 + 69 X12 - X22   <=  50
   15)  3 X6 + 8 X7 + 12 X8 + 7 X9 + 4 X10 + 4 X11 + 4 X12 - X23   <=  20
   16)  5 X6 + 10 X7 + 4 X8 + 4 X9 + 3 X10 + 2 X11 + 2 X12 - X24 <=  0
   17)  150 X6 + 60 X7 + 70 X9 - X25 <=  30
   18)  80 X6 + 87 X7 + 88 X8 + 90 X9 + 32 X10 + 35 X11 + 58 X12 - X26   <=  0
   19)  55 X6 + 57 X7 + 37 X9 + 21 X10 + 35 X11 - X27 <=  0
   20)  36 X6 + 37 X7 + 15 X8 + 24 X9 + 15 X12 - X28 <=  0
   21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12   <=  76.5
   22) - 50 X1 + X29 <=  0
   23) - 56 X2 + X30 <=  0
   24) - 14 X3 + X31 <=  0
   25) - 22 X4 + X32 <=  0
   26) - 19 X5 + X33 <=  0
   27)  X34 - 102 X6 <=  0
   28)  X35 - 52 X7 <=  0
   29)  X36 - 13 X8 <=  0
   30)  X37 - 19 X9 <=  0
   31)  X38 - 15 X10 <=  0
   32)  X39 - 11 X11 <=  0
   33)  X40 - 6 X12 <=  0
   34)  2600 X1 + 2800 X2 + 1500 X3 + 6000 X4 + 900 X5 + 4000 X6 + 45 X13 + 30 X14
       + 150 X15 + 250 X16 + 25 X17 + 10 X18 + 15 X19 + 9 X20 - X41 + X44 <=  3000
   35)  X45 + 7000 X6 + 2900 X7 + 1100 X8 + 7200 X9 + 1600 X10 + 1300 X11 + 1100
       X12 + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 10 X26 + 15 X27 + 9 X28
       - 570 X29 - 560 X30 - 1650 X31 - 1690 X32- 550 X33 - X44 + 1.04 X42 =   0
   36)  X41 >=  0
   37) - X41 + X42 =   0
   38)  X43 - X41 + X42 =   0
   39)  X1 + X2 + X7 >=  .6
   40)  X4 <=  .2
   41)  X6 <=  .2
   42)  X9 <=  .15
END
```

SMALL FARMERS - MIDDLE REGION (MS_3)

```
MAX   900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39
      + 2200 X40 - 1.08 X43 + X45
SUBJECT TO
   2)  X1 + X2 + X3 + X4 + X5 + X6 <=  .94
   3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=  .94
   4)  52 X1 + 63 X2 + 20 X3 + 40 X4 + 30 X5 + 60 X6 - X13 <=  60
   5)  80 X1 + 85 X2 + 42 X3 + 85 X4 + 43 X5 + 30 X6 - X14 <=  50
   6)  6 X1 + 6 X2 + 4 X3 + 7 X4 + 6 X5 + 7 X6 - X15 <=  20
   7)  8 X1 + 10 X2 + 6 X3 + 8 X4 + 3 X5 - X16 <=  0
   8)  45 X1 + 50 X2 + 40 X3 + 50 X4 + 40 X5 - X17 <=  40
   9)  98 X1 + 115 X2 + 55 X3 + 53 X4 + 50 X5 + 80 X6 - X18 <=  0
  10)  46 X1 + 60 X2 + 40 X4 + 60 X6 - X19 <=  0
  11)  42 X1 + 62 X2 + 28 X3 + 56 X4 + 36 X6 - X20 <=  0
  12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 <=  73.6
  13)  48 X6 + 57 X7 + 20 X8 + 92 X9 + 40 X10 + 13 X11 + 25 X12 - X21   <=  60
  14)  40 X6 + 82 X7 + 102 X8 + 115 X9 + 90 X10 + 53 X11 + 69 X12 - X22   <=  50
  15)  3 X6 + 8 X7 + 12 X8 + 7 X9 + 4 X10 + 4 X11 + 4 X12 - X23   <=  20
  16)  5 X6 + 10 X7 + 4 X8 + 4 X9 + 3 X10 + 2 X11 + 2 X12 - X24 <=  0
  17)  150 X6 + 60 X7 + 70 X9 - X25 <=  30
  18)  80 X6 + 87 X7 + 88 X8 + 90 X9 + 32 X10 + 35 X11 + 58 X12 - X26   <=  0
  19)  55 X6 + 57 X7 + 37 X9 + 21 X10 + 35 X11 - X27 <=  0
  20)  36 X6 + 37 X7 + 15 X8 + 24 X9 + 15 X12 - X28 <=  0
  21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12   <=  68
  22) - 50 X1 + X29 <=  0
  23) - 56 X2 + X30 <=  0
  24) - 14 X3 + X31 <=  0
  25) - 22 X4 + X32 <=  0
  26) - 19 X5 + X33 <=  0
  27)  X34 - 102 X6 <=  0
  28)  X35 - 52 X7 <=  0
  29)  X36 - 13 X8 <=  0
  30)  X37 - 19 X9 <=  0
  31)  X38 - 15 X10 <=  0
  32)  X39 - 11 X11 <=  0
  33)  X40 - 6 X12 <=  0
  34)  2600 X1 + 2800 X2 + 1500 X3 + 6000 X4 + 900 X5 + 4000 X6 + 45 X13 + 30 X14
       + 150 X15 + 250 X16 + 25 X17 + 10 X18 + 15 X19+ 9 X20 - X41 + X44 <=  3000
  35)  X45 + 7000 X6 + 2900 X7 + 1100 X8 + 7200 X9 + 1600 X10 + 1300 X11 + 1100
       X12 + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 10 X26 + 15 X27 + 9 X28
       - 570 X29 - 560 X30 - 1650 X31 - 1690 X32 - 550 X33 - X44 + 1.04 X42 =  0
  36)  X41 >=  0
  37) - X41 + X42 =  0
  38)  X43 - X41 + X42 =  0
  39)  X1 + X2 + X7 >=  .6
  40)  X4 <=  .2
  41)  X6 <=  .2
  42)  X9 <=  .15
END
```

SMALL FARMERS - MIDDLE REGION (MS_4)

```
MAX  900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39
     + 2200 X40 - 1.08 X43 + X45
.SUBJECT TO
   2)  X1 + X2 + X3 + X4 + X5 + X6 <=  .94
   3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=  .94
   4)  52 X1 + 63 X2 + 20 X3 + 40 X4 + 30 X5 + 60 X6 - X13 <=  60
   5)  80 X1 + 85 X2 + 42 X3 + 85 X4 + 43 X5 + 30 X6 - X14 <=  50
   6)  6 X1 + 6 X2 + 4 X3 + 7 X4 + 6 X5 + 7 X6 - X15 <=  20
   7)  8 X1 + 10 X2 + 6 X3 + 8 X4 + 3 X5 - X16 <=  0
   8)  45 X1 + 50 X2 + 40 X3 + 50 X4 + 40 X5 - X17 <=  40
   9)  98 X1 + 115 X2 + 55 X3 + 53 X4 + 50 X5 + 80 X6 - X18 <=  0
  10)  46 X1 + 60 X2 + 40 X4 + 60 X6 - X19 <=  0
  11)  42 X1 + 62 X2 + 28 X3 + 56 X4 + 36 X6 - X20 <=  0
  12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 40 X5 + 100 X6 <=  64.4
  13)  48 X6 + 57 X7 + 20 X8 + 92 X9 + 40 X10 + 13 X11 + 25 X12 - X21   <=  60
  14)  40 X6 + 82 X7 + 102 X8 + 115 X9 + 90 X10 + 53 X11 + 69 X12 - X22   <=  50
  15)  3 X6 + 8 X7 + 12 X8 + 7 X9 + 4 X10 + 4 X11 + 4 X12 - X23   <=  20
  16)  5 X6 + 10 X7 + 4 X8 + 4 X9 + 3 X10 + 2 X11 + 2 X12 - X24 <=  0
  17)  150 X6 + 60 X7 + 70 X9 - X25 <=  30
  18)  80 X6 + 87 X7 + 88 X8 + 90 X9 + 32 X10 + 35 X11 + 58 X12 - X26   <=  0
  19)  55 X6 + 57 X7 + 37 X9 + 21 X10 + 35 X11 - X27 <=  0
  20)  36 X6 + 37 X7 + 15 X8 + 24 X9 + 15 X12 - X28 <=  0
  21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12  <=  59.5
  22) - 50 X1 + X29 <=  0
  23) - 56 X2 + X30 <=  0
  24) - 14 X3 + X31 <=  0
  25) - 22 X4 + X32 <=  0
  26) - 19 X5 + X33 <=  0
  27)  X34 - 102 X6 <=  0
  28)  X35 - 52 X7 <=  0
  29)  X36 - 13 X8 <=  0
  30)  X37 - 19 X9 <=  0
  31)  X38 - 15 X10 <=  0
  32)  X39 - 11 X11 <=  0
  33)  X40 - 6 X12 <=  0
  34)  2600 X1 + 2800 X2 + 1500 X3 + 6000 X4 + 900 X5 + 4000 X6 + 45 X13 + 30 X14 +
       150 X15 + 250 X16 + 25 X17 + 10 X18 + 15 X19  + 9 X20 - X41 + X44 <=  3000
  35)  X45 + 7000 X6 + 2900 X7 + 1100 X8 + 7200 X9 + 1600 X10  + 1300 X11 + 1100
       X12 + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25  + 10 X26 + 15 X27 + 9
       X28 - 570 X29 - 560 X30 - 1650 X31 - 1690 X32 - 550 X33 - X44 + 1.04 X42 =   0
  36)  X41 >=  0
  37) - X41 + X42 =   0
  38)  X43 - X41 + X42 =  0
  39)  X1 + X2 + X7 >=  .6
  40)  X4 <=  .2
  41)  X6 <=  .2
  42)  X9 <=  .15
END
```

INPUT-OUTPUT MATRIX OF LARGE FARMERS- MIDDLE REGION (Page 1 of 5)

	KPA1D	KPA9D	KSFM	KSFH	KGNJ	KSUC	RPAD	RCOT	RCHI
KILD	1	1	1	1	1	1			
RILD							1	1	1
MLRK	62	69	20	23	47	50			
WLRK	85	91	44	52	99	24			
BLRK	2	2	3	3	5	7			
TPRK	12	12	7	8	8				
FYMK	50	50	50	50	60				
NFRK	118	130	60	60	53	85			
PFRK	59	60	0	0	41	65			
KFRK	54	62	32	34	60	35			
IWRK	125	125	45	45	45	100			
MLRR						65	61	24	95
WLRR						50	89	110	121
BLRR						2	2	13	6
TPRR						6	12	5	5
FYMR						150	65	0	80
NFRR						85	110	88	92
PFRR						55	57	0	37
KFRR						37	38	15	24
IWRR						100	150	70	60
KPA_1Y	-55								
KPA_9Y		-59							
KSMY			-15						
KSHY				-16					
KGNY					-23				
KSCY						-108			
RPAY							-52		
RCOY								-14	
RCHY									-19
RCPY									
RGGY									
RGIY									
CASK	2800	3000	1680	1590	2300	7500			
CASR						6000	3000	665	8000
BORK									
DEMK									
DEMR									
MIPA	1	1					1		
MSUC						1			
MGNT					1				
MCHI									1
MCOT								1	
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS- MIDDLE REGION (Page 2 of 5)

	RCOW	RGRG	RGIN	HMLK	HWLK	HBLK	HTPK	PFMK	PNFK
KILD									
RILD	1	1	1						
MLRK				-1					
WLRK					-1				
BLRK						-1			
TPRK							-1		
FYMK								-1	
NFRK									-1
PFRK									
KFRK									
IWRK									
MLRR	45	15	30						
WLRR	96	60	75						
BLRR	3	3	0						
TPRR	3	4	4						
FYMR	0	0	40						
NFRR	32	42	63						
PFRR	22	42	0						
KFRR	0	0	20						
IWRR	40	25	25						
KPA_1Y									
KPA_9Y									
KSMY									
KSHY									
KGNY									
KSCY									
RPAY									
RCOY									
RCHY									
RCPY	-15								
RGGY		-11							
RGIY			-7						
CASK				45	30	150	250	25	11
CASR	1500	1400	1100						
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MGNT									
MCHI									
MCOT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS- MIDDLE REGION (Page 3 of 5)

	PPFK	PKFK	HMLR	HWLR	HBLR	HTPR	PFMR	PNFR	PPFR
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK									
NFRK									
PFRK	-1								
KFRK		-1							
IWRK									
MLRR			-1						
WLRR				-1					
BLRR					-1				
TPRR						-1			
FYMR							-1		
NFRR								-1	
PFRR									-1
KFRR									
IWRR									
KPA$_1$Y									
KPA$_9$Y									
KSMY									
KSHY									
KGNY									
KSCY									
RPAY									
RCOY									
RCHY									
RCPY									
RGGY									
RGIY									
CASK	15	9							
CASR			45	30	150	250	25	11	15
BORK									
DEMK									
DEMR									
MIPA									
MSUC									
MGNT									
MCHI									
MCOT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS- MIDDLE REGION (Page 4 of 5)

	PKFR	SKP1A	SKP9A	SKSM	SKSH	SKGN	SKSC	SRPS	SRCO	SRCH
KILD										
RILD										
MLRK										
WLRK										
BLRK										
TPRK										
FYMK										
NFRK										
PFRK										
KFRK										
IWRK										
MLRR										
WLRR										
BLRR										
TPRR										
FYMR										
NFRR										
PFRR										
KFRR	-1									
IWRR										
KPA_1Y		1								
KPA_9Y			1							
KSMY				1						
KSHY					1					
KGNY						1				
KSCY							1			
RPAY								1		
RCOY									1	
RCHY										1
RCPY										
RGGY										
RGIY										
CASK										
CASR	9	-550	-560	-1600	-1680	-1700				
BORK										
DEMK										
DEMR										
MIPA										
MSUC										
MGNT										
MCHI										
MCOT										
Z							900	540	1750	2100

INPUT-OUTPUT MATRIX OF LARGE FARMERS- MIDDLE REGION (Page 5 of 5)

	SRCP	SRGG	SRGI	BORK	RKLR	RKLZ	KCTR	RCTZ	SIGN	COEF
KILD									<=	2.09
RILD									<=	2.09
MLRK									<=	0
WLRK									<=	0
BLRK									<=	0
TPRK									<=	0
FYMK									<=	40
NFRK									<=	0
PFRK									<=	0
KFRK									<=	0
IWRK									<=	200
MLRR									<=	0
WLRR									<=	0
BLRR									<=	0
TPRR									<=	0
FYMR									<=	40
NFRR									<=	0
PFRR									<=	0
KFRR									<=	0
IWRR									<=	160
KPA_1Y									<=	0
KPA_9Y									<=	0
KSMY									<=	0
KSHY									<=	0
KGNY									<=	0
KSCY									<=	0
RPAY									<=	0
RCOY									<=	0
RCHY									<=	0
RCPY	1								<=	0
RGGY		1							<=	0
RGIY			1						<=	0
CASK				-1			1		<=	10000
CASR					1.04		-1	1	=	0
BORK				1					>=	0
DEMK				-1	1				=	0
DEMR				-1	1	1			=	0
MIPA									>=	0.8
MSUC									<=	0.6
MGNT									<=	0.6
MCHI									<=	0.4
MCOT									<=	0.6
Z	1350	1500	2200			-1.08		1		

LARGE FARMERS - MIDDLE REGION (ML$_1$)

```
MAX   900 X34 + 550 X35 + 1750 X36 + 2100 X37 + 1350 X38 + 1500 X39 + 2200 X40 -
      1.08 X43 + X45
SUBJECT TO
  2)  X1 + X2 + X3 + X4 + X5 + X6 <=  2.09
  3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=  2.09
  4)  62 X1 + 69 X2 + 20 X3 + 23 X4 + 47 X5 + 50 X6 - X13 <=  0
  5)  85 X1 + 91 X2 + 44 X3 + 52 X4 + 99 X5 + 24 X6 - X14 <=  0
  6)  2 X1 + 2 X2 + 3 X3 + 3 X4 + 5 X5 + 7 X6 - X15 <=  0
  7)  12 X1 + 12 X2 + 7 X3 + 8 X4 + 8 X5 - X16 <=  0
  8)  50 X1 + 50 X2 + 50 X3 + 50 X4 + 60 X5 - X17 <=  40
  9)  118 X1 + 130 X2 + 60 X3 + 60 X4 + 53 X5 + 85 X6 - X18 <=  0
 10)  59 X1 + 60 X2 + 41 X5 + 65 X6 - X19 <=  0
 11)  54 X1 + 62 X2 + 32 X3 + 34 X4 + 60 X5 + 35 X6 - X20 <=  0
 12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 100 X6 <=  200
 13)  65 X6 + 61 X7 + 24 X8 + 95 X9 + 45 X10 + 15 X11 + 30 X12 - X21   <=  0
 14)  50 X6 + 89 X7 + 110 X8 + 121 X9 + 96 X10 + 60 X11 + 75 X12 - X22   <=  0
 15)  2 X6 + 2 X7 + 13 X8 + 6 X9 + 3 X10 + 3 X11 - X23 <=  0
 16)  6 X6 + 12 X7 + 5 X8 + 5 X9 + 3 X10 + 4 X11 + 4 X12 - X24 <=  0
 17)  150 X6 + 65 X7 + 80 X9 + 40 X12 - X25 <=  40
 18)  80 X6 + 110 X7 + 88 X8 + 92 X9 + 32 X10 + 42 X11 + 63 X12 - X26   <=  0
 19)  56 X6 + 57 X7 + 37 X9 + 22 X10 + 42 X11 - X27 <=  0
 20)  37 X6 + 38 X7 + 15 X8 + 24 X9 + 20 X12 - X28 <=  0
 21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12   <=  160
 22) - 55 X1 + X29 <=  0
 23) - 59 X2 + X30 <=  0
 24) - 15 X3 + X31 <=  0
 25) - 16 X4 + X32 <=  0
 26) - 23 X5 + X33 <=  0
 27)  X34 - 108 X6 <=  0
 28)  X35 - 62.5 X7 <=  0
 29)  X36 - 16 X8 <=  0
 30)  X37 - 19 X9 <=  0
 31)  X38 - 15 X10 <=  0
 32)  X39 - 11 X11 <=  0
 33)  X40 - 7.7 X12 <=  0
 34)  2800 X1 + 3000 X2 + 1680 X3 + 1590 X4 + 2300 X5 + 7500 X6 + 45 X13 + 30 X14
      + 150 X15 + 250 X16 + 25 X17 + 11 X18 + 15 X19 + 9 X20 - X41 + X44 <=  10000
 35)  X45 + 6000 X6 + 3000 X7 + 665 X8 + 800 X9 + 1500 X10 + 1400 X11 + 1100 X12
      + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 11 X26 + 15 X27 + 9 X28 -
      550 X29 - 560 X30 - 1620 X31 - 1680 X32 - 1700 X33 - X44 + 1.04 X42 =   0
 36)  X41 >=  0
 37) - X41 + X42 =   0
 38)  X43 - X41 + X42 =   0
 39)  X1 + X2 + X7 >=  .8
 40)  X5 <=  .6
 41)  X8 <=  .6
 42)  X9 <=  .4
 43)  X6 <=  .6
END
```

LARGE FARMERS - MIDDLE REGION (ML_2)

MAX 900 X34 + 550 X35 + 1750 X36 + 2100 X37 + 1350 X38 + 1500 X39 + 2200 X40 - 1.08 X43 + X45

SUBJECT TO

2) X1 + X2 + X3 + X4 + X5 + X6 <= 2.09

3) X6 + X7 + X8 + X9 + X10 + X11 + X12 <= 2.09

4) 62 X1 + 69 X2 + 20 X3 + 23 X4 + 47 X5 + 50 X6 - X13 <= 0

5) 85 X1 + 91 X2 + 44 X3 + 52 X4 + 99 X5 + 24 X6 - X14 <= 0

6) 2 X1 + 2 X2 + 3 X3 + 3 X4 + 5 X5 + 7 X6 - X15 <= 0

7) 12 X1 + 12 X2 + 7 X3 + 8 X4 + 8 X5 - X16 <= 0

8) 50 X1 + 50 X2 + 50 X3 + 50 X4 + 60 X5 - X17 <= 40

9) 118 X1 + 130 X2 + 60 X3 + 60 X4 + 53 X5 + 85 X6 - X18 <= 0

10) 59 X1 + 60 X2 + 41 X5 + 65 X6 - X19 <= 0

11) 54 X1 + 62 X2 + 32 X3 + 34 X4 + 60 X5 + 35 X6 - X20 <= 0

12) 125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 100 X6 <= 180

13) 65 X6 + 61 X7 + 24 X8 + 95 X9 + 45 X10 + 15 X11 + 30 X12 - X21 <= 0

14) 50 X6 + 89 X7 + 110 X8 + 121 X9 + 96 X10 + 60 X11 + 75 X12 - X22 <= 0

15) 2 X6 + 2 X7 + 13 X8 + 6 X9 + 3 X10 + 3 X11 - X23 <= 0

16) 6 X6 + 12 X7 + 5 X8 + 5 X9 + 3 X10 + 4 X11 + 4 X12 - X24 <= 0

17) 150 X6 + 65 X7 + 80 X9 + 40 X12 - X25 <= 40

18) 80 X6 + 110 X7 + 88 X8 + 92 X9 + 32 X10 + 42 X11 + 63 X12 - X26 <= 0

19) 56 X6 + 57 X7 + 37 X9 + 22 X10 + 42 X11 - X27 <= 0

20) 37 X6 + 38 X7 + 15 X8 + 24 X9 + 20 X12 - X28 <= 0

21) 100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12 <= 144

22) - 55 X1 + X29 <= 0

23) - 59 X2 + X30 <= 0

24) - 15 X3 + X31 <= 0

25) - 16 X4 + X32 <= 0

26) - 23 X5 + X33 <= 0

27) X34 - 108 X6 <= 0

28) X35 - 62.5 X7 <= 0

29) X36 - 16 X8 <= 0

30) X37 - 19 X9 <= 0

31) X38 - 15 X10 <= 0

32) X39 - 11 X11 <= 0

33) X40 - 7.7 X12 <= 0

34) 2800 X1 + 3000 X2 + 1680 X3 + 1590 X4 + 2300 X5 + 7500 X6 + 45 X13 + 30 X14 + 150 X15 + 250 X16 + 25 X17 + 11 X18 + 15 X19 + 9 X20 - X41 + X44 <= 10000

35) X45 + 6000 X6 + 3000 X7 + 665 X8 + 800 X9 + 1500 X10 + 1400 X11 + 1100 X12 + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 11 X26 + 15 X27 + 9 X28 - 550 X29 - 560 X30 - 1620 X31 - 1680 X32 - 1700 X33 - X44 + 1.04 X42 = 0

36) X41 >= 0

37) - X41 + X42 = 0

38) X43 - X41 + X42 = 0

39) X1 + X2 + X7 >= .8

40) X5 <= .6

41) X8 <= .6

42) X9 <= .4

43) X6 <= .6

END

LARGE FARMERS - MIDDLE REGION (ML_3)

```
MAX   900 X34 + 550 X35 + 1750 X36 + 2100 X37 + 1350 X38 + 1500 X39  + 2200 X40 -
      1.08 X43 + X45
SUBJECT TO
      2)  X1 + X2 + X3 + X4 + X5 + X6 <=   2.09
      3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=   2.09
      4)  62 X1 + 69 X2 + 20 X3 + 23 X4 + 47 X5 + 50 X6 - X13 <=   0
      5)  85 X1 + 91 X2 + 44 X3 + 52 X4 + 99 X5 + 24 X6 - X14 <=   0
      6)  2 X1 + 2 X2 + 3 X3 + 3 X4 + 5 X5 + 7 X6 - X15 <=   0
      7)  12 X1 + 12 X2 + 7 X3 + 8 X4 + 8 X5 - X16 <=   0
      8)  50 X1 + 50 X2 + 50 X3 + 50 X4 + 60 X5 - X17 <=   40
      9)  118 X1 + 130 X2 + 60 X3 + 60 X4 + 53 X5 + 85 X6 - X18 <=   0
     10)  59 X1 + 60 X2 + 41 X5 + 65 X6 - X19 <=   0
     11)  54 X1 + 62 X2 + 32 X3 + 34 X4 + 60 X5 + 35 X6 - X20 <=   0
     12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 100 X6 <=   160
     13)  65 X6 + 61 X7 + 24 X8 + 95 X9 + 45 X10 + 15 X11 + 30 X12 - X21     <=   0
     14)  50 X6 + 89 X7 + 110 X8 + 121 X9 + 96 X10 + 60 X11 + 75 X12 - X22     <=   0
     15)  2 X6 + 2 X7 + 13 X8 + 6 X9 + 3 X10 + 3 X11 - X23 <=   0
     16)  6 X6 + 12 X7 + 5 X8 + 5 X9 + 3 X10 + 4 X11 + 4 X12 - X24 <=   0
     17)  150 X6 + 65 X7 + 80 X9 + 40 X12 - X25 <=   40
     18)  80 X6 + 110 X7 + 88 X8 + 92 X9 + 32 X10 + 42 X11 + 63 X12 - X26     <=   0
     19)  56 X6 + 57 X7 + 37 X9 + 22 X10 + 42 X11 - X27 <=   0
     20)  37 X6 + 38 X7 + 15 X8 + 24 X9 + 20 X12 - X28 <=   0
     21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12     <=   128
     22) - 55 X1 + X29 <=   0
     23) - 59 X2 + X30 <=   0
     24) - 15 X3 + X31 <=   0
     25) - 16 X4 + X32 <=   0
     26) - 23 X5 + X33 <=   0
     27)  X34 - 108 X6 <=   0
     28)  X35 - 62.5 X7 <=   0
     29)  X36 - 16 X8 <=   0
     30)  X37 - 19 X9 <=   0
     31)  X38 - 15 X10 <=   0
     32)  X39 - 11 X11 <=   0
     33)  X40 - 7.7 X12 <=   0
     34)  2800 X1 + 3000 X2 + 1680 X3 + 1590 X4 + 2300 X5 + 7500 X6+ 45 X13 + 30 X14
          + 150 X15 + 250 X16 + 25 X17 + 11 X18 + 15 X19 + 9 X20 - X41 + X44 <=10000
     35)  X45 + 6000 X6 + 3000 X7 + 665 X8 + 800 X9 + 1500 X10 + 1400 X11 + 1100 X12
          + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 11 X26 + 15 X27 + 9 X28 -
          550 X29 - 560 X30 - 1620 X31 - 1680 X32 - 1700 X33 - X44 + 1.04 X42 =    0
     36)  X41 >=   0
     37) - X41 + X42 =    0
     38)  X43 - X41 + X42 =    0
     39)  X1 + X2 + X7 >=   .8
     40)  X5 <=   .6
     41)  X8 <=   .6
     42)  X9 <=   .4
     43)  X6 <=   .6
END
```

LARGE FARMERS - MIDDLE REGION (ML_4)

```
MAX   900 X34 + 550 X35 + 1750 X36 + 2100 X37 + 1350 X38 + 1500 X39 + 2200 X40 -
      1.08 X43 + X45
SUBJECT TO
    2)  X1 + X2 + X3 + X4 + X5 + X6 <=   2.09
    3)  X6 + X7 + X8 + X9 + X10 + X11 + X12 <=   2.09
    4)  62 X1 + 69 X2 + 20 X3 + 23 X4 + 47 X5 + 50 X6 - X13 <=   0
    5)  85 X1 + 91 X2 + 44 X3 + 52 X4 + 99 X5 + 24 X6 - X14 <=   0
    6)  2 X1 + 2 X2 + 3 X3 + 3 X4 + 5 X5 + 7 X6 - X15 <=   0
    7)  12 X1 + 12 X2 + 7 X3 + 8 X4 + 8 X5 - X16 <=   0
    8)  50 X1 + 50 X2 + 50 X3 + 50 X4 + 60 X5 - X17 <=   40
    9)  118 X1 + 130 X2 + 60 X3 + 60 X4 + 53 X5 + 85 X6 - X18 <=   0
   10)  59 X1 + 60 X2 + 41 X5 + 65 X6 - X19 <=   0
   11)  54 X1 + 62 X2 + 32 X3 + 34 X4 + 60 X5 + 35 X6 - X20 <=   0
   12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 100 X6 <=   140
   13)  65 X6 + 61 X7 + 24 X8 + 95 X9 + 45 X10 + 15 X11 + 30 X12 - X21     <=   0
   14)  50 X6 + 89 X7 + 110 X8 + 121 X9 + 96 X10 + 60 X11 + 75 X12 - X22     <=   0
   15)  2 X6 + 2 X7 + 13 X8 + 6 X9 + 3 X10 + 3 X11 - X23 <=   0
   16)  6 X6 + 12 X7 + 5 X8 + 5 X9 + 3 X10 + 4 X11 + 4 X12 - X24 <=   0
   17)  150 X6 + 65 X7 + 80 X9 + 40 X12 - X25 <=   40
   18)  80 X6 + 110 X7 + 88 X8 + 92 X9 + 32 X10 + 42 X11 + 63 X12 - X26     <=   0
   19)  56 X6 + 57 X7 + 37 X9 + 22 X10 + 42 X11 - X27 <=   0
   20)  37 X6 + 38 X7 + 15 X8 + 24 X9 + 20 X12 - X28 <=   0
   21)  100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12     <=   112
   22) - 55 X1 + X29 <=   0
   23) - 59 X2 + X30 <=   0
   24) - 15 X3 + X31 <=   0
   25) - 16 X4 + X32 <=   0
   26) - 23 X5 + X33 <=   0
   27)  X34 - 108 X6 <=   0
   28)  X35 - 62.5 X7 <=   0
   29)  X36 - 16 X8 <=   0
   30)  X37 - 19 X9 <=   0
   31)  X38 - 15 X10 <=   0
   32)  X39 - 11 X11 <=   0
   33)  X40 - 7.7 X12 <=   0
   34)  2800 X1 +3000 X2 +1680 X3 +1590 X4 +2300 X5 + 7500 X6 + 45 X13 + 30 X14 +
       150 X15 + 250 X16 + 25 X17 + 11 X18 + 15 X19 + 9 X20 - X41 + X44 <=   10000
   35)  X45 + 6000 X6 + 3000 X7 + 665 X8 + 800 X9 + 1500 X10 + 1400 X11+ 1100 X12
       + 45 X21 + 30 X22 + 150 X23 + 250 X24 + 25 X25 + 11 X26 + 15 X27 + 9 X28 -
       550 X29 - 560 X30 - 1620 X31 - 1680 X32 - 1700 X33- X44 + 1.04 X42 =   0
   36)  X41 >=   0
   37) - X41 + X42 =   0
   38)  X43 - X41 + X42 =   0
   39)  X1 + X2 + X7 >=   .8
   40)  X5 <=   .6
   41)  X8 <=   .6
   42)  X9 <=   .4
   43)  X6 <=   .6
END
```

INPUT-OUTPUT MATRIX OF SMALL FARMERS- TAIL REGION (Page 1 of 4)

	KPA1D	KSFM	KGNJ	KBRI	RPAD	RCOT	RGRG	RGIN	HMLK	HWLK
KILD	1	1	1	1						
RILD					1	1	1	1		
MLRK	52	20	40	60					-1	
WLRK	77	41	98	69						-1
BLRK	6	3	6	7						
TPRK	8	7	7	6						
FYMK	45	40	50	60						
NFRK	118	69	57	52						
PFRK	59	0	46	68						
KFRK	54	48	51	55						
IWRK	125	45	45	55						
MLRR					59	20	16	23		
WLRR					89	102	59	71		
BLRR					7	11	4	5		
TPRR					6	6	2	2		
FYMR					50	0	0	40		
NFRR					111	92	35	63		
PFRR					57	58	35	0		
KFRR					38	21	0	23		
IWRR					150	70	25	25		
KPA_1Y	-53									
KSMY		-12								
KGNY			-20							
KBRY				-160						
RPAY					-50					
RCOY						-17				
RGGY							-12			
RGIY								-8		
CASK	2700	1600	5500	3380					50	30
CASR					2700	1450	895	1100		
BORK										
DEMK										
DEMR										
MIPA	1				1					
MBRI				1						
MCOT						1				
Z										

INPUT-OUTPUT MATRIX OF SMALL FARMERS- TAIL REGION (Page 2 of 4)

	HBLK	HTPK	PFMK	PNFK	PPFK	PKFK	HMLR	HWLR	HBLR	HTPR
KILD										
RILD										
MLRK										
WLRK										
BLRK	-1									
TPRK		-1								
FYMK			-1							
NFRK				-1						
PFRK					-1					
KFRK						-1				
IWRK										
MLRR							-1			
WLRR								-1		
BLRR									-1	
TPRR										-1
FYMR										
NFRR										
PFRR										
KFRR										
IWRR										
KPA_1Y										
KSMY										
KGNY										
KBRY										
RPAY										
RCOY										
RGGY										
RGIY										
CASK	150	300	25	10	15	9				
CASR							50	30	150	300
BORK										
DEMK										
DEMR										
MIPA										
MBRI										
MCOT										
Z										

INPUT-OUTPUT MATRIX OF SMALL FARMERS- TAIL REGION (Page 3 of 4)

	PFMR	PNFR	PPFR	PKFR	SKP1A	SKSM	SKGN	SKBR	SRPS	SRCO
KILD										
RILD										
MLRK										
WLRK										
BLRK										
TPRK										
FYMK										
NFRK										
PFRK										
KFRK										
IWRK										
MLRR										
WLRR										
BLRR										
TPRR										
FYMR	-1									
NFRR		-1								
PFRR			-1							
KFRR				-1						
IWRR										
KPA$_1$Y					1					
KSMY						1				
KGNY							1			
KBRY								1		
RPAY									1	
RCOY										1
RGGY										
RGIY										
CASK										
CASR	25	10	15	9	-560	-1550	-1750	-250		
BORK										
DEMK										
DEMR										
MIPA										
MBRI										
MCOT										
Z									550	1750

INPUT-OUTPUT MATRIX OF SMALL FARMERS- TAIL REGION (Page 4 of 4)

	SRGG	SRGI	BORK	RKLR	RKLZ	KCTR	RCTZ	SIGN	COEF
KILD								<=	0.93
RILD								<=	0.93
MLRK								<=	50
WLRK								<=	50
BLRK								<=	15
TPRK								<=	0
FYMK								<=	40
NFRK								<=	0
PFRK								<=	0
KFRK								<=	0
IWRK								<=	75
MLRR								<=	40
WLRR								<=	40
BLRR								<=	15
TPRR								<=	0
FYMR								<=	35
NFRR								<=	0
PFRR								<=	0
KFRR								<=	0
IWRR								<=	70
$KPA_{I}Y$								<=	0
KSMY								<=	0
KGNY								<=	0
KBRY								<=	0
RPAY								<=	0
RCOY								<=	0
RGGY	1							<=	0
RGIY		1						<=	0
CASK			-1			1		<=	3500
CASR				1.04		-1	1	=	0
BORK			1					>=	0
DEMK			-1	1				=	0
DEMR			-1	1	1			=	0
MIPA								>=	0.4
MBRI								<=	0.4
MCOT								<=	0.4
Z	1600	2000			-1.08		1		

SMALL FARMERS - TAIL REGION (TS_1)

```
MAX     550 X29 + 1750 X30 + 1600 X31 + 2000 X32 - 1.08 X35 + X37
SUBJECT TO
      2)  X1 + X2 + X3 + X4 <=   .93
      3)  X5 + X6 + X7 + X8 <=   .93
      4)  52 X1 + 20 X2 + 40 X3 + 60 X4 - X9 <=   50
      5)  77 X1 + 41 X2 + 98 X3 + 69 X4 - X10 <=   50
      6)  6 X1 + 3 X2 + 6 X3 + 7 X4 - X11 <=   15
      7)  8 X1 + 7 X2 + 7 X3 + 6 X4 - X12 <=   0
      8)  45 X1 + 40 X2 + 50 X3 + 60 X4 - X13 <=   40
      9)  118 X1 + 69 X2 + 57 X3 + 52 X4 - X14 <=   0
     10)  59 X1 + 46 X3 + 68 X4 - X15 <=   0
     11)  54 X1 + 48 X2 + 51 X3 + 55 X4 - X16 <=   0
     12)  125 X1 + 45 X2 + 45 X3 + 55 X4 <=   75
     13)  59 X5 + 20 X6 + 16 X7 + 23 X8 - X17 <=   40
     14)  89 X5 + 102 X6 + 59 X7 + 71 X8 - X18 <=   40
     15)  7 X5 + 11 X6 + 4 X7 + 5 X8 - X19 <=   15
     16)  6 X5 + 6 X6 + 2 X7 + 2 X8 - X20 <=   0
     17)  50 X5 + 40 X8 - X21 <=   35
     18)  111 X5 + 92 X6 + 35 X7 + 63 X8 - X22 <=   0
     19)  57 X5 + 58 X6 + 35 X7 - X23 <=   0
     20)  38 X5 + 21 X6 + 23 X8 - X24 <=   0
     21)  150 X5 + 70 X6 + 25 X7 + 25 X8 <=   70
     22) - 53 X1 + X25 <=   0
     23) - 12 X2 + X26 <=   0
     24) - 20 X3 + X27 <=   0
     25) - 120 X4 + X28 <=   0
     26)  X29 - 50 X5 <=   0
     27)  X30 - 17 X6 <=   0
     28)  X31 - 12 X7 <=   0
     29)  X32 - 8 X8 <=   0
     30)  2700 X1 + 1600 X2 + 5500 X3 + 3380 X4 + 50 X9 + 30 X10 + 150 X11+ 300 X12
        + 25 X13 + 10 X14 + 15 X15 + 9 X16 - X33 + X36 <=   3500
     31)  X37 + 2700 X5 + 1450 X6 + 895 X7 + 1100 X8 + 50 X17 + 30 X18 + 150 X19 +
        300 X20 + 25 X21 + 10 X22 + 15 X23 + 9 X24 - 560 X25 - 1550 X26 - 1750 X27 -
        300 X28 - X36 + 1.04 X34 =    0
     32)  X33 >=   0
     33) - X33 + X34 =    0
     34)  X35 - X33 + X34 =    0
     35)  X1 + X5 >=   .4
     36)  X6 <=   .4
     37)  X4 <=   .4
END
```

SMALL FARMERS - TAIL REGION (TS_2)

```
MAX     550 X29 + 1750 X30 + 1600 X31 + 2000 X32 - 1.08 X35 + X37
SUBJECT TO
     2)  X1 + X2 + X3 + X4 <=  .93
     3)  X5 + X6 + X7 + X8 <=  .93
     4)  52 X1 + 20 X2 + 40 X3 + 60 X4 - X9 <=  50
     5)  77 X1 + 41 X2 + 98 X3 + 69 X4 - X10 <=  50
     6)  6 X1 + 3 X2 + 6 X3 + 7 X4 - X11 <=  15
     7)  8 X1 + 7 X2 + 7 X3 + 6 X4 - X12 <=  0
     8)  45 X1 + 40 X2 + 50 X3 + 60 X4 - X13 <= 40
     9)  118 X1 + 69 X2 + 57 X3 + 52 X4 - X14 <=  0
    10)  59 X1 + 46 X3 + 68 X4 - X15 <=  0
    11)  54 X1 + 48 X2 + 51 X3 + 55 X4 - X16 <=  0
    12)  125 X1 + 45 X2 + 45 X3 + 55 X4 <=  67.5
    13)  59 X5 + 20 X6 + 16 X7 + 23 X8 - X17 <=  40
    14)  89 X5 + 102 X6 + 59 X7 + 71 X8 - X18 <=  40
    15)  7 X5 + 11 X6 + 4 X7 + 5 X8 - X19 <=  15
    16)  6 X5 + 6 X6 + 2 X7 + 2 X8 - X20 <=  0
    17)  50 X5 + 40 X8 - X21 <=  35
    18)  111 X5 + 92 X6 + 35 X7 + 63 X8 - X22 <=  0
    19)  57 X5 + 58 X6 + 35 X7 - X23 <=  0
    20)  38 X5 + 21 X6 + 23 X8 - X24 <=  0
    21)  150 X5 + 70 X6 + 25 X7 + 25 X8 <=  63
    22) - 53 X1 + X25 <= 0
    23) - 12 X2 + X26 <= 0
    24) - 20 X3 + X27 <= 0
    25) - 120 X4 + X28 <= 0
    26)  X29 - 50 X5 <=  0
    27)  X30 - 17 X6 <=  0
    28)  X31 - 12 X7 <=  0
    29)  X32 - 8 X8 <=  0
    30)  2700 X1 + 1600 X2 + 5500 X3 + 3380 X4 + 50 X9 + 30 X10 + 150 X11 + 300 X12
       + 25 X13 + 10 X14 + 15 X15 + 9 X16 - X33 + X36 <=  3500
    31)  X37 + 2700 X5 + 1450 X6 + 895 X7 + 1100 X8 + 50 X17 + 30 X18 + 150 X19 +
       300 X20 + 25 X21 + 10 X22 + 15 X23 + 9 X24 - 560 X25 - 1550 X26 - 1750 X27 -
       300 X28 - X36 + 1.04 X34 =  0
    32)  X33 >=  0
    33) - X33 + X34 = 0
    34)  X35 - X33 + X34 =  0
    35)  X1 + X5 >=  .4
    36)  X6 <=  .4
    37)  X4 <=  .4
END
```

SMALL FARMERS - TAIL REGION (TS_3)

```
MAX    550 X29 + 1750 X30 + 1600 X31 + 2000 X32 - 1.08 X35 + X37
SUBJECT TO
     2)  X1 + X2 + X3 + X4 <=  .93
     3)  X5 + X6 + X7 + X8 <=  .93
     4)  52 X1 + 20 X2 + 40 X3 + 60 X4 - X9 <=  50
     5)  77 X1 + 41 X2 + 98 X3 + 69 X4 - X10 <=  50
     6)  6 X1 + 3 X2 + 6 X3 + 7 X4 - X11 <=  15
     7)  8 X1 + 7 X2 + 7 X3 + 6 X4 - X12 <=  0
     8)  45 X1 + 40 X2 + 50 X3 + 60 X4 - X13 <=  40
     9)  118 X1 + 69 X2 + 57 X3 + 52 X4 - X14 <=  0
    10)  59 X1 + 46 X3 + 68 X4 - X15 <=  0
    11)  54 X1 + 48 X2 + 51 X3 + 55 X4 - X16 <=  0
    12)  125 X1 + 45 X2 + 45 X3 + 55 X4 <=  60
    13)  59 X5 + 20 X6 + 16 X7 + 23 X8 - X17 <=  40
    14)  89 X5 + 102 X6 + 59 X7 + 71 X8 - X18 <=  40
    15)  7 X5 + 11 X6 + 4 X7 + 5 X8 - X19 <=  15
    16)  6 X5 + 6 X6 + 2 X7 + 2 X8 - X20 <=  0
    17)  50 X5 + 40 X8 - X21 <=  35
    18)  111 X5 + 92 X6 + 35 X7 + 63 X8 - X22 <=  0
    19)  57 X5 + 58 X6 + 35 X7 - X23 <=  0
    20)  38 X5 + 21 X6 + 23 X8 - X24 <=  0
    21)  150 X5 + 70 X6 + 25 X7 + 25 X8 <=  56
    22) - 53 X1 + X25 <=  0
    23) - 12 X2 + X26 <=  0
    24) - 20 X3 + X27 <=  0
    25) - 120 X4 + X28 <=  0
    26)  X29 - 50 X5 <=  0
    27)  X30 - 17 X6 <=  0
    28)  X31 - 12 X7 <=  0
    29)  X32 - 8 X8 <=  0
    30)  2700 X1 + 1600 X2 + 5500 X3 + 3380 X4 + 50 X9 + 30 X10 + 150 X11 + 300 X12
        + 25 X13 + 10 X14 + 15 X15 + 9 X16 - X33 + X36 <=  3500
    31)  X37 + 2700 X5 + 1450 X6 + 895 X7 + 1100 X8 + 50 X17 + 30 X18  + 150 X19 +
        300 X20 + 25 X21 + 10 X22 + 15 X23 + 9 X24 - 560 X25 - 1550 X26 - 1750 X27 -
        300 X28 - X36 + 1.04 X34 =   0
    32)  X33 >=  0
    33) - X33 + X34 =   0
    34)  X35 - X33 + X34 =   0
    35)  X1 + X5 >=  .4
    36)  X6 <=  .4
    37)  X4 <=  .4
END
```

SMALL FARMERS - TAIL REGION (TS$_4$)

```
MAX     550 X29 + 1750 X30 + 1600 X31 + 2000 X32 - 1.08 X35 + X37
SUBJECT TO
     2)  X1 + X2 + X3 + X4 <=  .93
     3)  X5 + X6 + X7 + X8 <=  .93
     4)  52 X1 + 20 X2 + 40 X3 + 60 X4 - X9 <=   50
     5)  77 X1 + 41 X2 + 98 X3 + 69 X4 - X10 <=   50
     6)  6 X1 + 3 X2 + 6 X3 + 7 X4 - X11 <=   15
     7)  8 X1 + 7 X2 + 7 X3 + 6 X4 - X12 <=   0
     8)  45 X1 + 40 X2 + 50 X3 + 60 X4 - X13 <=   40
     9)  118 X1 + 69 X2 + 57 X3 + 52 X4 - X14 <=   0
    10)  59 X1 + 46 X3 + 68 X4 - X15 <=   0
    11)  54 X1 + 48 X2 + 51 X3 + 55 X4 - X16 <=   0
    12)  125 X1 + 45 X2 + 45 X3 + 55 X4 <=   52.5
    13)  59 X5 + 20 X6 + 16 X7 + 23 X8 - X17 <=   40
    14)  89 X5 + 102 X6 + 59 X7 + 71 X8 - X18 <=   40
    15)  7 X5 + 11 X6 + 4 X7 + 5 X8 - X19 <=   15
    16)  6 X5 + 6 X6 + 2 X7 + 2 X8 - X20 <=   0
    17)  50 X5 + 40 X8 - X21 <=   35
    18)  111 X5 + 92 X6 + 35 X7 + 63 X8 - X22 <=   0
    19)  57 X5 + 58 X6 + 35 X7 - X23 <=   0
    20)  38 X5 + 21 X6 + 23 X8 - X24 <=   0
    21)  150 X5 + 70 X6 + 25 X7 + 25 X8 <=   49
    22) - 53 X1 + X25 <=   0
    23) - 12 X2 + X26 <=   0
    24) - 20 X3 + X27 <=   0
    25) - 120 X4 + X28 <=   0
    26)  X29 - 50 X5 <=   0
    27)  X30 - 17 X6 <=   0
    28)  X31 - 12 X7 <=   0
    29)  X32 - 8 X8 <=   0
    30)  2700 X1 + 1600 X2 + 5500 X3 + 3380 X4 + 50 X9 + 30 X10 + 150 X11 + 300 X12
       + 25 X13 + 10 X14 + 15 X15 + 9 X16 - X33 + X36 <=   3500
    31)  X37 + 2700 X5 + 1450 X6 + 895 X7 + 1100 X8 + 50 X17 + 30 X18 + 150 X19 +
       300 X20 + 25 X21 + 10 X22 + 15 X23 + 9 X24 - 560 X25 - 1550 X26 - 1750 X27 -
       300 X28 - X36 + 1.04 X34 =    0
    32)  X33 >=   0
    33) - X33 + X34 =    0
    34)  X35 - X33 + X34 =    0
    35)  X1 + X5 >=   .4
    36)  X6 <=   .4
    37)  X4 <=   .4
END
```

INPUT-OUTPUT MATRIX OF LARGE FARMERS - TAIL REGION (Page 1 of 5)

	KPA1D	KPA9D	KSFM	KSFH	KGNJ	KBRI	RPAD	RCOT	RGRG
KILD	1	1	1	1	1	1			
RILD							1	1	1
MLRK	55	64	22	24	45	65			
WLRK	80	92	42	55	103	72			
BLRK	2	3	3	3	5	6			
TPRK	10	11	8	7	8	8			
FYMK	50	55	45	50	55	80			
NFRK	130	137	88	88	58	53			
PFRK	78	79	0	0	52	68			
KFRK	77	81	50	48	51	56			
IWRK	125	125	45	45	45	55			
MLRR							63	23	18
WLRR							92	108	62
BLRR							3	10	3
TPRR							10	6	4
FYMR							55	0	0
NFRR							118	92	35
PFRR							60	59	35
KFRR							38	21	0
IWRR							150	70	25
KPA_1Y	-51								
KPA_9Y		-53							
KSMY			-11						
KSHY				-12					
KGNY					-21				
KBRY						-159			
RPAY							-50		
RCOY								-19	
RGGY									-13
RGIY									
CASK	2300	2450	1250	1800	5200	3500			
CASR							2700	1500	1150
BORK									
DEMK									
DEMR									
MIPA	1	1					1		
MBRI						1			
MCOT								1	
MGNT					1				
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - TAIL REGION (Page 2 of 5)

	RGIN	HMLK	HWLK	HBLK	HTPK	PFMK	PNFK	PPFK	PKFK
KILD									
RILD	1								
MLRK		-1							
WLRK			-1						
BLRK				-1					
TPRK					-1				
FYMK						-1			
NFRK							-1		
PFRK								-1	
KFRK									-1
IWRK									
MLRR	28								
WLRR	72								
BLRR	4								
TPRR	3								
FYMR	40								
NFRR	63								
PFRR	0								
KFRR	23								
IWRR	25								
KPA_1Y									
KPA_9Y									
KSMY									
KSHY									
KGNY									
KBRY									
RPAY									
RCOY									
RGGY									
RGIY	-8								
CASK		50	30	150	300	25	10	15	9
CASR	1200								
BORK									
DEMK									
DEMR									
MIPA									
MBRI									
MCOT									
MGNT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - TAIL REGION (Page 3 of 5)

	HMLR	HWLR	HBLR	HTPR	PFMR	PNFR	PPFR	PKFR	SKP1A
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK									
NFRK									
PFRK									
KFRK									
IWRK									
MLRR	-1								
WLRR		-1							
BLRR			-1						
TPRR				-1					
FYMR					-1				
NFRR						-1			
PFRR							-1		
KFRR								-1	
IWRR									
KPA_1Y									1
KPA_9Y									
KSMY									
KSHY									
KGNY									
KBRY									
RPAY									
RCOY									
RGGY									
RGIY									
CASK									
CASR	50	30	150	300	25	10	15	9	-560
BORK									
DEMK									
DEMR									
MIPA									
MBRI									
MCOT									
MGNT									
Z									

INPUT-OUTPUT MATRIX OF LARGE FARMERS - TAIL REGION (Page 4 of 5)

	SKP9A	SKSM	SKSH	SKGN	SKBR	SRPS	SRCO	SRGG	SRGI
KILD									
RILD									
MLRK									
WLRK									
BLRK									
TPRK									
FYMK									
NFRK									
PFRK									
KFRK									
IWRK									
MLRR									
WLRR									
BLRR									
TPRR									
FYMR									
NFRR									
PFRR									
KFRR									
IWRR									
KPA_1Y									
KPA_9Y	1								
KSMY		1							
KSHY			1						
KGNY				1					
KBRY					1				
RPAY						1			
RCOY							1		
RGGY								1	
RGIY									1
CASK									
CASR	-580	-1600	-1700	-1750	-300				
BORK									
DEMK									
DEMR									
MIPA									
MBRI									
MCOT									
MGNT									
Z						560	1750	1600	2100

INPUT-OUTPUT MATRIX OF LARGE FARMERS - TAIL REGION (Page 5 of 5)

	BORK	RKLR	RKLZ	KCTR	RCTZ	SIGN	COEF
KILD						<=	2.01
RILD						<=	2.01
MLRK						<=	0
WLRK						<=	0
BLRK						<=	0
TPRK						<=	0
FYMK						<=	40
NFRK						<=	0
PFRK						<=	0
KFRK						<=	0
IWRK						<=	182
MLRR						<=	0
WLRR						<=	0
BLRR						<=	0
TPRR						<=	0
FYMR						<=	35
NFRR						<=	0
PFRR						<=	0
KFRR						<=	0
IWRR						<=	140
KPA_1Y						<=	0
KPA_9Y						<=	0
KSMY						<=	0
KSHY						<=	0
KGNY						<=	0
KBRY						<=	0
RPAY						<=	0
RCOY						<=	0
RGGY						<=	0
RGIY						<=	0
CASK	-1			1		<=	15000
CASR		1.04		-1	1	=	0
BORK	1					>=	0
DEMK	-1	1				=	0
DEMR	-1	1	1			=	0
MIPA						>=	0.6
MBRI						<=	0.3
MCOT						<=	0.9
MGNT						<=	0.6
Z			-1.08		1		

LARGE FARMERS - TAIL REGION (TL_1)

```
MAX     560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41
SUBJECT TO
      2)  X1 + X2 + X3 + X4 + X5 + X6 <=  2.01
      3)  X7 + X8 + X9 + X10 <=  2.01
      4)  55 X1 + 64 X2 + 22 X3 + 24 X4 + 45 X5 + 65 X6 - X11 <=  0
      5)  80 X1 + 92 X2 + 42 X3 + 55 X4 + 103 X5 + 72 X6 - X12 <=  0
      6)  2 X1 + 3 X2 + 3 X3 + 3 X4 + 5 X5 + 6 X6 - X13 <=  0
      7)  10 X1 + 11 X2 + 8 X3 + 7 X4 + 8 X5 + 8 X6 - X14 <=  0
      8)  50 X1 + 55 X2 + 45 X3 + 50 X4 + 55 X5 + 80 X6 - X15 <=  40
      9)  130 X1 + 137 X2 + 88 X3 + 88 X4 + 58 X5 + 53 X6 - X16 <=  0
     10)  78 X1 + 79 X2 + 52 X5 + 68 X6 - X17 <=  0
     11)  77 X1 + 81 X2 + 50 X3 + 48 X4 + 51 X5 + 56 X6 - X18 <=  0
     12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 55 X6 <=  182
     13)  63 X7 + 23 X8 + 18 X9 + 28 X10 - X19 <=  0
     14)  92 X7 + 108 X8 + 62 X9 + 72 X10 - X20 <=  0
     15)  3 X7 + 10 X8 + 3 X9 + 4 X10 - X21 <=  0
     16)  10 X7 + 6 X8 + 4 X9 + 3 X10 - X22 <=  0
     17)  55 X7 + 40 X10 - X23 <=  35
     18)  118 X7 + 92 X8 + 35 X9 + 63 X10 - X24 <=  0
     19)  60 X7 + 59 X8 + 35 X9 - X25 <=  0
     20)  38 X7 + 21 X8 + 23 X10 - X26 <=  0
     21)  150 X7 + 70 X8 + 25 X9 + 25 X10 <=  140
     22) - 51 X1 + X27 <=  0
     23) - 53 X2 + X28 <=  0
     24) - 11 X3 + X29 <=  0
     25) - 12 X4 + X30 <=  0
     26) - 21 X5 + X31 <=  0
     27) - 120 X6 + X32 <=  0
     28)  X33 - 50 X7 <=  0
     29)  X34 - 19 X8 <=  0
     30)  X35 - 13 X9 <=  0
     31)  X36 - 8 X10 <=  0
     32)  2300 X1 + 2450 X2 + 1250 X3 + 1800 X4 + 5200 X5 + 3500 X6 + 50 X11 + 30 X12 + 150
          X13 + 300 X14 + 25 X15 + 10 X16 + 15 X17 + 9 X18 - X37 + X40 <=  15000
     33)  X41 + 2700 X7 + 1500 X8 + 1150 X9 + 1200 X10 + 50 X19 + 30 X20 + 150 X21 + 300 X22
          + 25 X23 + 10 X24 + 15 X25 + 9 X26 - 560 X27 - 580 X28 - 1600 X29 - 1700 X30 - 1750
          X31 -   350 X32 - X40 + 1.04 X38   =   0
     34)  X37 >=  0
     35) - X37 + X38 =   0
     36)  X39 - X37 + X38 =   0
     37)  X1 + X2 >=  .6
     38)  X7 >=  .4
     39)  X5 <=  .6
     40)  X6 <=  .3
     41)  X8 <=  .9
END
```

LARGE FARMERS - TAIL REGION (TL_2)

```
MAX    560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41
SUBJECT TO
    2)  X1 + X2 + X3 + X4 + X5 + X6 <=  2.01
    3)  X7 + X8 + X9 + X10 <=  2.01
    4)  55 X1 + 64 X2 + 22 X3 + 24 X4 + 45 X5 + 65 X6 - X11 <=  0
    5)  80 X1 + 92 X2 + 42 X3 + 55 X4 + 103 X5 + 72 X6 - X12 <=  0
    6)  2 X1 + 3 X2 + 3 X3 + 3 X4 + 5 X5 + 6 X6 - X13 <=  0
    7)  10 X1 + 11 X2 + 8 X3 + 7 X4 + 8 X5 + 8 X6 - X14 <=  0
    8)  50 X1 + 55 X2 + 45 X3 + 50 X4 + 55 X5 + 80 X6 - X15 <=  40
    9)  130 X1 + 137 X2 + 88 X3 + 88 X4 + 58 X5 + 53 X6 - X16 <=  0
   10)  78 X1 + 79 X2 + 52 X5 + 68 X6 - X17 <=  0
   11)  77 X1 + 81 X2 + 50 X3 + 48 X4 + 51 X5 + 56 X6 - X18 <=  0
   12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 55 X6 <=  163.8
   13)  63 X7 + 23 X8 + 18 X9 + 28 X10 - X19 <=  0
   14)  92 X7 + 108 X8 + 62 X9 + 72 X10 - X20 <=  0
   15)  3 X7 + 10 X8 + 3 X9 + 4 X10 - X21 <=  0
   16)  10 X7 + 6 X8 + 4 X9 + 3 X10 - X22 <=  0
   17)  55 X7 + 40 X10 - X23 <=  35
   18)  118 X7 + 92 X8 + 35 X9 + 63 X10 - X24 <=  0
   19)  60 X7 + 59 X8 + 35 X9 - X25 <=  0
   20)  38 X7 + 21 X8 + 23 X10 - X26 <=  0
   21)  150 X7 + 70 X8 + 25 X9 + 25 X10 <=  126
   22) - 51 X1 + X27 <=  0
   23) - 53 X2 + X28 <=  0
   24) - 11 X3 + X29 <=  0
   25) - 12 X4 + X30 <=  0
   26) - 21 X5 + X31 <=  0
   27) - 120 X6 + X32 <=  0
   28)  X33 - 50 X7 <=  0
   29)  X34 - 19 X8 <=  0
   30)  X35 - 13 X9 <=  0
   31)  X36 - 8 X10 <=  0
   32)  2300 X1 + 2450 X2 + 1250 X3 + 1800 X4 + 5200 X5 + 3500 X6 + 50 X11 + 30 X12 + 150
        X13 + 300 X14 + 25 X15 + 10 X16 + 15 X17 + 9 X18 - X37 + X40 <=  15000
   33) X41 + 2700 X7 + 1500 X8 + 1150 X9 + 1200 X10 + 50 X19 + 30 X20 + 150 X21 + 300 X22
        + 25 X23 + 10 X24 + 15 X25 + 9 X26 - 560 X27 - 580 X28 - 1600 X29 - 1700 X30 -
        1750 X31 -     350 X32 - X40 + 1.04 X38 =  0
   34)  X37 >=  0
   35) - X37 + X38 =  0
   36)  X39 - X37 + X38 =  0
   37)  X1 + X2 >=  .6
   38)  X7 >=  .4
   39)  X5 <=  .6
   40)  X6 <=  .3
   41)  X8 <=  .9
END
```

LARGE FARMERS - TAIL REGION (TL_3)

```
MAX    560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41
SUBJECT TO
     2)  X1 + X2 + X3 + X4 + X5 + X6 <=  2.01
     3)  X7 + X8 + X9 + X10 <=  2.01
     4)  55 X1 + 64 X2 + 22 X3 + 24 X4 + 45 X5 + 65 X6 - X11 <=  0
     5)  80 X1 + 92 X2 + 42 X3 + 55 X4 + 103 X5 + 72 X6 - X12 <=  0
     6)  2 X1 + 3 X2 + 3 X3 + 3 X4 + 5 X5 + 6 X6 - X13 <=  0
     7)  10 X1 + 11 X2 + 8 X3 + 7 X4 + 8 X5 + 8 X6 - X14 <=  0
     8)  50 X1 + 55 X2 + 45 X3 + 50 X4 + 55 X5 + 80 X6 - X15 <=  40
     9)  130 X1 + 137 X2 + 88 X3 + 88 X4 + 58 X5 + 53 X6 - X16 <=  0
    10)  78 X1 + 79 X2 + 52 X5 + 68 X6 - X17 <=  0
    11)  77 X1 + 81 X2 + 50 X3 + 48 X4 + 51 X5 + 56 X6 - X18 <=  0
    12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 55 X6 <=  145.6
    13)  63 X7 + 23 X8 + 18 X9 + 28 X10 - X19 <=  0
    14)  92 X7 + 108 X8 + 62 X9 + 72 X10 - X20 <=  0
    15)  3 X7 + 10 X8 + 3 X9 + 4 X10 - X21 <=  0
    16)  10 X7 + 6 X8 + 4 X9 + 3 X10 - X22 <=  0
    17)  55 X7 + 40 X10 - X23 <=  35
    18)  118 X7 + 92 X8 + 35 X9 + 63 X10 - X24 <=  0
    19)  60 X7 + 59 X8 + 35 X9 - X25 <=  0
    20)  38 X7 + 21 X8 + 23 X10 - X26 <=  0
    21)  150 X7 + 70 X8 + 25 X9 + 25 X10 <=  112
    22) - 51 X1 + X27 <=  0
    23) - 53 X2 + X28 <=  0
    24) - 11 X3 + X29 <=  0
    25) - 12 X4 + X30 <=  0
    26) - 21 X5 + X31 <=  0
    27) - 120 X6 + X32 <=  0
    28)  X33 - 50 X7 <=  0
    29)  X34 - 19 X8 <=  0
    30)  X35 - 13 X9 <=  0
    31)  X36 - 8 X10 <=  0
    32)  2300 X1 + 2450 X2 + 1250 X3 + 1800 X4 + 5200 X5 + 3500 X6 + 50 X11 + 30 X12 + 150
         X13 + 300 X14 + 25 X15 + 10 X16 + 15 X17 + 9 X18 - X37 + X40 <=  15000
    33)  X41 + 2700 X7 + 1500 X8 + 1150 X9 + 1200 X10 + 50 X19 + 30 X20 + 150 X21 + 300 X22
         + 25 X23 + 10 X24 + 15 X25 + 9 X26 - 560 X27 - 580 X28 - 1600 X29 - 1700 X30 - 1750
         X31 - 350 X32 - X40 + 1.04 X38   =   0
    34)  X37 >=  0
    35) - X37 + X38 =   0
    36)  X39 - X37 + X38 =   0
    37)  X1 + X2 >=  .6
    38)  X7 >=  .4
    39)  X5 <=  .6
    40)  X6 <=  .3
    41)  X8 <=  .9
END
```

LARGE FARMERS - TAIL REGION (TL_4)

```
MAX     560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41
SUBJECT TO
     2)  X1 + X2 + X3 + X4 + X5 + X6 <=   2.01
     3)  X7 + X8 + X9 + X10 <=   2.01
     4)  55 X1 + 64 X2 + 22 X3 + 24 X4 + 45 X5 + 65 X6 - X11 <=   0
     5)  80 X1 + 92 X2 + 42 X3 + 55 X4 + 103 X5 + 72 X6 - X12 <=   0
     6)  2 X1 + 3 X2 + 3 X3 + 3 X4 + 5 X5 + 6 X6 - X13 <=   0
     7)  10 X1 + 11 X2 + 8 X3 + 7 X4 + 8 X5 + 8 X6 - X14 <=   0
     8)  50 X1 + 55 X2 + 45 X3 + 50 X4 + 55 X5 + 80 X6 - X15 <=   40
     9)  130 X1 + 137 X2 + 88 X3 + 88 X4 + 58 X5 + 53 X6 - X16 <=   0
    10)  78 X1 + 79 X2 + 52 X5 + 68 X6 - X17 <=   0
    11)  77 X1 + 81 X2 + 50 X3 + 48 X4 + 51 X5 + 56 X6 - X18 <=   0
    12)  125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 55 X6 <=   127.4
    13)  63 X7 + 23 X8 + 18 X9 + 28 X10 - X19 <=   0
    14)  92 X7 + 108 X8 + 62 X9 + 72 X10 - X20 <=   0
    15)  3 X7 + 10 X8 + 3 X9 + 4 X10 - X21 <=   0
    16)  10 X7 + 6 X8 + 4 X9 + 3 X10 - X22 <=   0
    17)  55 X7 + 40 X10 - X23 <=   35
    18)  118 X7 + 92 X8 + 35 X9 + 63 X10 - X24 <=   0
    19)  60 X7 + 59 X8 + 35 X9 - X25 <=   0
    20)  38 X7 + 21 X8 + 23 X10 - X26 <=   0
    21)  150 X7 + 70 X8 + 25 X9 + 25 X10 <=   98
    22) - 51 X1 + X27 <=   0
    23) - 53 X2 + X28 <=   0
    24) - 11 X3 + X29 <=   0
    25) - 12 X4 + X30 <=   0
    26) - 21 X5 + X31 <=   0
    27) - 120 X6 + X32 <=   0
    28)  X33 - 50 X7 <=   0
    29)  X34 - 19 X8 <=   0
    30)  X35 - 13 X9 <=   0
    31)  X36 - 8 X10 <=   0
    32)  2300 X1 + 2450 X2 + 1250 X3 + 1800 X4 + 5200 X5 + 3500 X6 + 50 X11 + 30 X12 + 150
         X13 + 300 X14 + 25 X15 + 10 X16 + 15 X17 + 9 X18 - X37 + X40 <=   15000
    33)  X41 + 2700 X7 + 1500 X8 + 1150 X9 + 1200 X10 + 50 X19 + 30 X20 + 150 X21 + 300
X22      + 25 X23 + 10 X24 + 15 X25 + 9 X26 - 560 X27 - 580 X28 - 1600 X29 - 1700 X30 - 1750
         X31 - 350 X32 - X40 + 1.04 X38 =    0
    34)  X37 >=   0
    35) - X37 + X38 =    0
    36)  X39 - X37 + X38 =    0
    37)  X1 + X2 >=   .6
    38)  X7 >=   .4
    39)  X5 <=   .6
    40)  X6 <=   .3
    41)  X8 <=   .9
END
```