

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

By

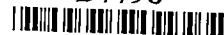
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**M.Sc.(Ag.)**

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IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF

**DOCTOR OF PHILOSOPHY**

IN THE FACULTY OF AGRICULTURAL SCIENCES  
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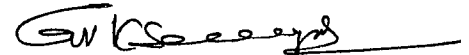
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**JULY 2006**

## 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.

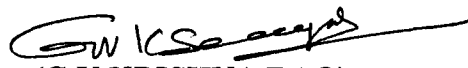
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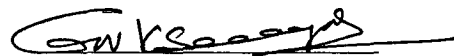
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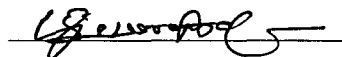
  
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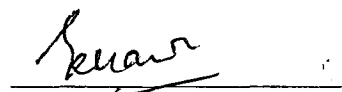
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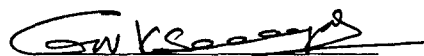


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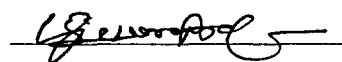
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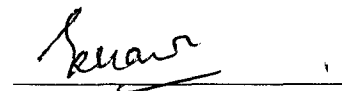
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*Ch. SriLatha*  
Challa Sri Latha

## 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.

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### **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*

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## 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.

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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 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> five years plan period. The increase in irrigated area has been on an average 2.1 M ha per year during 6<sup>th</sup> plan, 2.6 M ha per year during 7<sup>th</sup> plan period and 2.5 M ha per year during the 8<sup>th</sup> 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 8<sup>th</sup> (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 tonnes 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 tonnes 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 losing 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*

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## 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 dairy 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 Maharashtra 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 Maharashtra. In the optimal plan, sunflower during the *khariif* and safflower during the *rabi* season had been introduced. The area under *khariif* 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, Maharashtra. 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 an 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.

Ramakrishnaiah 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	5	5	10
		Nukana palli	5	5	10
	Ananthasagaram	Ananthasagaram	5	5	10
		Inagalur	5	5	10
Middle	Atmakur	Depur	5	5	10
		Vasili	5	5	10
	Chejerla	Chejerla	5	5	10
		Paderu	5	5	10
Tail	Kavali	Budamgunta	5	5	10
		Kothapalli	5	5	10
	Podalakur	Ayyavaripalem	5	5	10
		Navur	5	5	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.  $\sum_{j=1}^n a_{ij} X_j \geq b_i$  ( $i = 1, \dots, K$  constraints)
2.  $\sum_{j=1}^n a_{ij} X_j \leq b_i$  ( $i = K+1, \dots, m$  constraints)
3.  $\sum_{j=1}^n a_{ij} X_j = b_i$  ( $i = m+1, \dots, v$  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  $j^{\text{th}}$  activity during *kharif* and *rabi* seasons of the year.

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

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

$b_i$  = supply levels of  $i^{\text{th}}$  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<sup>2</sup>) 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 (*khariif*) 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

*khariif* season. Accordingly, the credit availability was specified in *khariif* 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, income, employment and resource use pattern.

*AGRO-ECONOMIC FEATURES*

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## 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.

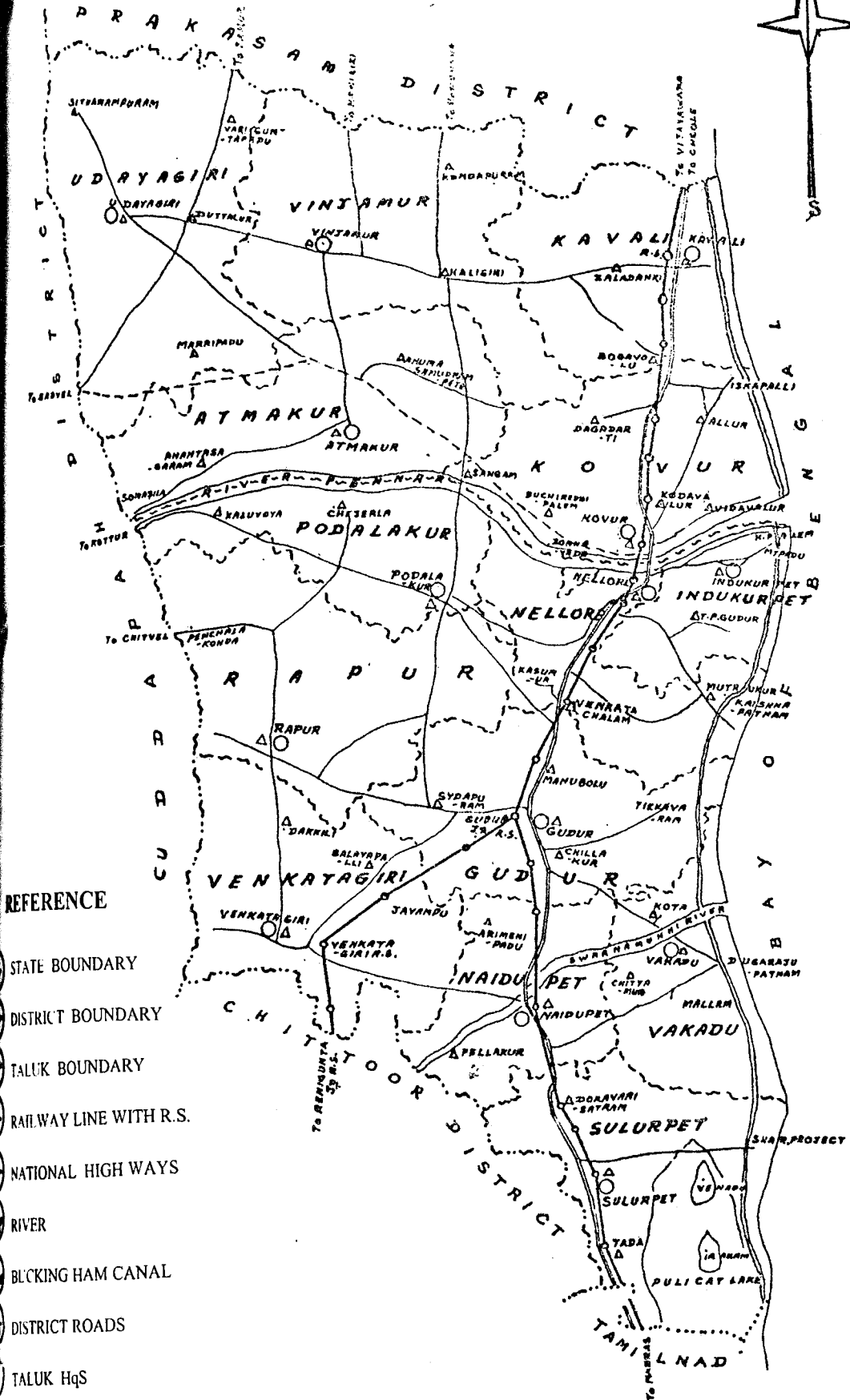
#### 4.1 GEOGRAPHICAL FEATURES

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 Changelpet 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 HIGHWAYS
- RIVER
- BUCKINGHAM 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**

<b>S.No.</b>	<b>Particulars</b>	<b>Unit</b>	<b>Year 2001</b>
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
			<b>935</b>	<b>100.00</b>

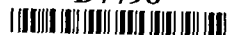
Source : Hand Book of District Statistics, C.P.O., Nellore, Statistical Abstracts, Andhra Pradesh - 2005

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.

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#### 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)**

<b>Source</b>	<b>2003-04</b>
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**

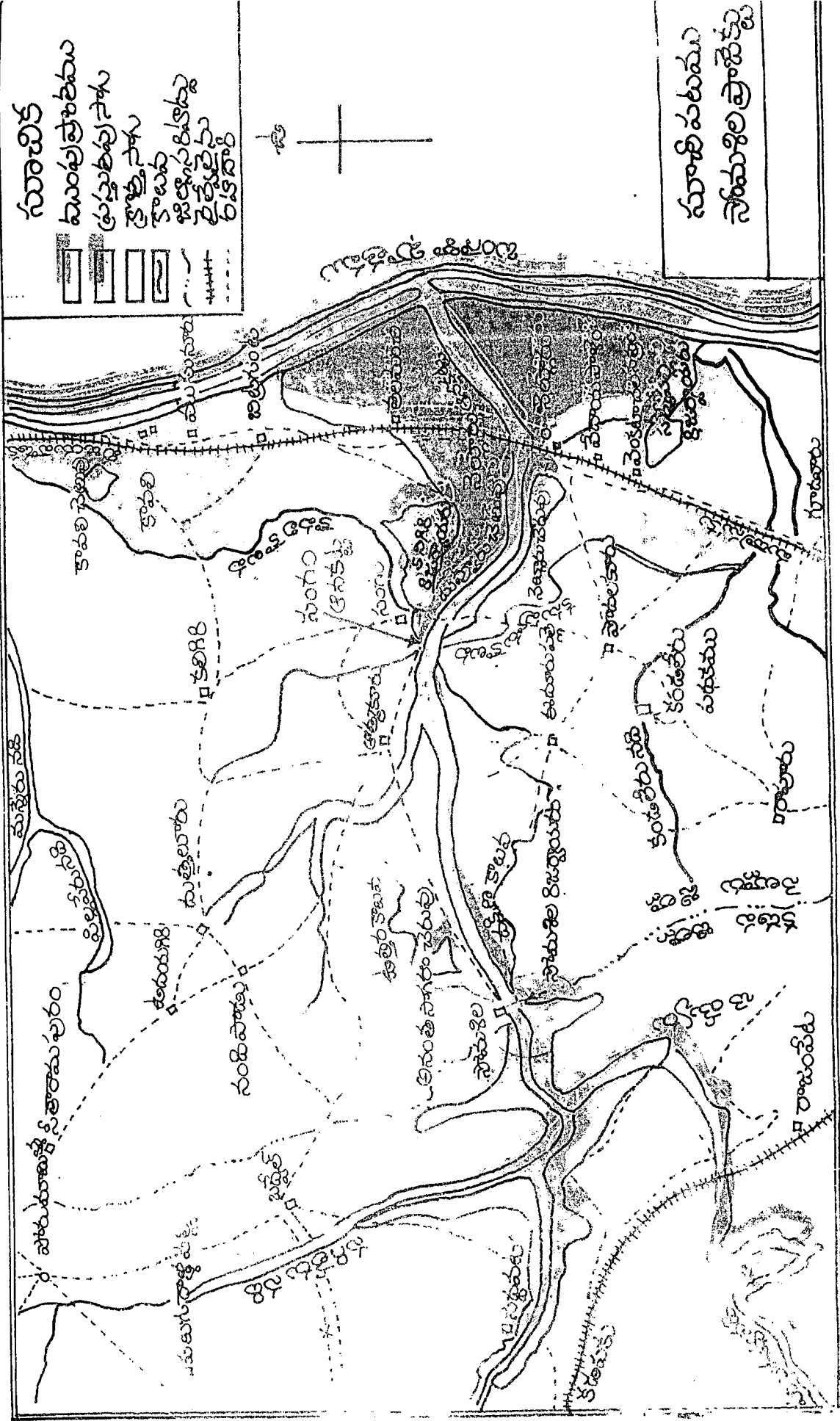
Somasial project is located on the border of Kadapa and Nellore districts, across river Pennar at Somasila village, Ananthasagaram Mandal,

సూచిక

-  ఘంటసాల ప్రాంతము
-  ప్రస్తుత ప్రాంతము
-  కాలనెల
-  కాలువ
-  జిల్లా సరిహద్దు
-  రైల్వే మార్గము
-  రహదారి



సూచి పటము  
సోమశిల ప్రాజెక్టు



Nellore district. River Pennar originates 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, alluvial, 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*.

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### 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 *kharif* are the 2<sup>nd</sup> 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)**

Crop	( hectares)	
	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
<b>10.</b>	<b>Total geographical area</b>	<b>13,16,042</b>	<b>100.00</b>

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 per cent 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*

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## 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	
		Small	Large	Small	Large	Small	Large
	Family size						
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 per cent 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
<b>Kharif irrigated land</b>												
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	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total</b>	0.98	100.00	2.43	100.00	0.94	100.00	2.09	100.00	0.93	100.00	2.01	100.00
<b>Rabi Irrigated land</b>												
Paddy (Molagolakulu)	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
<b>Total</b>	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 <sub>1</sub>		Model HS <sub>2</sub>		Model HS <sub>3</sub>		Model HS <sub>4</sub>	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
<i>Kharif irrigated land</i>										
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
<i>Rabi irrigated land</i>										
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<sub>1</sub>, 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<sub>1</sub>. 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<sub>2</sub> developed by decreasing 10 per cent of water supply resulted in different cropping pattern to that of model HS<sub>1</sub>. On *kharif*

irrigated land, the area under groundnut, sugarcane and brinjal remained the same as in optimum model HS<sub>1</sub>. However, it recommended to increase the area for sunflower from 0.06 ha (6.12 per cent) in model HS<sub>1</sub> to 0.17 ha (17.35 per cent) in model HS<sub>2</sub>. The model also suggested to reduce the area for paddy (1009) from 0.42 ha in HS<sub>1</sub> to 0.31 ha in model HS<sub>2</sub> 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<sub>1</sub>. The area under paddy declined from 0.29 ha in model HS<sub>1</sub> to 0.21 ha in model HS<sub>2</sub>. Consequently, the area under less water consuming greengram crop increased from 0.14 ha in model HS<sub>1</sub> to 0.22 ha in model HS<sub>2</sub>. The cropping intensity remained the same as in model HS<sub>1</sub>.

The cropping pattern suggested by model HS<sub>2</sub> 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<sub>3</sub>. 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<sub>2</sub>. However, the plan suggested to increase the area from 0.17 ha in model HS<sub>2</sub> 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<sub>2</sub> to 0.09 ha in model HS<sub>3</sub>. The area under greengram increased from 0.22 ha in model HS<sub>2</sub> 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<sub>4</sub>) 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<sub>1</sub>, HS<sub>2</sub> and HS<sub>3</sub> was completely eliminated in this model.

The cropping intensity declined from 200 per cent in model HS<sub>3</sub> to 187.76 per cent in model HS<sub>4</sub>. The cropping pattern suggested by the model HS<sub>4</sub> 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<sub>1</sub>, 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<sub>1</sub>.

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 <sub>1</sub>		Model HL <sub>2</sub>		Model HL <sub>3</sub>		Model HL <sub>4</sub>	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
<i>Kharif irrigated land</i>										
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
<i>Rabi irrigated land</i>										
Paddy (Molaglakulu)	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<sub>1</sub> 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<sub>2</sub> (10 per cent decrease in water availability) suggested same crops with changes in the acreage as in model HL<sub>1</sub>. During *kharif*, groundnut, sugarcane and brinjal occupied the same area as in model HL<sub>1</sub>. 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<sub>1</sub> to 0.80 ha in model HL<sub>2</sub> 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<sub>1</sub>, 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<sub>1</sub>, 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<sub>3</sub>) 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<sub>1</sub>, and 0.80 ha in HL<sub>2</sub> 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<sub>1</sub> to 0.82 ha in HL<sub>3</sub>.

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<sub>2</sub> to 0.87 ha in HL<sub>3</sub>. 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<sub>3</sub> enabled the farmers to realize a net farm returns of Rs.1,06,544.

The results of optimum model HL<sub>4</sub> 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<sub>4</sub> 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<sub>3</sub> to Rs.41,922.22 in HL<sub>4</sub>.

### 5.3.3 Small Farmers of Middle Region

The reorganization of resources with the existing irrigation water availability (MS<sub>1</sub>) 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<sub>1</sub> 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 <sub>1</sub>		Model MS <sub>2</sub>		Model MS <sub>3</sub>		Model MS <sub>4</sub>	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
<b>Kharif irrigated land</b>										
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
<b>Rabi irrigated land</b>										
Paddy (Molaglakulu)	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<sub>1</sub>. The crop mix suggested by Model MS<sub>1</sub> 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<sub>1</sub> except decrease in the area of paddy from 0.48 ha in MS<sub>1</sub> to 0.37 ha and increase in the area of sunflower from 0.06 ha in MS<sub>1</sub> 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<sub>1</sub> 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<sub>1</sub> to 0.23 ha. However, chillies occupied the same acreage as in MS<sub>1</sub>.

The cropping intensity remained the same as in model MS<sub>1</sub>. The cropping pattern suggested by model MS<sub>2</sub> 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 analysed through model MS<sub>3</sub>. This plan suggested to reduce the area of paddy and sugarcane from 0.37 ha and 0.20 ha in model MS<sub>2</sub> 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<sub>2</sub> to 0.44 ha by completely eliminating cowpea, which was found in MS<sub>2</sub> with 0.26 ha. There was a slight increase in the area of paddy over MS<sub>2</sub>. Chillies continued to occupy the same area as in the previous models.

The crop mix recommended by the model MS<sub>3</sub> 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<sub>4</sub>) 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<sub>3</sub> 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<sub>3</sub> to 0.04 ha. The proportionate area under paddy increased from 36.17 per cent in MS<sub>3</sub> to 40.43 per cent in MS<sub>4</sub>.

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<sub>4</sub> 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<sub>1</sub> 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<sub>2</sub> (10 per cent decrease in water availability) suggested almost the same cropping pattern as that model ML<sub>1</sub> during *kharif*.

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

Crop	Existing Plan		Model ML <sub>1</sub>		Model ML <sub>2</sub>		Model ML <sub>3</sub>		Model ML <sub>4</sub>	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
<b>Kharif irrigated land</b>										
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
<b>Rabi irrigated land</b>										
Paddy (Molaglakulu)	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	

During *rabi*, paddy was favoured in 0.14 ha, maintaining the same area for chillies as in optimum plan ML<sub>1</sub>. The plan indicated to reduce the area of cotton by 0.26 ha over the model ML<sub>1</sub> 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<sub>1</sub> and ML<sub>2</sub>. but net farm returns declined from Rs.99,199.60 in optimum plan ML<sub>1</sub> to Rs.96,404 in optimum model ML<sub>2</sub>.

The optimum model ML<sub>3</sub> recommended to reduce the area of paddy and sugarcane from 0.66 ha and 0.60 ha in model ML<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>4</sub> developed with 30 per cent decrease in water availability favoured the extension of area under sunflower from 0.54 ha in ML<sub>3</sub> to 0.88 ha, by reducing area of sugarcane to the extent of 0.29 ha over the ML<sub>2</sub>. 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<sub>1</sub>, 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<sub>1</sub> 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 <sub>1</sub>		Model TS <sub>2</sub>		Model TS <sub>3</sub>		Model TS <sub>4</sub>	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
<b>Kharif irrigated land</b>										
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
<b>Rabi irrigated land</b>										
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<sub>1</sub>. 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<sub>1</sub>. The net farm returns were higher by Rs.13,674.28 over the existing plan.

Model TS<sub>2</sub> 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<sub>1</sub> 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<sub>1</sub> and TS<sub>2</sub>. Cotton occupied one acre of *rabi* irrigated land.

The intensity of cropping remained the same as in Model TS<sub>1</sub>. The net farm returns increased from Rs.28,054.68 in the existing plan to Rs.41,406.22.

The optimum model TS<sub>3</sub> evolved by decreasing 20 per cent of water supply suggested crop activities similar to that of model TS<sub>2</sub> 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<sub>2</sub> 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<sub>4</sub> 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<sub>3</sub> to 0.63 ha during *kharif* and in increase of 0.12 ha for the production of greengram during *rabi* over the model TS<sub>3</sub>.

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<sub>1</sub> 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<sub>1</sub> 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<sub>2</sub> suggested a different crop mix from that of model TL<sub>1</sub> 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<sub>1</sub>. Groundnut and brinjal occupied the same area as in model TL<sub>1</sub> during the *kharif*. Greengram

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

Crop	Existing Plan		Model TL <sub>1</sub>		Model TL <sub>2</sub>		Model TL <sub>3</sub>		Model TL <sub>4</sub>	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
<b>Khari irrigated land</b>										
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
<b>Rabi irrigated land</b>										
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<sub>1</sub>. The net farm returns were increased by 36.56 per cent over the existing plan.

The normative plan TL<sub>3</sub> 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 brinjal 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<sub>2</sub> 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<sub>2</sub>.

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<sub>4</sub> 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<sub>1</sub>, TL<sub>2</sub> and TL<sub>3</sub>. 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<sub>3</sub> to 0.60 and

0.20 ha in Model TL<sub>4</sub> 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<sub>1</sub> and TS<sub>2</sub>) and large farmers of middle region (Model ML<sub>1</sub>) 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 programme. 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 <sub>1</sub>	Change over E-Plan	Model-H <sub>2</sub>	Change over E-Plan	Model-H <sub>3</sub>	Change over E-Plan	Model-H <sub>4</sub>	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<sub>1</sub> (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<sub>2</sub> 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<sub>3</sub> 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<sub>4</sub> (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<sub>1</sub> (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<sub>2</sub> (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<sub>2</sub>. The net farm returns of model MS<sub>2</sub> 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<sub>3</sub>) 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<sub>4</sub> 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<sub>1</sub> 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<sub>2</sub> (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<sub>3</sub> 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 <sub>1</sub>	Change over E-Plan	Model-M <sub>2</sub>	Change over E-Plan	Model-M <sub>3</sub>	Change over E-Plan	Model-M <sub>4</sub>	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<sub>4</sub> (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<sub>1</sub> (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 enhance their net farm returns by mere reorganization of resources (Table 5.11).

Model TS<sub>2</sub> (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<sub>3</sub> (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<sub>4</sub> (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<sub>1</sub> 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<sub>1</sub> 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 <sub>1</sub>	Change over E-Plan	Model-T <sub>2</sub>	Change over E-Plan	Model-T <sub>3</sub>	Change over E-Plan	Model-T <sub>4</sub>	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<sub>2</sub> (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<sub>3</sub>) recording a raise of 30.35 per cent over the present level of income.

Optimal plan TL<sub>4</sub> 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<sub>1</sub> and HL<sub>1</sub> 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<sub>3</sub> and HL<sub>3</sub> 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 <sub>1</sub>	Model - H <sub>2</sub>	Change over Model - H <sub>1</sub>	Model - H <sub>3</sub>	Change over Model - H <sub>1</sub>	Change over Model - H <sub>2</sub>	Model - H <sub>4</sub>	Change over Model - H <sub>1</sub>	Change over Model - H <sub>2</sub>	Change over Model - H <sub>3</sub>
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 <sub>1</sub>	Model - M <sub>2</sub>	Change over Model - M <sub>1</sub>	Model - M <sub>3</sub>	Change over Model - M <sub>1</sub>	Change over Model - M <sub>2</sub>	Model - M <sub>4</sub>	Change over Model - M <sub>1</sub>	Change over Model - M <sub>2</sub>	Change over Model - M <sub>3</sub>
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

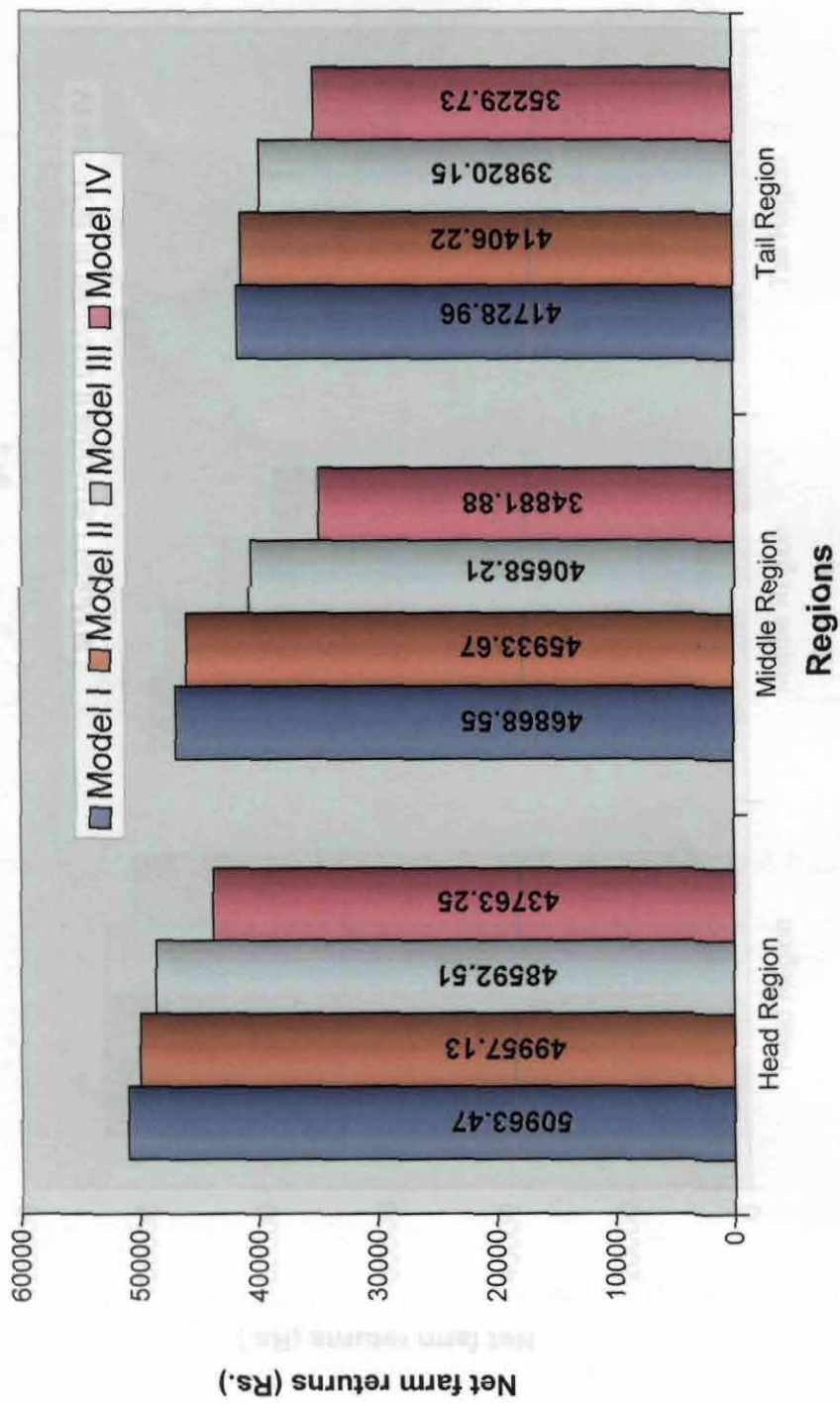


Fig 5.1: Impact of irrigation water on net farm income under different optimum plans - Small farmers

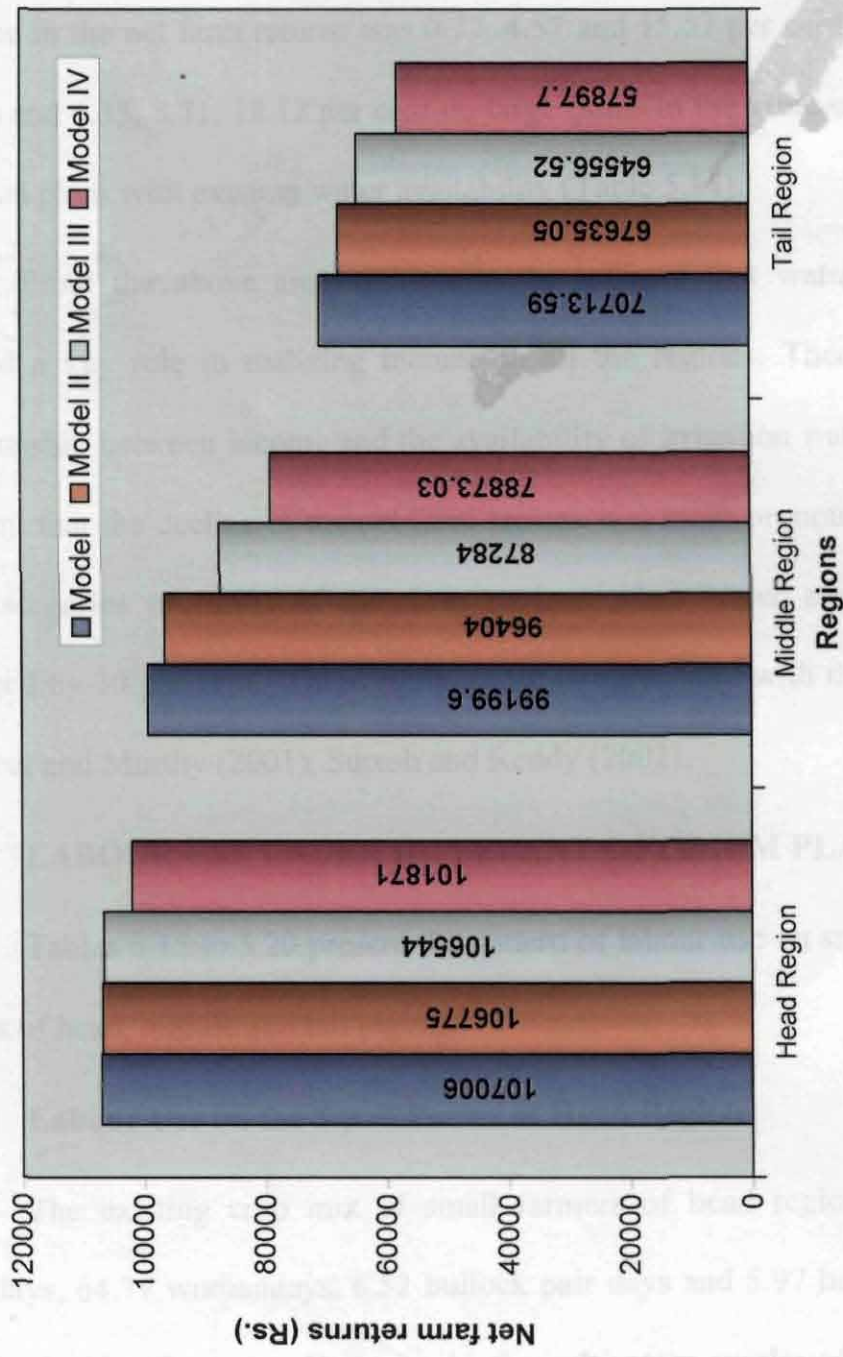


Fig 5.2: Impact of irrigation water on net farm income under different optimum plans - Large farmers

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 <sub>1</sub>	Model - T <sub>2</sub>	Change over Model - T <sub>1</sub>	Model - T <sub>3</sub>	Change over Model - T <sub>1</sub>	Change over Model - T <sub>2</sub>	Model - T <sub>4</sub>	Change over Model - T <sub>1</sub>	Change over Model - T <sub>2</sub>	Change over Model - T <sub>3</sub>
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<sub>1</sub> 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<sub>1</sub> was 92.06 mandays, 140.14 womandays, 14.39 bullock pair days and 11.02 tractor hours.

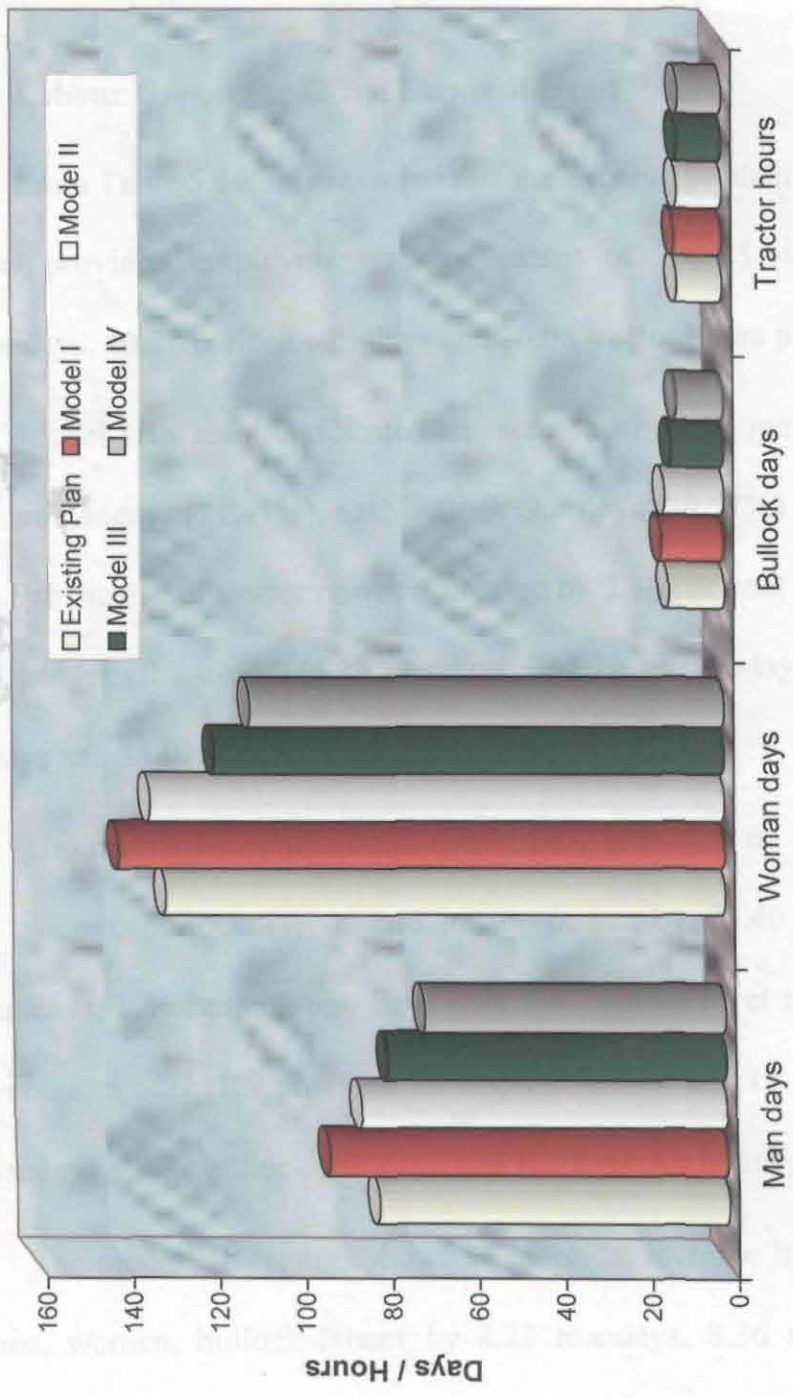
The results of model HS<sub>2</sub> indicated an increase of 3.60 mandays, 3.44 womandays, 0.80 bullock pair days and 0.05 tractor hours per annum over the existing plan. However, the increase in the labour use was marginal as compared with the optimum model HS<sub>1</sub>. Model HS<sub>2</sub> used 84.48 mandays, 132.84 womandays, 13.69 bullock pair days and 10.51 tractor power in terms of hours.

Model HS<sub>3</sub> 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 in terms 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<sub>4</sub> 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 <sub>1</sub>		Model-HS <sub>2</sub>		Model-HS <sub>3</sub>		Model-HS <sub>4</sub>				
			Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent		
<i>Kharrif season</i>													
a.	Man days	45.88	48.70	2.82	6.15	-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	-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	-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	-0.29	4.86	5.46	-0.51	8.54	5.08	-0.89	14.91
<i>Rabi season</i>													
a.	Man days	35.00	43.36	8.36	23.89	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	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	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	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	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	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	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	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<sub>1</sub> 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<sub>1</sub> 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<sub>2</sub> 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<sub>2</sub> 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<sub>3</sub> 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 <sub>1</sub>		Model-HL <sub>2</sub>		Model-HL <sub>3</sub>		Model-HL <sub>4</sub>			
			Normative Employment (days/hours)	Change over E-plan (days / hours)	Normative Employment (days/hours)	Change over E-plan (days / hours)	Normative Employment (days/hours)	Change over E-plan (days / hours)	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	
<i>Kharif season</i>												
a.	Man days	122.61	132.81	10.2	8.32	121.28	-1.33	109.75	-12.86	89.70	-32.91	26.84
b.	Woman days	180.82	173.98	-6.84	3.78	164.14	-16.68	154.29	-26.53	145.86	-34.96	19.33
c.	Bullock days	10.25	12.94	2.69	26.24	13.22	2.97	13.50	3.25	12.62	2.37	23.12
d.	Tractor hours	23.56	19.54	-4.02	17.06	18.42	-5.14	17.29	-6.27	17.47	-6.09	25.85
<i>Rabi season</i>												
a.	Man days	81.14	113.52	32.38	39.91	105.87	24.73	98.23	17.09	92.78	11.64	14.35
b.	Woman days	149.75	194.31	44.56	29.76	189.48	39.73	184.64	34.89	149.84	0.09	0.06
c.	Bullock days	10.02	15.35	5.33	53.19	15.50	5.48	15.66	5.64	9.63	-0.39	3.89
d.	Tractor hours	12.49	15.47	2.98	23.86	14.37	1.88	13.28	0.79	15.29	2.8	22.42
Total Man days		203.75	246.33	42.58	20.89	227.15	23.40	207.98	4.23	182.48	-21.27	10.44
Total Woman days		330.57	368.29	37.72	11.41	353.62	23.05	338.93	8.36	295.7	-34.87	10.55
Total Bullock days		20.27	28.29	8.02	39.57	28.72	8.45	29.16	8.89	22.25	1.98	9.77
Total Tractor hours		36.05	35.01	-1.04	2.88	32.79	-3.26	30.57	-5.48	32.76	-3.29	9.13

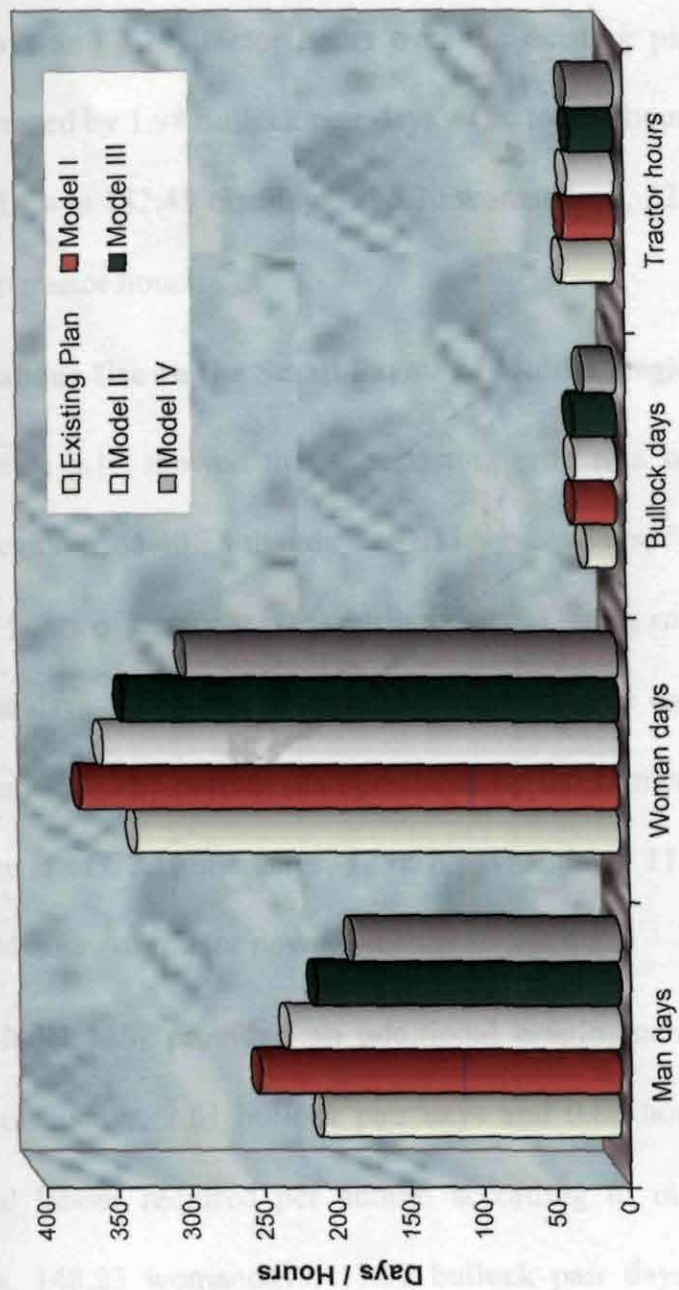


Fig. 5.4: Labour employment on large farms under different optimum models - Head region

HL<sub>3</sub> 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<sub>4</sub> 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<sub>4</sub> 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

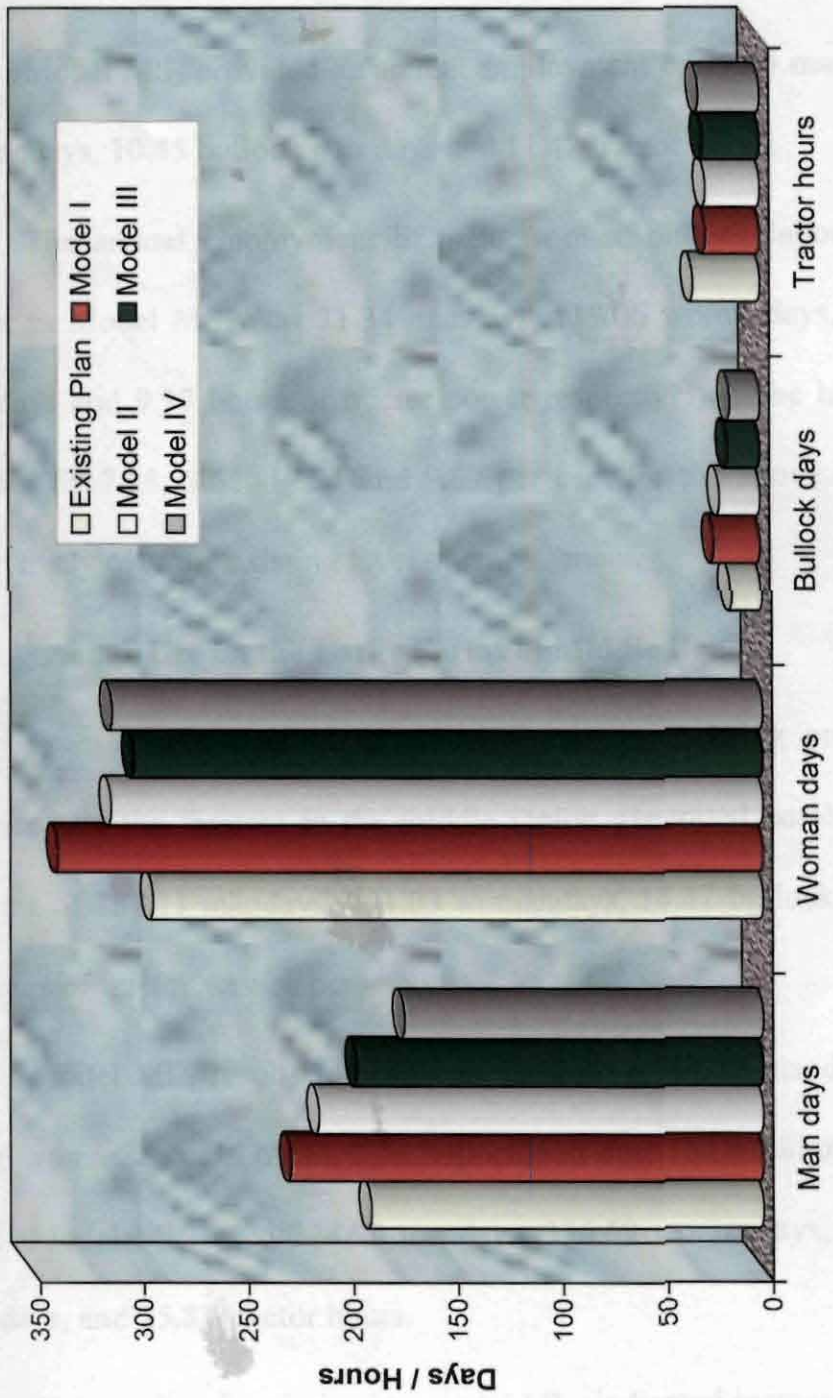
Table 5.17 showed that the existing crop mix of small farms in the middle region used 40.78 mandays, 61.11 womandays, 5.63 bullock pair days and 5.99 hours of tractor service during *kharif*. During *rabi*, farmers employed 36.41 mandays, 62.46 womandays, 5.68 bullock pair days and 5.05 hours of tractor 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<sub>1</sub> 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<sub>1</sub> was 93.59 mandays, 148.23 womandays, 13.92 bullock pair days and 11.84 hours of tractor service.

The results of model MS<sub>2</sub> 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 <sub>1</sub>		Model-MS <sub>2</sub>		Model-MS <sub>3</sub>		Model-MS <sub>4</sub>					
			Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent			
<i>Khariif season</i>														
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
<i>Rabi season</i>														
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<sub>2</sub> used 94.82 mandays, 134.2 womandays, 10.62 bullock pair days and 11.20 hours of tractor service.

Model MS<sub>3</sub> provided an annual employment of 79.05 mandays, 132.2 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<sub>4</sub> 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 service 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<sub>1</sub> 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<sub>1</sub> used 224.99 mandays, 336.69 womandays, 21.93 bullock pair days, and 25.83 tractor hours.

The results of optimization model ML<sub>2</sub> 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<sub>2</sub> provided a

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

S.No	Items	Existing plan E-plan	Model-ML <sub>1</sub>		Model-ML <sub>2</sub>		Model-ML <sub>3</sub>		Model-ML <sub>4</sub>				
			Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent		
<i>Kharif season</i>													
a.	Man days	107.76	109.45	1.69	1.57	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	-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	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	-4.44	23.37	15.68	-3.32	17.47	17.84	-1.16	6.11
<i>Rabi season</i>													
a.	Man days	79.35	115.54	36.19	45.61	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	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	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	-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	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	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	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	-6.04	18.88	27.26	-4.74	14.81	29.22	-2.78	8.69

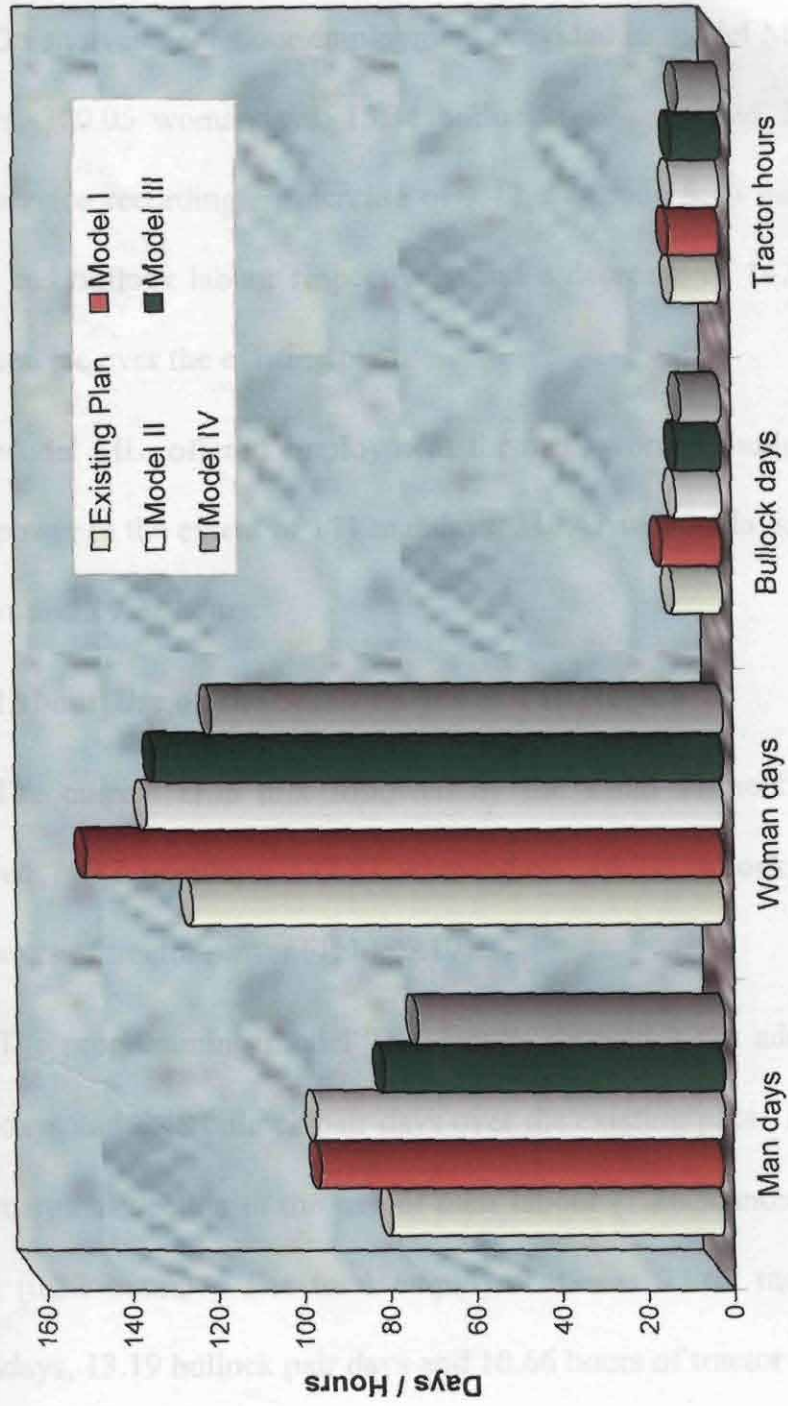


Fig. 5.5: Labour employment on small farms under different optimum models - Middle region

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<sub>3</sub> 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<sub>4</sub> 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<sub>1</sub>, 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<sub>2</sub> 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 <sub>1</sub>		Model-TS <sub>2</sub>		Model-TS <sub>3</sub>		Model-TS <sub>4</sub>					
			Normative Employment (days/hours)	Change over E-plan (days / hours)	Normative Employment (days/hours)	Change over E-plan (days / hours)	Normative Employment (days/hours)	Change over E-plan (days / hours)	Normative Employment (days/hours)	Change over E-plan (days / hours)				
<i>Kharif season</i>														
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
<i>Rabi season-</i>														
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	28.70
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

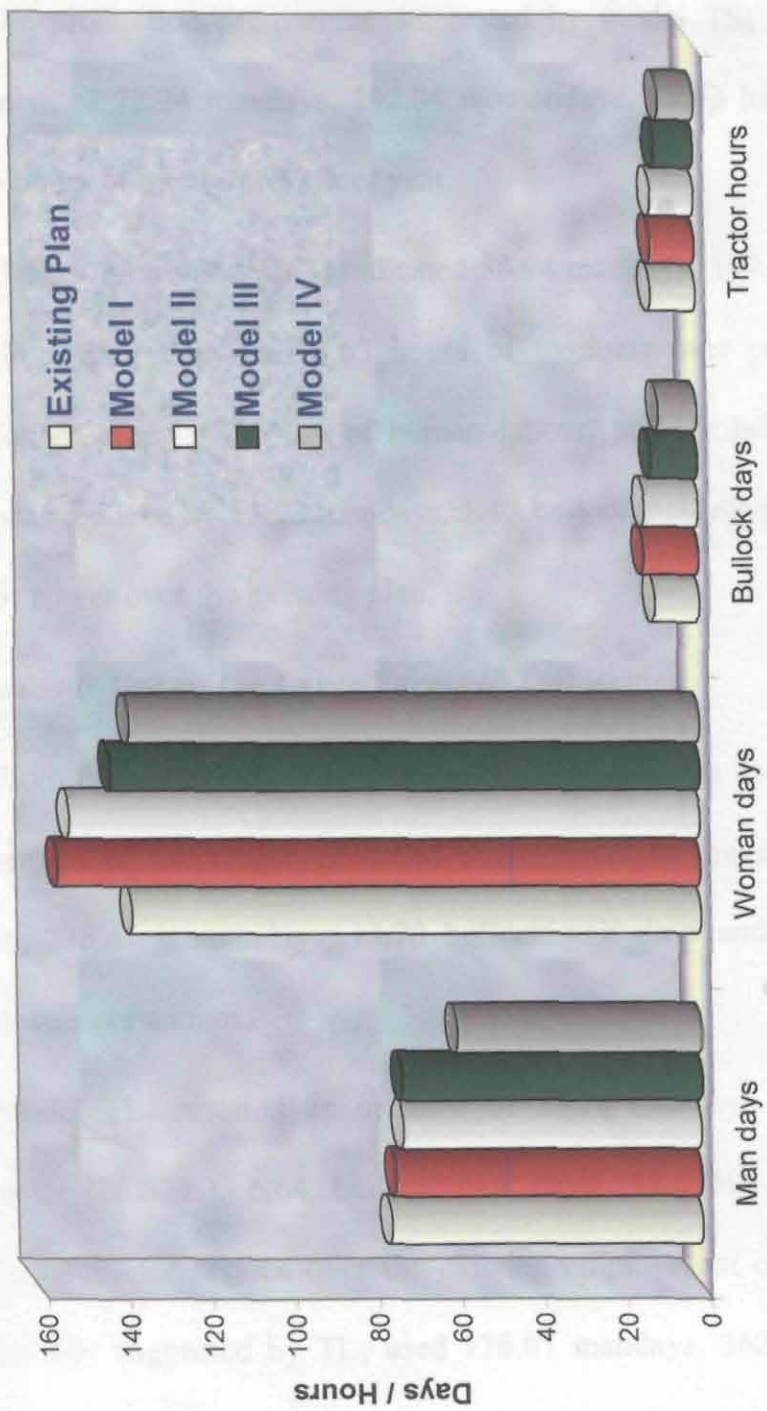


Fig. 5.7: Labour employment on small farms under different optimum models - Tail region

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

The production programme suggested by model TS<sub>3</sub> 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<sub>4</sub> 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<sub>1</sub> 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<sub>1</sub> used 176.01 mandays, 362.65 womandays, 20.34 bullock pair days and 31.59 hours of tractor power per year.

Model TL<sub>2</sub> 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	Model-TL <sub>1</sub>		Model-TL <sub>2</sub>		Model-TL <sub>3</sub>		Model-TL <sub>4</sub>					
		Existing plan E-plan	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent	Normative Employment (days/hours)	Change over E-plan (days / hours)	Per cent		
<i>Khariif season</i>													
a.	Man days	98.11	117.42	19.32	19.68	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	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	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	-0.19	1.02	17.57	-1.1	5.89	15.18	-3.49	18.69
<i>Rabi season</i>													
a.	Man days	54.74	58.59	3.85	7.03	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	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	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	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	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	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	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	1.55	5.44	28.53	0.02	0.07	25.26	-3.25	11.40

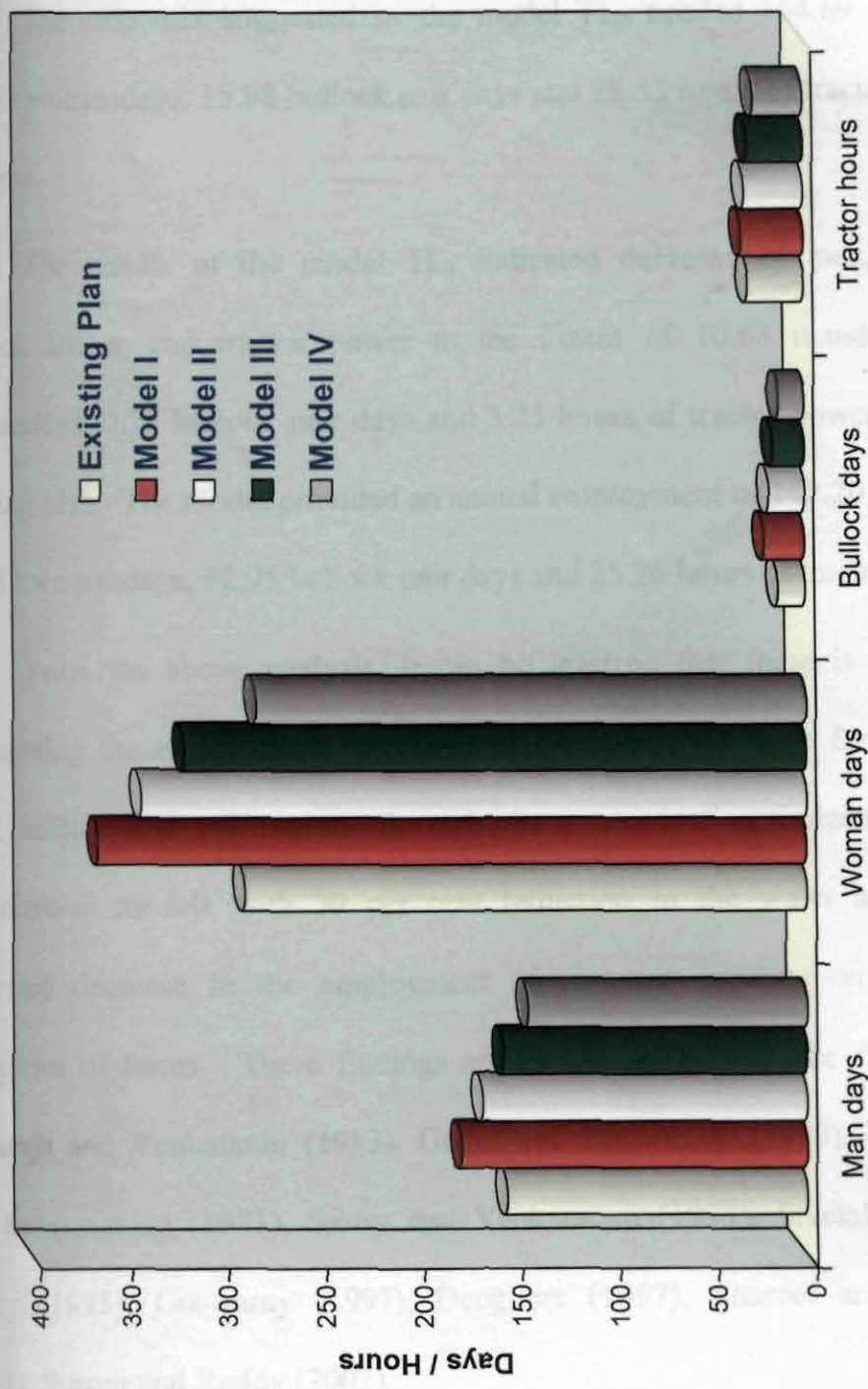


Fig. 5.8: Labour employment on large farms under different optimum models - Tail region

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<sub>3</sub> 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<sub>4</sub> 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  $HS_1$  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 ( $HS_4$ ).

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 <sub>1</sub>	Model-T <sub>2</sub>	Change over Model T <sub>1</sub>	Model-T <sub>3</sub>	Change over Model T <sub>1</sub>	Change over Model T <sub>2</sub>	Model-T <sub>4</sub>	Change over Model T <sub>1</sub>	Change over Model T <sub>2</sub>	Change over Model T <sub>3</sub>
<b>Small farmers</b>										
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)
<b>Large farmers</b>										
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<sub>4</sub> over MS<sub>1</sub>.

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<sub>1</sub> to 58.94 mandays, 137.51 womandays, 9.28 bullock pair days and 8.63 hours of tractor service in TS<sub>4</sub>.

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<sub>4</sub> over model TL<sub>1</sub>.

**Table S.22: Impact of irrigation water on labour employment of small and large farms – Middle Region**

	Model-T <sub>1</sub>	Model-T <sub>2</sub>	Change over Model T <sub>1</sub>	Model-T <sub>3</sub>	Change over Model T <sub>1</sub>	Change over Model T <sub>2</sub>	Model-T <sub>4</sub>	Change over Model T <sub>1</sub>	Change over Model T <sub>2</sub>	Change over Model T <sub>3</sub>
<b>Small farmers</b>										
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)
<b>Large farmers</b>										
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 <sub>1</sub>	Model-T <sub>2</sub>	Change over Model T <sub>1</sub>	Model-T <sub>3</sub>	Change over Model T <sub>1</sub>	Change over Model T <sub>2</sub>	Model-T <sub>4</sub>	Change over Model T <sub>1</sub>	Change over Model T <sub>2</sub>	Change over Model T <sub>3</sub>
<b>Small farmers</b>										
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)
<b>Large farmers</b>										
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 <sub>1</sub>		Model-HS <sub>2</sub>		Model-HS <sub>3</sub>		Model				
			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
<i>Kharif season</i>													
a.	FYM (Qtl.)	39.3	45.92	6.62	16.84	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	-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	-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	1.3	4.08	32.03	0.18	0.56	28.86	-2.99	9.38
<i>Rabi season</i>													
a.	FYM (Qtl.)	42.6	61.16	18.56	43.57	56.84	14.24	33.43	56.07	13.47	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	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	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	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	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	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	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	45.13	-7.91	14.91

Model HS<sub>2</sub> 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<sub>3</sub> 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<sub>4</sub> 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<sub>1</sub>) 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<sub>2</sub> 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<sub>3</sub> 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 <sub>1</sub>		Model-HL <sub>2</sub>		Model-HL <sub>3</sub>		Model-HL <sub>4</sub>					
			Normative use	Change over E-plan Kg/QtI Per cent	Normative use	Change over E-plan Kg/QtI Per cent	Normative use	Change over E-plan Kg/QtI Per cent	Normative use	Change over E-plan Kg/QtI Per cent				
<i>Kharif season</i>														
a.	FYM (QtI.)	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 (QtI.)	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 (QtI.)		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<sub>1</sub> 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<sub>2</sub> 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 <sub>1</sub>		Model-MS <sub>2</sub>		Model-MS <sub>3</sub>		Model-MS <sub>4</sub>				
			Normative use	Change over E-plan Kg/Qtl	Per cent	Normative use	Change over E-plan Kg/Qtl	Per cent	Normative use	Change over E-plan Kg/Qtl	Per cent		
<i>Khariif season</i>													
a.	FYM (Qtl.)	35.80	36.44	0.64	1.79	-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	-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	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	8.21	21.70	43.96	6.12	16.17	38.60	0.76	2.01
<i>Rabi season</i>													
a.	FYM (Qtl.)	45.20	51.52	6.32	13.98	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	-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	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	-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	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	-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	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	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<sub>3</sub>) 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<sub>4</sub>) 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<sub>1</sub> 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<sub>2</sub> 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<sub>3</sub> 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 <sub>1</sub>		Model-ML <sub>2</sub>		Model-ML <sub>3</sub>		Model-ML <sub>4</sub>					
			Normative use	Change over E-plan Kg/QtI Per cent	Normative use	Change over E-plan Kg/QtI Per cent	Normative use	Change over E-plan Kg/QtI Per cent	Normative use	Change over E-plan Kg/QtI Per cent				
<i>Khariif season</i>														
a.	FYM (QtI.)	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
<i>Rabi season</i>														
a.	FYM (QtI.)	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 (QtI.)		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<sub>1</sub> 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<sub>2</sub>) 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<sub>3</sub> 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<sub>4</sub> 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 <sub>1</sub>			Model-TS <sub>2</sub>			Model-TS <sub>3</sub>			Model-TS <sub>4</sub>		
			Normative use	Change over E-plan Kg/Qtl	Per cent	Normative use	Change over E-plan Kg/Qtl	Per cent	Normative use	Change over E-plan Kg/Qtl	Per cent	Normative use	Change over E-plan Kg/Qtl	Per cent
<i>Kharif season</i>														
a.	FYM (Qtl.)	42.30	49.65	7.35	17.38	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	-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	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	0.88	1.80	49.56	0.73	1.49	42.49	-6.34	12.98	
<i>Rabi season</i>														
a.	FYM (Qtl.)	27.00	11.50	-15.50	57.41	-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	-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	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	-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	-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	-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	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	-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<sub>1</sub>) 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<sub>2</sub> 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<sub>3</sub> 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<sub>4</sub> 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 <sub>1</sub>		Model-TL <sub>2</sub>		Model-TL <sub>3</sub>		Model-TL <sub>4</sub>					
			Normative use	Change over E-plan Kg/Qtl	Normative use	Change over E-plan Kg/Qtl	Normative use	Change over E-plan Kg/Qtl	Normative use	Change over E-plan Kg/Qtl	Per cent			
												Per cent		
<i>Kharif season</i>														
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
<i>Rabi season</i>														
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<sub>4</sub>) 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 <sub>1</sub>	Model - HS <sub>2</sub>	Model - HS <sub>3</sub>	Model - HS <sub>4</sub>
<i>Kharif</i> irrigated land	12064.12	12064.12	10231.18	-
<i>Rabi</i> irrigated land	14366.20	14366.20	13560.22	10686.21
<i>Kharif</i> 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
<i>Rabi</i> 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 <sub>1</sub>	Model - HL <sub>2</sub>	Model - HL <sub>3</sub>	Model - HL <sub>4</sub>
<i>Kharif</i> irrigated land	19131.12	19131.12	19131.12	4875.38
<i>Rabi</i> irrigated land	13588.00	13588.00	13588.00	8519.29
<i>Kharif</i> 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
<i>Rabi</i> 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<sub>4</sub>, all other programming models indicated shadow prices for land resource. The

normative plan MS<sub>4</sub> 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<sub>1</sub> and TS<sub>2</sub>). 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 <sub>1</sub>	Model - MS <sub>2</sub>	Model - MS <sub>3</sub>	Model - MS <sub>4</sub>
<i>Kharif</i> irrigated land	16345.93	5261.12	1193.29	--
<i>Rabi</i> irrigated land	16498.88	8068.33	6621.99	5910.21
<i>Kharif</i> 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
<i>Rabi</i> 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 <sub>1</sub>	Model – ML <sub>2</sub>	Model – ML <sub>3</sub>	Model – ML <sub>4</sub>
<i>Kharif</i> irrigated land	17674.96	9969.32	4106.40	4106.40
<i>Rabi</i> irrigated land	8972.49	5322.44	3237.85	3237.85
<i>Kharif</i> 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
<i>Rabi</i> 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 <sub>1</sub>	Model - TS <sub>2</sub>	Model - TS <sub>3</sub>	Model - TS <sub>4</sub>
<i>Kharif</i> irrigated land	20950.64	20950.64	14190.81	--
<i>Rabi</i> irrigated land	13907.38	13907.38	11503.89	6458.26
<i>Kharif</i> 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
<i>Rabi</i> 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 <sub>1</sub>	Model - TL <sub>2</sub>	Model - TL <sub>3</sub>	Model - TL <sub>4</sub>
<i>Kharij</i> irrigated land	8559.61	8559.61	8559.61	--
<i>Rabi</i> irrigated land	10086.67	10086.67	10086.67	--
<i>Kharij</i> 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
<i>Rabi</i> 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*

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## 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 assess 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 greengram 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<sub>1</sub>, 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<sub>1</sub>. 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<sub>2</sub> developed by decreasing 10 per cent of water supply resulted in different cropping pattern to that of model HS<sub>1</sub>. On *kharif*-irrigated land, the area under groundnut, sugarcane and brinjal remained the same as in optimum model HS<sub>1</sub>. However, it recommended to increase the area for sunflower from 0.06 ha (6.12 per cent) in model HS<sub>1</sub> to 0.17 ha (17.35 per cent) in model HS<sub>2</sub>. The model also suggested to reduce the area for paddy (1009) from 0.42 ha in HS<sub>1</sub> to 0.31 ha in model HS<sub>2</sub> 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<sub>1</sub>. The area under paddy declined from 0.29 ha in model HS<sub>1</sub> to 0.21 ha in model HS<sub>2</sub>. Consequently, the area under less water consuming

greengram crop increased from 0.14 ha in model HS<sub>1</sub> to 0.22 ha in model HS<sub>2</sub>. The cropping intensity remained the same as in model HS<sub>1</sub>.

The cropping pattern suggested by model HS<sub>2</sub> 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<sub>3</sub>. 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<sub>2</sub>. However, the plan suggested to increase the area from 0.17 ha in model HS<sub>2</sub> 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<sub>2</sub> to 0.09 ha in model HS<sub>3</sub>. The area under greengram increased from 0.22 ha in model HS<sub>2</sub> 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<sub>4</sub>) 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<sub>3</sub> to 187.76 per cent in model HS<sub>4</sub>. The cropping pattern suggested by the model HS<sub>4</sub> helped small farmers of head region to realize Rs.43,763.25 as net farm returns.

Model HL<sub>1</sub>, 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<sub>1</sub>. 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<sub>1</sub> 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<sub>2</sub> (10 per cent decrease in water availability) suggested same crops with changes in the acreage as in model HL<sub>1</sub>. During *kharif*, groundnut, sugarcane and brinjal occupied the same area as in model HL<sub>1</sub>. 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<sub>1</sub> to 0.80 ha in model HL<sub>2</sub> 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<sub>1</sub>, during *rabi* season. As a result, the area under the production of greengram, which requires less water increased to 0.71 ha. Cotton and chillies 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<sub>1</sub>, 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<sub>3</sub>) 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<sub>1</sub>, and 0.80 ha in HL<sub>2</sub> 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<sub>1</sub> to 0.82 ha in HL<sub>3</sub>. 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<sub>2</sub> to 0.87 ha to HL<sub>3</sub>. 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<sub>3</sub> enabled the farmers realize a net farm returns of Rs.1,06,544.

The results of optimum model HL<sub>4</sub> 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<sub>4</sub> 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<sub>1</sub>) 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<sub>1</sub> 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 chillies 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<sub>1</sub>. The crop mix suggested by Model MS<sub>1</sub> 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<sub>1</sub> except decrease in the area of paddy from 0.48 ha in MS<sub>1</sub> to 0.37 ha and increase in the area of sunflower from 0.06 ha in MS<sub>1</sub> 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<sub>1</sub> 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<sub>1</sub> to 0.23 ha. However, chillies occupied the same acreage as in MS<sub>1</sub>.

The cropping intensity remained the same as in model MS<sub>1</sub>. The cropping pattern suggested by model MS<sub>2</sub> 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 analysed through model MS<sub>3</sub>. This plan suggested to reduce the area of paddy and sugarcane from 0.37 and 0.20 ha in model MS<sub>2</sub> 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<sub>2</sub> to 0.44 ha by completely eliminating cowpea, which was found in MS<sub>2</sub> with 0.26 ha. There was a slight increase in the area of paddy over MS<sub>2</sub>. Chillies continued to occupy the same area as in the previous models.

The crop mix recommended by the model MS<sub>3</sub> 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<sub>4</sub>) 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<sub>3</sub> 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<sub>3</sub> to 0.04 ha. The proportionate area under paddy increased from 36.17 per cent in MS<sub>3</sub> to 40.43 per cent in MS<sub>4</sub>. 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<sub>4</sub> 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<sub>1</sub> 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, 0.40 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 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<sub>2</sub> (10 per cent decrease in water availability) suggested almost the same cropping pattern as that model ML<sub>1</sub> during *kharif*. During *rabi*, paddy was favoured in 0.14 ha, maintaining the same area for chillies as in optimum plan ML<sub>4</sub>. The plan indicated to reduce the area of cotton by 0.26 ha over the model ML<sub>1</sub> 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 *kharij*. 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<sub>1</sub> 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<sub>1</sub> 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<sub>1</sub>. 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<sub>1</sub>. The net farm returns were higher by Rs.13,674.28 over the existing plan.

Model TS<sub>2</sub> 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<sub>1</sub> on *khariif*-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 and 0.36 ha between models TS<sub>1</sub> and TS<sub>2</sub>. Cotton occupied one acre of *rabi* irrigated land. The intensity of cropping remained the same as in model TS<sub>1</sub>. The net farm returns increased from Rs.28,054.68 in the existing plan to Rs.41,406.22.

The optimum model TS<sub>3</sub> suggested crop activities similar to that of model TS<sub>2</sub> 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<sub>2</sub> during *khariif*. 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<sub>4</sub> recommended for the complete elimination of brinjal during *khariif* 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<sub>3</sub> to 0.63 ha during *kharif* and an increase of 0.12 ha for the production of greengram during *rabi* over the model TS<sub>3</sub>. 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<sub>1</sub> 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<sub>1</sub> 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<sub>2</sub> suggested a different crop mix from that of model TL<sub>1</sub> 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<sub>1</sub>. Groundnut and brinjal occupied the same area as in model TL<sub>1</sub> 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<sub>1</sub>. The net farm returns were increased by 36.56 per cent over the existing plan.

The normative plan TL<sub>3</sub> 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<sub>2</sub> 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<sub>2</sub>. 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<sub>4</sub> 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<sub>1</sub>, ML<sub>2</sub> and ML<sub>3</sub>. 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<sub>3</sub> to 0.60 ha and 0.20 ha in model TL<sub>4</sub> 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<sub>4</sub>, MS<sub>4</sub>, TS<sub>4</sub>, TL<sub>4</sub>) 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<sub>1</sub>, TS<sub>2</sub> and ML<sub>1</sub>).

### 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 patten 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.

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- 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.

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\* original not seen

*APPENDICES*

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

**Row Symbols**

KILD	:	<i>Kharif Irrigated Land</i>
RILD	:	<i>Rabi Irrigated Land</i>
MLRK	:	Men Labour Required In <i>Kharif</i>
WLRK	:	Women Labour Required In <i>Kharif</i>
BLRK	:	Bullock Labour Required In <i>Kharif</i>
TPRK	:	Tractor Power Required In <i>Kharif</i>
NFRK	:	Nitrogen Fertilizer Required In <i>Kharif</i>
PFRK	:	Phosphatic Fertilizer Required In <i>Kharif</i>
KFRK	:	Potassic Fertilizer Required In <i>Kharif</i>
FYMK	:	Farm Yard Mannure Required in <i>Kharif</i>
IWRK	:	Irrigation Water Requirement in <i>Kharif</i>
MLRR	:	Men Labour Required In <i>Rabi</i>
WLRR	:	Women Labour Required In <i>Rabi</i>
BLRR	:	Bullock Labour Required In <i>Rabi</i>
TPRR	:	Tractor Power Required In <i>Rabi</i>
NFRK	:	Nitrogen Fertilizer Required In <i>Rabi</i>
PFRK	:	Phosphatic Fertilizer Required In <i>Rabi</i>
KFRK	:	Potassic Fertilizer Required In <i>Rabi</i>
FYMK	:	Farm Yard Mannure Required in <i>Rabi</i>
IWRK	:	Irrigation Water Requirement in <i>Rabi</i>
KPA <sub>1</sub> Y	:	<i>Kharif Paddy Yield (1001)</i>
KPA <sub>9</sub> Y	:	<i>Kharif Paddy Yield (1009)</i>
KSMY	:	<i>Kharif Sunflower (Morden) Yield</i>

KSHY	:	Kharif Sunflower (Hybrid) Yield
KGJY	:	<i>Kharif</i> Groundnut (JL-24) Yield
KBJY	:	<i>Kharif</i> Bajra Yield
KSCY	:	<i>Kharif</i> Sugarcane (092) Yield
KBRY	:	<i>Kharif</i> Brinjal Yield
RPAY	:	<i>Rabi</i> Paddy Yield
RCOY	:	<i>Rabi</i> Cotton Yield
RCHY	:	<i>Rabi</i> Chilli Yield
RCPY	:	<i>Rabi</i> Cowpea Yield
RGGY	:	<i>Rabi</i> Greengram Yield
RGIY	:	<i>Rabi</i> Gingelly Yield
CASK	:	Cash Availability In <i>Kharif</i>
CASR	:	Cash Availability In <i>Rabi</i>
BORK	:	Borrowing In <i>Kharif</i>
DEMK	:	Debt Management In <i>Kharif</i>
DEMR	:	Debt Management In <i>Rabi</i>
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 <sub>1</sub> D	:	<i>Kharif Paddy (1001)</i>
KPA <sub>9</sub> D	:	<i>Kharif Paddy (1009)</i>
KSFM	:	<i>Kharif Sunflower (Morden)</i>
KSFH	:	<i>Kharif Sunflower (Hybrid)</i>
KGNJ	:	<i>Kharif Groundnut (JL-24)</i>
KBAJ	:	<i>Kharif Bajra</i>
KSUC	:	<i>Kharif Sugarcane (092)</i>
KBRI	:	<i>Kharif Brinjal</i>
RPAD	:	<i>Rabi Paddy</i>
RCOT	:	<i>Rabi Cotton</i>
RCHI	:	<i>Rabi Chilli</i>
RCOW	:	<i>Rabi Cowpea</i>
RGRG	:	<i>Rabi Greengram</i>
RGIN	:	<i>Rabi Gingelly</i>
HMLK	:	<i>Hired Men Labour In Kharif</i>
HWLK	:	<i>Hired Women Labour In Kharif</i>
HBLK	:	<i>Hired Bullock Labour In Kharif</i>
HTPK	:	<i>Hired Tractor Labour In Kharif</i>
PNFK	:	<i>Purchase of Nitrogen Fertilizer In Kharif</i>
PPFK	:	<i>Purchase of Phosphatic Fertilizer In Kharif</i>
PKFK	:	<i>Purchase of Potassic Fertilizer In Kharif</i>
PFMK	:	<i>Purchase of Farm Yard Manure In Kharif</i>
HMLR	:	<i>Hired Men Labour In Rabi</i>
HWLR	:	<i>Hired Women Labour In Rabi</i>
HBLR	:	<i>Hired Bullock Labour In Rabi</i>

HTPR	:	Hired Tractor Labour In <i>Rabi</i>
PNFR	:	Purchase of Nitrogen Fertilizer In <i>Rabi</i>
PPFR	:	Purchase of Phosphatic Fertilizer In <i>Rabi</i>
PKFR	:	Purchase of Potassic Fertilizer In <i>Rabi</i>
PFMR	:	Purchase of Farm Yard Manure In <i>Rabi</i>
SKP <sub>1</sub> A	:	Sale of <i>Kharif</i> Paddy
SKP <sub>9</sub> A	:	Sale of <i>Kharif</i> Paddy
SKSM	:	Sale of <i>Kharif</i> Sunflower (Morden)
SKSH	:	Sale of <i>Kharif</i> Sunflower (Hybrid)
SKGN	:	Sale of <i>Kharif</i> Groundnut (JL-24)
SKBJ	:	Sale of <i>Kharif</i> Bajra
SKSC	:	Sale of <i>Kharif</i> Sugarcane (092)
SKBR	:	Sale of <i>Kharif</i> Brinjal
SRPS	:	Sale of <i>Rabi</i> Paddy
SRCO	:	Sale of <i>Rabi</i> Cotton
SRCH	:	Sale of <i>Rabi</i> Chilli
SRCP	:	Sale of <i>Rabi</i> Cowpea
SRGG	:	Sale of <i>Rabi</i> Greengram
SRGI	:	Sale of <i>Rabi</i> Gingelly
BORK	:	Borrowing of Credit in <i>Kharif</i>
RKLR	:	Repayment of <i>Kharif</i> loan in <i>Rabi</i>
RKLZ	:	Repayment of <i>Khairf</i> loan at end
KCTR	:	<i>Kharif</i> Cash Transfer to <i>Rabi</i>
RCTZ	:	<i>Rabi</i> Cash Transfer to Objective Function









**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 <sub>1</sub> Y									
KPA <sub>9</sub> Y									
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 <sub>1</sub> Y				⇐	0
KPA <sub>9</sub> Y				⇐	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<sub>1</sub>)**

$$\text{MAX } 925 X_{35} + 550 X_{37} + 1800 X_{38} + 2300 X_{39} + 1400 X_{40} + 1600 X_{41} + 2400 X_{42} - 1.08 X_{45} + X_{47}$$

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 \leq .98$
- 3)  $X_6 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} \leq .98$
- 4)  $55 X_1 + 58 X_2 + 20 X_3 + 35 X_4 + 30 X_5 + 50 X_6 + 60 X_7 - X_{14} \leq 50$
- 5)  $80 X_1 + 87 X_2 + 42 X_3 + 80 X_4 + 35 X_5 + 20 X_6 + 63 X_7 - X_{15} \leq 60$
- 6)  $8 X_1 + 7 X_2 + 4 X_3 + 9 X_4 + 6 X_5 + 3 X_6 + 7 X_7 - X_{16} \leq 30$
- 7)  $7 X_1 + 9 X_2 + 7 X_3 + 6 X_4 + 2 X_5 + 5 X_7 - X_{17} \leq 0$
- 8)  $45 X_1 + 40 X_2 + 35 X_3 + 60 X_4 + 30 X_5 + 150 X_7 - X_{18} \leq 60$
- 9)  $80 X_1 + 80 X_2 + 53 X_3 + 52 X_4 + 45 X_5 + 60 X_6 + 70 X_7 - X_{19} \leq 0$
- 10)  $58 X_1 + 58 X_2 + 40 X_4 + 18 X_5 + 35 X_6 + 60 X_7 - X_{20} \leq 0$
- 11)  $38 X_1 + 38 X_2 + 28 X_3 + 42 X_4 + 25 X_6 + 32 X_7 - X_{21} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 40 X_5 + 100 X_6 + 55 X_7 \leq 90$
- 13)  $63 X_6 + 56 X_8 + 18 X_9 + 88 X_{10} + 37 X_{11} + 10 X_{12} + 24 X_{13} - X_{22} \leq 50$
- 14)  $42 X_6 + 79 X_8 + 106 X_9 + 102 X_{10} + 82 X_{11} + 48 X_{12} + 69 X_{13} - X_{23} \leq 60$
- 15)  $7 X_6 + 9 X_8 + 11 X_9 + 8 X_{10} + 3 X_{11} + 4 X_{12} + 2 X_{13} - X_{24} \leq 30$
- 16)  $4 X_6 + 8 X_8 + 3 X_9 + 7 X_{10} + 3 X_{11} + 4 X_{12} + 5 X_{13} - X_{25} \leq 0$
- 17)  $180 X_6 + 60 X_8 + 80 X_{10} + 40 X_{13} - X_{26} \leq 30$
- 18)  $100 X_6 + 86 X_8 + 70 X_9 + 76 X_{10} + 28 X_{11} + 32 X_{12} + 58 X_{13} - X_{27} \leq 0$
- 19)  $80 X_6 + 58 X_8 + 46 X_{10} + 21 X_{11} + 31 X_{12} - X_{28} \leq 0$
- 20)  $50 X_6 + 38 X_8 + 14 X_9 + 20 X_{10} + 15 X_{13} - X_{29} \leq 0$
- 21)  $100 X_6 + 150 X_8 + 70 X_9 + 60 X_{10} + 40 X_{11} + 25 X_{12} + 25 X_{13} \leq 90$
- 22)  $-56 X_1 + X_{30} \leq 0$
- 23)  $-58 X_2 + X_{31} \leq 0$
- 24)  $-14 X_3 + X_{32} \leq 0$
- 25)  $-23 X_4 + X_{33} \leq 0$
- 26)  $-25 X_5 + X_{34} \leq 0$
- 27)  $X_{35} - 100 X_6 \leq 0$
- 28)  $-100 X_7 + X_{36} \leq 0$
- 29)  $X_{37} - 54 X_8 \leq 0$
- 30)  $X_{38} - 13 X_9 \leq 0$
- 31)  $X_{39} - 18 X_{10} \leq 0$
- 32)  $X_{40} - 13 X_{11} \leq 0$
- 33)  $X_{41} - 12 X_{12} \leq 0$
- 34)  $X_{42} - 8 X_{13} \leq 0$
- 35)  $2800 X_1 + 2880 X_2 + 1600 X_3 + 7300 X_4 + 1000 X_5 + 4000 X_6 + 4500 X_7 + 45 X_{14} + 25 X_{15} + 120 X_{16} + 250 X_{17} + 25 X_{18} + 11 X_{19} + 15 X_{20} + 9 X_{21} - X_{43} + X_{46} \leq 2500$
- 36)  $X_{47} + 8000 X_6 + 2800 X_8 + 1000 X_9 + 9000 X_{10} + 1200 X_{11} + 1000 X_{12} + 1000 X_{13} + 45 X_{22} + 25 X_{23} + 120 X_{24} + 250 X_{25} + 25 X_{26} + 11 X_{27} + 15 X_{28} + 9 X_{29} - 540 X_{30} - 565 X_{31} - 1570 X_{32} - 1816 X_{33} - 600 X_{34} - 350 X_{36} - X_{46} + 1.04 X_{44} = 0$
- 37)  $X_{43} \geq 0$
- 38)  $-X_{43} + X_{44} = 0$
- 39)  $X_{45} - X_{43} + X_{44} = 0$
- 40)  $X_1 + X_2 + X_8 \geq .4$
- 41)  $X_6 \leq .2$
- 42)  $X_{10} \leq .1$
- 43)  $X_7 \leq .1$
- 44)  $X_9 \leq .25$
- 45)  $X_4 \leq .2$

END

SMALL FARMERS - HEAD REGION - (HS<sub>2</sub>)

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

SUBJECT TO

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

END

**SMALL FARMERS - HEAD REGION - (HS<sub>3</sub>)**

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

SUBJECT TO

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

END

**SMALL FARMERS - HEAD REGION - (HS<sub>4</sub>)**

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

SUBJECT TO

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

END









**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 <sub>1</sub> Y									
KPA <sub>9</sub> Y									
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 <sub>1</sub> Y					≤	0
KPA <sub>9</sub> 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<sub>1</sub>)**

MAX 925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47  
+ X49

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 \leq 2.43$
- 3)  $X_7 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} \leq 2.43$
- 4)  $62 X_1 + 63 X_2 + 22 X_3 + 22 X_4 + 45 X_5 + 32 X_6 + 56 X_7 + 67 X_8 - X_{15} \leq 0$
- 5)  $90 X_1 + 88 X_2 + 47 X_3 + 53 X_4 + 97 X_5 + 40 X_6 + 24 X_7 + 75 X_8 - X_{16} \leq 0$
- 6)  $3 X_1 + 3 X_2 + 3 X_3 + 4 X_4 + 9 X_5 + 5 X_6 + 7 X_7 + 8 X_8 - X_{17} \leq 0$
- 7)  $11 X_1 + 12 X_2 + 8 X_3 + 8 X_4 + 8 X_5 + 3 X_6 + 7 X_8 - X_{18} \leq 0$
- 8)  $109 X_1 + 109 X_2 + 59 X_3 + 59 X_4 + 52 X_5 + 45 X_6 + 80 X_7 + 78 X_8 - X_{19} \leq 0$
- 9)  $58 X_1 + 58 X_2 + 40 X_5 + 18 X_6 + 75 X_7 + 68 X_8 - X_{20} \leq 0$
- 10)  $38 X_1 + 38 X_2 + 32 X_3 + 32 X_4 + 42 X_5 + 40 X_7 + 40 X_8 - X_{21} \leq 0$
- 11)  $55 X_1 + 50 X_2 + 30 X_3 + 30 X_4 + 50 X_5 + 30 X_6 + 150 X_8 - X_{22} \leq 50$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 40 X_6 + 100 X_7 + 55 X_8 \leq 225$
- 13)  $68 X_7 + 62 X_9 + 23 X_{10} + 97 X_{11} + 40 X_{12} + 13 X_{13} + 27 X_{14} - X_{23} \leq 0$
- 14)  $41 X_7 + 85 X_9 + 120 X_{10} + 105 X_{11} + 90 X_{12} + 54 X_{13} + 72 X_{14} - X_{24} \leq 0$
- 15)  $3 X_7 + 3 X_9 + 14 X_{10} + 6 X_{11} + 4 X_{12} + 4 X_{13} + 2 X_{14} - X_{25} \leq 0$
- 16)  $5 X_7 + 12 X_9 + 3 X_{10} + 9 X_{11} + 3 X_{12} + 5 X_{13} + 5 X_{14} - X_{26} \leq 0$
- 17)  $80 X_7 + 85 X_9 + 74 X_{10} + 89 X_{11} + 32 X_{12} + 35 X_{13} + 58 X_{14} - X_{27} \leq 0$
- 18)  $35 X_7 + 58 X_9 + 56 X_{11} + 20 X_{12} + 35 X_{13} - X_{28} \leq 0$
- 19)  $35 X_7 + 38 X_9 + 14 X_{10} + 21 X_{11} + 15 X_{14} - X_{29} \leq 0$
- 20)  $180 X_7 + 50 X_9 + 70 X_{11} + 40 X_{14} - X_{30} \leq 50$
- 21)  $100 X_7 + 150 X_9 + 70 X_{10} + 60 X_{11} + 40 X_{12} + 25 X_{13} + 25 X_{14} \leq 195$
- 22)  $-58 X_1 + X_{31} \leq 0$
- 23)  $-64 X_2 + X_{32} \leq 0$
- 24)  $-15 X_3 + X_{33} \leq 0$
- 25)  $-17 X_4 + X_{34} \leq 0$
- 26)  $-25 X_5 + X_{35} \leq 0$
- 27)  $-20 X_6 + X_{36} \leq 0$
- 28)  $X_{37} - 105 X_7 \leq 0$
- 29)  $-120 X_8 + X_{38} \leq 0$
- 30)  $X_{39} - 53 X_9 \leq 0$
- 31)  $X_{40} - 13 X_{10} \leq 0$
- 32)  $X_{41} - 20 X_{11} \leq 0$
- 33)  $X_{42} - 12 X_{12} \leq 0$
- 34)  $X_{43} - 12 X_{13} \leq 0$
- 35)  $X_{44} - 8 X_{14} \leq 0$
- 36)  $3000 X_1 + 3200 X_2 + 1800 X_3 + 2000 X_4 + 7300 X_5 + 1000 X_6 + 4000 X_7 + 5000 X_8 + 45 X_{15} + 25 X_{16} + 120 X_{17} + 250 X_{18} + 11 X_{19} + 15 X_{20} + 10 X_{21} + 25 X_{22} - X_{45} + X_{48} \leq 10000$
- 37)  $X_{49} + 8000 X_7 + 3100 X_9 + 950 X_{10} + 9300 X_{11} + 1200 X_{12} + 1000 X_{13} + 1000 X_{14} + 45 X_{23} + 25 X_{24} + 120 X_{25} + 250 X_{26} + 11 X_{27} + 15 X_{28} + 10 X_{29} + 25 X_{30} - 540 X_{31} - 565 X_{32} - 1600 X_{33} - 1670 X_{34} - 1750 X_{35} - 600 X_{36} - 350 X_{38} - X_{48} + 1.04 X_{46} = 0$
- 38)  $X_{45} \geq 0$
- 39)  $-X_{45} + X_{46} = 0$
- 40)  $X_{47} - X_{45} + X_{46} = 0$
- 41)  $X_1 + X_2 + X_9 \geq .6$
- 42)  $X_7 \leq .5$
- 43)  $X_5 \leq .4$
- 44)  $X_8 \leq .2$
- 45)  $X_{11} \leq .3$
- 46)  $X_{10} \leq .6$

END

**LARGE FARMERS - HEAD REGION (HL<sub>2</sub>)**

MAX 925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47 + X49

SUBJECT TO

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

END

**LARGE FARMERS - HEAD REGION (HL<sub>3</sub>)**

MAX 925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47 + X49

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 \leq 2.43$
- 3)  $X_7 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} \leq 2.43$
- 4)  $62 X_1 + 63 X_2 + 22 X_3 + 22 X_4 + 45 X_5 + 32 X_6 + 56 X_7 + 67 X_8 - X_{15} \leq 0$
- 5)  $90 X_1 + 88 X_2 + 47 X_3 + 53 X_4 + 97 X_5 + 40 X_6 + 24 X_7 + 75 X_8 - X_{16} \leq 0$
- 6)  $3 X_1 + 3 X_2 + 3 X_3 + 4 X_4 + 9 X_5 + 5 X_6 + 7 X_7 + 8 X_8 - X_{17} \leq 0$
- 7)  $11 X_1 + 12 X_2 + 8 X_3 + 8 X_4 + 8 X_5 + 3 X_6 + 7 X_8 - X_{18} \leq 0$
- 8)  $109 X_1 + 109 X_2 + 59 X_3 + 59 X_4 + 52 X_5 + 45 X_6 + 80 X_7 + 78 X_8 - X_{19} \leq 0$
- 9)  $58 X_1 + 58 X_2 + 40 X_5 + 18 X_6 + 75 X_7 + 68 X_8 - X_{20} \leq 0$
- 10)  $38 X_1 + 38 X_2 + 32 X_3 + 32 X_4 + 42 X_5 + 40 X_7 + 40 X_8 - X_{21} \leq 0$
- 11)  $55 X_1 + 50 X_2 + 30 X_3 + 30 X_4 + 50 X_5 + 30 X_6 + 150 X_8 - X_{22} \leq 50$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 40 X_6 + 100 X_7 + 55 X_8 \leq 180$
- 13)  $68 X_7 + 62 X_9 + 23 X_{10} + 97 X_{11} + 40 X_{12} + 13 X_{13} + 27 X_{14} - X_{23} \leq 0$
- 14)  $41 X_7 + 85 X_9 + 120 X_{10} + 105 X_{11} + 90 X_{12} + 54 X_{13} + 72 X_{14} - X_{24} \leq 0$
- 15)  $3 X_7 + 3 X_9 + 14 X_{10} + 6 X_{11} + 4 X_{12} + 4 X_{13} + 2 X_{14} - X_{25} \leq 0$
- 16)  $5 X_7 + 12 X_9 + 3 X_{10} + 9 X_{11} + 3 X_{12} + 5 X_{13} + 5 X_{14} - X_{26} \leq 0$
- 17)  $80 X_7 + 85 X_9 + 74 X_{10} + 89 X_{11} + 32 X_{12} + 35 X_{13} + 58 X_{14} - X_{27} \leq 0$
- 18)  $35 X_7 + 58 X_9 + 56 X_{11} + 20 X_{12} + 35 X_{13} - X_{28} \leq 0$
- 19)  $35 X_7 + 38 X_9 + 14 X_{10} + 21 X_{11} + 15 X_{14} - X_{29} \leq 0$
- 20)  $180 X_7 + 50 X_9 + 70 X_{11} + 40 X_{14} - X_{30} \leq 50$
- 21)  $100 X_7 + 150 X_9 + 70 X_{10} + 60 X_{11} + 40 X_{12} + 25 X_{13} + 25 X_{14} \leq 156$
- 22)  $-58 X_1 + X_{31} \leq 0$
- 23)  $-64 X_2 + X_{32} \leq 0$
- 24)  $-15 X_3 + X_{33} \leq 0$
- 25)  $-17 X_4 + X_{34} \leq 0$
- 26)  $-25 X_5 + X_{35} \leq 0$
- 27)  $-20 X_6 + X_{36} \leq 0$
- 28)  $X_{37} - 105 X_7 \leq 0$
- 29)  $-120 X_8 + X_{38} \leq 0$
- 30)  $X_{39} - 53 X_9 \leq 0$
- 31)  $X_{40} - 13 X_{10} \leq 0$
- 32)  $X_{41} - 20 X_{11} \leq 0$
- 33)  $X_{42} - 12 X_{12} \leq 0$
- 34)  $X_{43} - 12 X_{13} \leq 0$
- 35)  $X_{44} - 8 X_{14} \leq 0$
- 36)  $3000 X_1 + 3200 X_2 + 1800 X_3 + 2000 X_4 + 7300 X_5 + 1000 X_6 + 4000 X_7 + 5000 X_8 + 45 X_{15} + 25 X_{16} + 120 X_{17} + 250 X_{18} + 11 X_{19} + 15 X_{20} + 10 X_{21} + 25 X_{22} - X_{45} + X_{48} \leq 10000$
- 37)  $X_{49} + 8000 X_7 + 3100 X_9 + 950 X_{10} + 9300 X_{11} + 1200 X_{12} + 1000 X_{13} + 1000 X_{14} + 45 X_{23} + 25 X_{24} + 120 X_{25} + 250 X_{26} + 11 X_{27} + 15 X_{28} + 10 X_{29} + 25 X_{30} - 540 X_{31} - 565 X_{32} - 1600 X_{33} - 1670 X_{34} - 1750 X_{35} - 600 X_{36} - 350 X_{38} - X_{48} + 1.04 X_{46} = 0$
- 38)  $X_{45} \geq 0$
- 39)  $-X_{45} + X_{46} = 0$
- 40)  $X_{47} - X_{45} + X_{46} = 0$
- 41)  $X_1 + X_2 + X_9 \geq .6$
- 42)  $X_7 \leq .5$
- 43)  $X_5 \leq .4$
- 44)  $X_8 \leq .2$
- 45)  $X_{11} \leq .3$
- 46)  $X_{10} \leq .6$

END

LARGE FARMERS - HEAD REGION (HL<sub>4</sub>)

MAX 925 X37 + 540 X39 + 1800 X40 + 2200 X41 + 1400 X42 + 1600 X43 + 2400 X44 - 1.08 X47 + X49

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 \leq 2.43$
- 3)  $X_7 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} \leq 2.43$
- 4)  $62 X_1 + 63 X_2 + 22 X_3 + 22 X_4 + 45 X_5 + 32 X_6 + 56 X_7 + 67 X_8 - X_{15} \leq 0$
- 5)  $90 X_1 + 88 X_2 + 47 X_3 + 53 X_4 + 97 X_5 + 40 X_6 + 24 X_7 + 75 X_8 - X_{16} \leq 0$
- 6)  $3 X_1 + 3 X_2 + 3 X_3 + 4 X_4 + 9 X_5 + 5 X_6 + 7 X_7 + 8 X_8 - X_{17} \leq 0$
- 7)  $11 X_1 + 12 X_2 + 8 X_3 + 8 X_4 + 8 X_5 + 3 X_6 + 7 X_8 - X_{18} \leq 0$
- 8)  $109 X_1 + 109 X_2 + 59 X_3 + 59 X_4 + 52 X_5 + 45 X_6 + 80 X_7 + 78 X_8 - X_{19} \leq 0$
- 9)  $58 X_1 + 58 X_2 + 40 X_5 + 18 X_6 + 75 X_7 + 68 X_8 - X_{20} \leq 0$
- 10)  $38 X_1 + 38 X_2 + 32 X_3 + 32 X_4 + 42 X_5 + 40 X_7 + 40 X_8 - X_{21} \leq 0$
- 11)  $55 X_1 + 50 X_2 + 30 X_3 + 30 X_4 + 50 X_5 + 30 X_6 + 150 X_8 - X_{22} \leq 50$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 40 X_6 + 100 X_7 + 55 X_8 \leq 157.5$
- 13)  $68 X_7 + 62 X_9 + 23 X_{10} + 97 X_{11} + 40 X_{12} + 13 X_{13} + 27 X_{14} - X_{23} \leq 0$
- 14)  $41 X_7 + 85 X_9 + 120 X_{10} + 105 X_{11} + 90 X_{12} + 54 X_{13} + 72 X_{14} - X_{24} \leq 0$
- 15)  $3 X_7 + 3 X_9 + 14 X_{10} + 6 X_{11} + 4 X_{12} + 4 X_{13} + 2 X_{14} - X_{25} \leq 0$
- 16)  $5 X_7 + 12 X_9 + 3 X_{10} + 9 X_{11} + 3 X_{12} + 5 X_{13} + 5 X_{14} - X_{26} \leq 0$
- 17)  $80 X_7 + 85 X_9 + 74 X_{10} + 89 X_{11} + 32 X_{12} + 35 X_{13} + 58 X_{14} - X_{27} \leq 0$
- 18)  $35 X_7 + 58 X_9 + 56 X_{11} + 20 X_{12} + 35 X_{13} - X_{28} \leq 0$
- 19)  $35 X_7 + 38 X_9 + 14 X_{10} + 21 X_{11} + 15 X_{14} - X_{29} \leq 0$
- 20)  $180 X_7 + 50 X_9 + 70 X_{11} + 40 X_{14} - X_{30} \leq 50$
- 21)  $100 X_7 + 150 X_9 + 70 X_{10} + 60 X_{11} + 40 X_{12} + 25 X_{13} + 25 X_{14} \leq 136.5$
- 22)  $-58 X_1 + X_{31} \leq 0$
- 23)  $-64 X_2 + X_{32} \leq 0$
- 24)  $-15 X_3 + X_{33} \leq 0$
- 25)  $-17 X_4 + X_{34} \leq 0$
- 26)  $-25 X_5 + X_{35} \leq 0$
- 27)  $-20 X_6 + X_{36} \leq 0$
- 28)  $X_{37} - 105 X_7 \leq 0$
- 29)  $-120 X_8 + X_{38} \leq 0$
- 30)  $X_{39} - 53 X_9 \leq 0$
- 31)  $X_{40} - 13 X_{10} \leq 0$
- 32)  $X_{41} - 20 X_{11} \leq 0$
- 33)  $X_{42} - 12 X_{12} \leq 0$
- 34)  $X_{43} - 12 X_{13} \leq 0$
- 35)  $X_{44} - 8 X_{14} \leq 0$
- 36)  $3000 X_1 + 3200 X_2 + 1800 X_3 + 2000 X_4 + 7300 X_5 + 1000 X_6 + 4000 X_7 + 5000 X_8 + 45 X_{15} + 25 X_{16} + 120 X_{17} + 250 X_{18} + 11 X_{19} + 15 X_{20} + 10 X_{21} + 25 X_{22} - X_{45} + X_{48} \leq 10000$
- 37)  $X_{49} + 8000 X_7 + 3100 X_9 + 950 X_{10} + 9300 X_{11} + 1200 X_{12} + 1000 X_{13} + 1000 X_{14} + 45 X_{23} + 25 X_{24} + 120 X_{25} + 250 X_{26} + 11 X_{27} + 15 X_{28} + 10 X_{29} + 25 X_{30} - 540 X_{31} - 565 X_{32} - 1600 X_{33} - 1670 X_{34} - 1750 X_{35} - 600 X_{36} - 350 X_{38} - X_{48} + 1.04 X_{46} = 0$
- 38)  $X_{45} \geq 0$
- 39)  $-X_{45} + X_{46} = 0$
- 40)  $X_{47} - X_{45} + X_{46} = 0$
- 41)  $X_1 + X_2 + X_9 \geq .6$
- 42)  $X_7 \leq .5$
- 43)  $X_5 \leq .4$
- 44)  $X_8 \leq .2$
- 45)  $X_{11} \leq .3$
- 46)  $X_{10} \leq .6$

END











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 <sub>1</sub> Y		1								
KPA <sub>9</sub> 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										
DEMRR										
MIPA										
MSUC										
MCHI										
MGNT										
Z							900	540	1750	2000

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**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 <sub>1</sub> Y									<=	0
KPA <sub>9</sub> Y									<=	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<sub>1</sub>)**

MAX 900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39 + 2200 X40 -  
1.08 X43 + X45

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq .94$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq .94$
- 4)  $52 X_1 + 63 X_2 + 20 X_3 + 40 X_4 + 30 X_5 + 60 X_6 - X_{13} \leq 60$
- 5)  $80 X_1 + 85 X_2 + 42 X_3 + 85 X_4 + 43 X_5 + 30 X_6 - X_{14} \leq 50$
- 6)  $6 X_1 + 6 X_2 + 4 X_3 + 7 X_4 + 6 X_5 + 7 X_6 - X_{15} \leq 20$
- 7)  $8 X_1 + 10 X_2 + 6 X_3 + 8 X_4 + 3 X_5 - X_{16} \leq 0$
- 8)  $45 X_1 + 50 X_2 + 40 X_3 + 50 X_4 + 40 X_5 - X_{17} \leq 40$
- 9)  $98 X_1 + 115 X_2 + 55 X_3 + 53 X_4 + 50 X_5 + 80 X_6 - X_{18} \leq 0$
- 10)  $46 X_1 + 60 X_2 + 40 X_4 + 60 X_6 - X_{19} \leq 0$
- 11)  $42 X_1 + 62 X_2 + 28 X_3 + 56 X_4 + 36 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 40 X_5 + 100 X_6 \leq 92$
- 13)  $48 X_6 + 57 X_7 + 20 X_8 + 92 X_9 + 40 X_{10} + 13 X_{11} + 25 X_{12} - X_{21} \leq 60$
- 14)  $40 X_6 + 82 X_7 + 102 X_8 + 115 X_9 + 90 X_{10} + 53 X_{11} + 69 X_{12} - X_{22} \leq 50$
- 15)  $3 X_6 + 8 X_7 + 12 X_8 + 7 X_9 + 4 X_{10} + 4 X_{11} + 4 X_{12} - X_{23} \leq 20$
- 16)  $5 X_6 + 10 X_7 + 4 X_8 + 4 X_9 + 3 X_{10} + 2 X_{11} + 2 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 60 X_7 + 70 X_9 - X_{25} \leq 30$
- 18)  $80 X_6 + 87 X_7 + 88 X_8 + 90 X_9 + 32 X_{10} + 35 X_{11} + 58 X_{12} - X_{26} \leq 0$
- 19)  $55 X_6 + 57 X_7 + 37 X_9 + 21 X_{10} + 35 X_{11} - X_{27} \leq 0$
- 20)  $36 X_6 + 37 X_7 + 15 X_8 + 24 X_9 + 15 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 85$
- 22)  $-50 X_1 + X_{29} \leq 0$
- 23)  $-56 X_2 + X_{30} \leq 0$
- 24)  $-14 X_3 + X_{31} \leq 0$
- 25)  $-22 X_4 + X_{32} \leq 0$
- 26)  $-19 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 102 X_6 \leq 0$
- 28)  $X_{35} - 52 X_7 \leq 0$
- 29)  $X_{36} - 13 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 6 X_{12} \leq 0$
- 34)  $2600 X_1 + 2800 X_2 + 1500 X_3 + 6000 X_4 + 900 X_5 + 4000 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 10 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 3000$
- 35)  $X_{45} + 7000 X_6 + 2900 X_7 + 1100 X_8 + 7200 X_9 + 1600 X_{10} + 1300 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 10 X_{26} + 15 X_{27} + 9 X_{28} - 570 X_{29} - 560 X_{30} - 1650 X_{31} - 1690 X_{32} - 550 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .6$
- 40)  $X_4 \leq .2$
- 41)  $X_6 \leq .2$
- 42)  $X_9 \leq .15$

END

**SMALL FARMERS - MIDDLE REGION (MS<sub>2</sub>)**

MAX 900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39  
+ 2200 X40 - 1.08 X43 + X45

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq .94$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq .94$
- 4)  $52 X_1 + 63 X_2 + 20 X_3 + 40 X_4 + 30 X_5 + 60 X_6 - X_{13} \leq 60$
- 5)  $80 X_1 + 85 X_2 + 42 X_3 + 85 X_4 + 43 X_5 + 30 X_6 - X_{14} \leq 50$
- 6)  $6 X_1 + 6 X_2 + 4 X_3 + 7 X_4 + 6 X_5 + 7 X_6 - X_{15} \leq 20$
- 7)  $8 X_1 + 10 X_2 + 6 X_3 + 8 X_4 + 3 X_5 - X_{16} \leq 0$
- 8)  $45 X_1 + 50 X_2 + 40 X_3 + 50 X_4 + 40 X_5 - X_{17} \leq 40$
- 9)  $98 X_1 + 115 X_2 + 55 X_3 + 53 X_4 + 50 X_5 + 80 X_6 - X_{18} \leq 0$
- 10)  $46 X_1 + 60 X_2 + 40 X_4 + 60 X_6 - X_{19} \leq 0$
- 11)  $42 X_1 + 62 X_2 + 28 X_3 + 56 X_4 + 36 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 40 X_5 + 100 X_6 \leq 82.8$
- 13)  $48 X_6 + 57 X_7 + 20 X_8 + 92 X_9 + 40 X_{10} + 13 X_{11} + 25 X_{12} - X_{21} \leq 60$
- 14)  $40 X_6 + 82 X_7 + 102 X_8 + 115 X_9 + 90 X_{10} + 53 X_{11} + 69 X_{12} - X_{22} \leq 50$
- 15)  $3 X_6 + 8 X_7 + 12 X_8 + 7 X_9 + 4 X_{10} + 4 X_{11} + 4 X_{12} - X_{23} \leq 20$
- 16)  $5 X_6 + 10 X_7 + 4 X_8 + 4 X_9 + 3 X_{10} + 2 X_{11} + 2 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 60 X_7 + 70 X_9 - X_{25} \leq 30$
- 18)  $80 X_6 + 87 X_7 + 88 X_8 + 90 X_9 + 32 X_{10} + 35 X_{11} + 58 X_{12} - X_{26} \leq 0$
- 19)  $55 X_6 + 57 X_7 + 37 X_9 + 21 X_{10} + 35 X_{11} - X_{27} \leq 0$
- 20)  $36 X_6 + 37 X_7 + 15 X_8 + 24 X_9 + 15 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 76.5$
- 22)  $-50 X_1 + X_{29} \leq 0$
- 23)  $-56 X_2 + X_{30} \leq 0$
- 24)  $-14 X_3 + X_{31} \leq 0$
- 25)  $-22 X_4 + X_{32} \leq 0$
- 26)  $-19 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 102 X_6 \leq 0$
- 28)  $X_{35} - 52 X_7 \leq 0$
- 29)  $X_{36} - 13 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 6 X_{12} \leq 0$
- 34)  $2600 X_1 + 2800 X_2 + 1500 X_3 + 6000 X_4 + 900 X_5 + 4000 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 10 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 3000$
- 35)  $X_{45} + 7000 X_6 + 2900 X_7 + 1100 X_8 + 7200 X_9 + 1600 X_{10} + 1300 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 10 X_{26} + 15 X_{27} + 9 X_{28} - 570 X_{29} - 560 X_{30} - 1650 X_{31} - 1690 X_{32} - 550 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .6$
- 40)  $X_4 \leq .2$
- 41)  $X_6 \leq .2$
- 42)  $X_9 \leq .15$

END

**SMALL FARMERS - MIDDLE REGION (MS<sub>3</sub>)**

MAX 900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39  
+ 2200 X40 - 1.08 X43 + X45

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq .94$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq .94$
- 4)  $52 X_1 + 63 X_2 + 20 X_3 + 40 X_4 + 30 X_5 + 60 X_6 - X_{13} \leq 60$
- 5)  $80 X_1 + 85 X_2 + 42 X_3 + 85 X_4 + 43 X_5 + 30 X_6 - X_{14} \leq 50$
- 6)  $6 X_1 + 6 X_2 + 4 X_3 + 7 X_4 + 6 X_5 + 7 X_6 - X_{15} \leq 20$
- 7)  $8 X_1 + 10 X_2 + 6 X_3 + 8 X_4 + 3 X_5 - X_{16} \leq 0$
- 8)  $45 X_1 + 50 X_2 + 40 X_3 + 50 X_4 + 40 X_5 - X_{17} \leq 40$
- 9)  $98 X_1 + 115 X_2 + 55 X_3 + 53 X_4 + 50 X_5 + 80 X_6 - X_{18} \leq 0$
- 10)  $46 X_1 + 60 X_2 + 40 X_4 + 60 X_6 - X_{19} \leq 0$
- 11)  $42 X_1 + 62 X_2 + 28 X_3 + 56 X_4 + 36 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 40 X_5 + 100 X_6 \leq 73.6$
- 13)  $48 X_6 + 57 X_7 + 20 X_8 + 92 X_9 + 40 X_{10} + 13 X_{11} + 25 X_{12} - X_{21} \leq 60$
- 14)  $40 X_6 + 82 X_7 + 102 X_8 + 115 X_9 + 90 X_{10} + 53 X_{11} + 69 X_{12} - X_{22} \leq 50$
- 15)  $3 X_6 + 8 X_7 + 12 X_8 + 7 X_9 + 4 X_{10} + 4 X_{11} + 4 X_{12} - X_{23} \leq 20$
- 16)  $5 X_6 + 10 X_7 + 4 X_8 + 4 X_9 + 3 X_{10} + 2 X_{11} + 2 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 60 X_7 + 70 X_9 - X_{25} \leq 30$
- 18)  $80 X_6 + 87 X_7 + 88 X_8 + 90 X_9 + 32 X_{10} + 35 X_{11} + 58 X_{12} - X_{26} \leq 0$
- 19)  $55 X_6 + 57 X_7 + 37 X_9 + 21 X_{10} + 35 X_{11} - X_{27} \leq 0$
- 20)  $36 X_6 + 37 X_7 + 15 X_8 + 24 X_9 + 15 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 68$
- 22)  $-50 X_1 + X_{29} \leq 0$
- 23)  $-56 X_2 + X_{30} \leq 0$
- 24)  $-14 X_3 + X_{31} \leq 0$
- 25)  $-22 X_4 + X_{32} \leq 0$
- 26)  $-19 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 102 X_6 \leq 0$
- 28)  $X_{35} - 52 X_7 \leq 0$
- 29)  $X_{36} - 13 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 6 X_{12} \leq 0$
- 34)  $2600 X_1 + 2800 X_2 + 1500 X_3 + 6000 X_4 + 900 X_5 + 4000 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 10 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 3000$
- 35)  $X_{45} + 7000 X_6 + 2900 X_7 + 1100 X_8 + 7200 X_9 + 1600 X_{10} + 1300 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 10 X_{26} + 15 X_{27} + 9 X_{28} - 570 X_{29} - 560 X_{30} - 1650 X_{31} - 1690 X_{32} - 550 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .6$
- 40)  $X_4 \leq .2$
- 41)  $X_6 \leq .2$
- 42)  $X_9 \leq .15$

END





SMALL FARMERS - MIDDLE REGION (MS<sub>4</sub>)

MAX 900 X34 + 540 X35 + 1750 X36 + 2000 X37 + 1420 X38 + 1550 X39  
+ 2200 X40 - 1.08 X43 + X45

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq .94$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq .94$
- 4)  $52 X_1 + 63 X_2 + 20 X_3 + 40 X_4 + 30 X_5 + 60 X_6 - X_{13} \leq 60$
- 5)  $80 X_1 + 85 X_2 + 42 X_3 + 85 X_4 + 43 X_5 + 30 X_6 - X_{14} \leq 50$
- 6)  $6 X_1 + 6 X_2 + 4 X_3 + 7 X_4 + 6 X_5 + 7 X_6 - X_{15} \leq 20$
- 7)  $8 X_1 + 10 X_2 + 6 X_3 + 8 X_4 + 3 X_5 - X_{16} \leq 0$
- 8)  $45 X_1 + 50 X_2 + 40 X_3 + 50 X_4 + 40 X_5 - X_{17} \leq 40$
- 9)  $98 X_1 + 115 X_2 + 55 X_3 + 53 X_4 + 50 X_5 + 80 X_6 - X_{18} \leq 0$
- 10)  $46 X_1 + 60 X_2 + 40 X_4 + 60 X_6 - X_{19} \leq 0$
- 11)  $42 X_1 + 62 X_2 + 28 X_3 + 56 X_4 + 36 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 40 X_5 + 100 X_6 \leq 64.4$
- 13)  $48 X_6 + 57 X_7 + 20 X_8 + 92 X_9 + 40 X_{10} + 13 X_{11} + 25 X_{12} - X_{21} \leq 60$
- 14)  $40 X_6 + 82 X_7 + 102 X_8 + 115 X_9 + 90 X_{10} + 53 X_{11} + 69 X_{12} - X_{22} \leq 50$
- 15)  $3 X_6 + 8 X_7 + 12 X_8 + 7 X_9 + 4 X_{10} + 4 X_{11} + 4 X_{12} - X_{23} \leq 20$
- 16)  $5 X_6 + 10 X_7 + 4 X_8 + 4 X_9 + 3 X_{10} + 2 X_{11} + 2 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 60 X_7 + 70 X_9 - X_{25} \leq 30$
- 18)  $80 X_6 + 87 X_7 + 88 X_8 + 90 X_9 + 32 X_{10} + 35 X_{11} + 58 X_{12} - X_{26} \leq 0$
- 19)  $55 X_6 + 57 X_7 + 37 X_9 + 21 X_{10} + 35 X_{11} - X_{27} \leq 0$
- 20)  $36 X_6 + 37 X_7 + 15 X_8 + 24 X_9 + 15 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 59.5$
- 22)  $-50 X_1 + X_{29} \leq 0$
- 23)  $-56 X_2 + X_{30} \leq 0$
- 24)  $-14 X_3 + X_{31} \leq 0$
- 25)  $-22 X_4 + X_{32} \leq 0$
- 26)  $-19 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 102 X_6 \leq 0$
- 28)  $X_{35} - 52 X_7 \leq 0$
- 29)  $X_{36} - 13 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 6 X_{12} \leq 0$
- 34)  $2600 X_1 + 2800 X_2 + 1500 X_3 + 6000 X_4 + 900 X_5 + 4000 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 10 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 3000$
- 35)  $X_{45} + 7000 X_6 + 2900 X_7 + 1100 X_8 + 7200 X_9 + 1600 X_{10} + 1300 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 10 X_{26} + 15 X_{27} + 9 X_{28} - 570 X_{29} - 560 X_{30} - 1650 X_{31} - 1690 X_{32} - 550 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .6$
- 40)  $X_4 \leq .2$
- 41)  $X_6 \leq .2$
- 42)  $X_9 \leq .15$

END







**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 <sub>1</sub> Y		1								
KPA <sub>9</sub> Y			1							
KSMY				1						
KSHY					1					
KGNY						1				
KSCY							1			
RPAY								1		
RCOY									1	
RCHY										1
RCPY										
GGY										
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 <sub>1</sub> Y									<=	0
KPA <sub>9</sub> Y									<=	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<sub>1</sub>)**

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

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq 2.09$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq 2.09$
- 4)  $62 X_1 + 69 X_2 + 20 X_3 + 23 X_4 + 47 X_5 + 50 X_6 - X_{13} \leq 0$
- 5)  $85 X_1 + 91 X_2 + 44 X_3 + 52 X_4 + 99 X_5 + 24 X_6 - X_{14} \leq 0$
- 6)  $2 X_1 + 2 X_2 + 3 X_3 + 3 X_4 + 5 X_5 + 7 X_6 - X_{15} \leq 0$
- 7)  $12 X_1 + 12 X_2 + 7 X_3 + 8 X_4 + 8 X_5 - X_{16} \leq 0$
- 8)  $50 X_1 + 50 X_2 + 50 X_3 + 50 X_4 + 60 X_5 - X_{17} \leq 40$
- 9)  $118 X_1 + 130 X_2 + 60 X_3 + 60 X_4 + 53 X_5 + 85 X_6 - X_{18} \leq 0$
- 10)  $59 X_1 + 60 X_2 + 41 X_5 + 65 X_6 - X_{19} \leq 0$
- 11)  $54 X_1 + 62 X_2 + 32 X_3 + 34 X_4 + 60 X_5 + 35 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 100 X_6 \leq 200$
- 13)  $65 X_6 + 61 X_7 + 24 X_8 + 95 X_9 + 45 X_{10} + 15 X_{11} + 30 X_{12} - X_{21} \leq 0$
- 14)  $50 X_6 + 89 X_7 + 110 X_8 + 121 X_9 + 96 X_{10} + 60 X_{11} + 75 X_{12} - X_{22} \leq 0$
- 15)  $2 X_6 + 2 X_7 + 13 X_8 + 6 X_9 + 3 X_{10} + 3 X_{11} - X_{23} \leq 0$
- 16)  $6 X_6 + 12 X_7 + 5 X_8 + 5 X_9 + 3 X_{10} + 4 X_{11} + 4 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 65 X_7 + 80 X_9 + 40 X_{12} - X_{25} \leq 40$
- 18)  $80 X_6 + 110 X_7 + 88 X_8 + 92 X_9 + 32 X_{10} + 42 X_{11} + 63 X_{12} - X_{26} \leq 0$
- 19)  $56 X_6 + 57 X_7 + 37 X_9 + 22 X_{10} + 42 X_{11} - X_{27} \leq 0$
- 20)  $37 X_6 + 38 X_7 + 15 X_8 + 24 X_9 + 20 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 160$
- 22)  $-55 X_1 + X_{29} \leq 0$
- 23)  $-59 X_2 + X_{30} \leq 0$
- 24)  $-15 X_3 + X_{31} \leq 0$
- 25)  $-16 X_4 + X_{32} \leq 0$
- 26)  $-23 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 108 X_6 \leq 0$
- 28)  $X_{35} - 62.5 X_7 \leq 0$
- 29)  $X_{36} - 16 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 7.7 X_{12} \leq 0$
- 34)  $2800 X_1 + 3000 X_2 + 1680 X_3 + 1590 X_4 + 2300 X_5 + 7500 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 11 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 10000$
- 35)  $X_{45} + 6000 X_6 + 3000 X_7 + 665 X_8 + 800 X_9 + 1500 X_{10} + 1400 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 11 X_{26} + 15 X_{27} + 9 X_{28} - 550 X_{29} - 560 X_{30} - 1620 X_{31} - 1680 X_{32} - 1700 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .8$
- 40)  $X_5 \leq .6$
- 41)  $X_8 \leq .6$
- 42)  $X_9 \leq .4$
- 43)  $X_6 \leq .6$

END

**LARGE FARMERS - MIDDLE REGION (ML<sub>2</sub>)**

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

SUBJECT TO

- 2)  $X1 + X2 + X3 + X4 + X5 + X6 \leq 2.09$
- 3)  $X6 + X7 + X8 + X9 + X10 + X11 + X12 \leq 2.09$
- 4)  $62 X1 + 69 X2 + 20 X3 + 23 X4 + 47 X5 + 50 X6 - X13 \leq 0$
- 5)  $85 X1 + 91 X2 + 44 X3 + 52 X4 + 99 X5 + 24 X6 - X14 \leq 0$
- 6)  $2 X1 + 2 X2 + 3 X3 + 3 X4 + 5 X5 + 7 X6 - X15 \leq 0$
- 7)  $12 X1 + 12 X2 + 7 X3 + 8 X4 + 8 X5 - X16 \leq 0$
- 8)  $50 X1 + 50 X2 + 50 X3 + 50 X4 + 60 X5 - X17 \leq 40$
- 9)  $118 X1 + 130 X2 + 60 X3 + 60 X4 + 53 X5 + 85 X6 - X18 \leq 0$
- 10)  $59 X1 + 60 X2 + 41 X5 + 65 X6 - X19 \leq 0$
- 11)  $54 X1 + 62 X2 + 32 X3 + 34 X4 + 60 X5 + 35 X6 - X20 \leq 0$
- 12)  $125 X1 + 125 X2 + 45 X3 + 45 X4 + 45 X5 + 100 X6 \leq 180$
- 13)  $65 X6 + 61 X7 + 24 X8 + 95 X9 + 45 X10 + 15 X11 + 30 X12 - X21 \leq 0$
- 14)  $50 X6 + 89 X7 + 110 X8 + 121 X9 + 96 X10 + 60 X11 + 75 X12 - X22 \leq 0$
- 15)  $2 X6 + 2 X7 + 13 X8 + 6 X9 + 3 X10 + 3 X11 - X23 \leq 0$
- 16)  $6 X6 + 12 X7 + 5 X8 + 5 X9 + 3 X10 + 4 X11 + 4 X12 - X24 \leq 0$
- 17)  $150 X6 + 65 X7 + 80 X9 + 40 X12 - X25 \leq 40$
- 18)  $80 X6 + 110 X7 + 88 X8 + 92 X9 + 32 X10 + 42 X11 + 63 X12 - X26 \leq 0$
- 19)  $56 X6 + 57 X7 + 37 X9 + 22 X10 + 42 X11 - X27 \leq 0$
- 20)  $37 X6 + 38 X7 + 15 X8 + 24 X9 + 20 X12 - X28 \leq 0$
- 21)  $100 X6 + 150 X7 + 70 X8 + 60 X9 + 40 X10 + 25 X11 + 25 X12 \leq 144$
- 22)  $-55 X1 + X29 \leq 0$
- 23)  $-59 X2 + X30 \leq 0$
- 24)  $-15 X3 + X31 \leq 0$
- 25)  $-16 X4 + X32 \leq 0$
- 26)  $-23 X5 + X33 \leq 0$
- 27)  $X34 - 108 X6 \leq 0$
- 28)  $X35 - 62.5 X7 \leq 0$
- 29)  $X36 - 16 X8 \leq 0$
- 30)  $X37 - 19 X9 \leq 0$
- 31)  $X38 - 15 X10 \leq 0$
- 32)  $X39 - 11 X11 \leq 0$
- 33)  $X40 - 7.7 X12 \leq 0$
- 34)  $2800 X1 + 3000 X2 + 1680 X3 + 1590 X4 + 2300 X5 + 7500 X6 + 45 X13 + 30 X14 + 150 X15 + 250 X16 + 25 X17 + 11 X18 + 15 X19 + 9 X20 - X41 + X44 \leq 10000$
- 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)  $X41 \geq 0$
- 37)  $-X41 + X42 = 0$
- 38)  $X43 - X41 + X42 = 0$
- 39)  $X1 + X2 + X7 \geq .8$
- 40)  $X5 \leq .6$
- 41)  $X8 \leq .6$
- 42)  $X9 \leq .4$
- 43)  $X6 \leq .6$

END

**LARGE FARMERS - MIDDLE REGION (ML<sub>3</sub>)**

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

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq 2.09$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq 2.09$
- 4)  $62 X_1 + 69 X_2 + 20 X_3 + 23 X_4 + 47 X_5 + 50 X_6 - X_{13} \leq 0$
- 5)  $85 X_1 + 91 X_2 + 44 X_3 + 52 X_4 + 99 X_5 + 24 X_6 - X_{14} \leq 0$
- 6)  $2 X_1 + 2 X_2 + 3 X_3 + 3 X_4 + 5 X_5 + 7 X_6 - X_{15} \leq 0$
- 7)  $12 X_1 + 12 X_2 + 7 X_3 + 8 X_4 + 8 X_5 - X_{16} \leq 0$
- 8)  $50 X_1 + 50 X_2 + 50 X_3 + 50 X_4 + 60 X_5 - X_{17} \leq 40$
- 9)  $118 X_1 + 130 X_2 + 60 X_3 + 60 X_4 + 53 X_5 + 85 X_6 - X_{18} \leq 0$
- 10)  $59 X_1 + 60 X_2 + 41 X_5 + 65 X_6 - X_{19} \leq 0$
- 11)  $54 X_1 + 62 X_2 + 32 X_3 + 34 X_4 + 60 X_5 + 35 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 100 X_6 \leq 160$
- 13)  $65 X_6 + 61 X_7 + 24 X_8 + 95 X_9 + 45 X_{10} + 15 X_{11} + 30 X_{12} - X_{21} \leq 0$
- 14)  $50 X_6 + 89 X_7 + 110 X_8 + 121 X_9 + 96 X_{10} + 60 X_{11} + 75 X_{12} - X_{22} \leq 0$
- 15)  $2 X_6 + 2 X_7 + 13 X_8 + 6 X_9 + 3 X_{10} + 3 X_{11} - X_{23} \leq 0$
- 16)  $6 X_6 + 12 X_7 + 5 X_8 + 5 X_9 + 3 X_{10} + 4 X_{11} + 4 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 65 X_7 + 80 X_9 + 40 X_{12} - X_{25} \leq 40$
- 18)  $80 X_6 + 110 X_7 + 88 X_8 + 92 X_9 + 32 X_{10} + 42 X_{11} + 63 X_{12} - X_{26} \leq 0$
- 19)  $56 X_6 + 57 X_7 + 37 X_9 + 22 X_{10} + 42 X_{11} - X_{27} \leq 0$
- 20)  $37 X_6 + 38 X_7 + 15 X_8 + 24 X_9 + 20 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 128$
- 22)  $-55 X_1 + X_{29} \leq 0$
- 23)  $-59 X_2 + X_{30} \leq 0$
- 24)  $-15 X_3 + X_{31} \leq 0$
- 25)  $-16 X_4 + X_{32} \leq 0$
- 26)  $-23 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 108 X_6 \leq 0$
- 28)  $X_{35} - 62.5 X_7 \leq 0$
- 29)  $X_{36} - 16 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 7.7 X_{12} \leq 0$
- 34)  $2800 X_1 + 3000 X_2 + 1680 X_3 + 1590 X_4 + 2300 X_5 + 7500 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 11 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 10000$
- 35)  $X_{45} + 6000 X_6 + 3000 X_7 + 665 X_8 + 800 X_9 + 1500 X_{10} + 1400 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 11 X_{26} + 15 X_{27} + 9 X_{28} - 550 X_{29} - 560 X_{30} - 1620 X_{31} - 1680 X_{32} - 1700 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .8$
- 40)  $X_5 \leq .6$
- 41)  $X_8 \leq .6$
- 42)  $X_9 \leq .4$
- 43)  $X_6 \leq .6$

END

**LARGE FARMERS - MIDDLE REGION (ML<sub>3</sub>)**

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

SUBJECT TO

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

END

**LARGE FARMERS - MIDDLE REGION (ML<sub>4</sub>)**

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

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq 2.09$
- 3)  $X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} \leq 2.09$
- 4)  $62 X_1 + 69 X_2 + 20 X_3 + 23 X_4 + 47 X_5 + 50 X_6 - X_{13} \leq 0$
- 5)  $85 X_1 + 91 X_2 + 44 X_3 + 52 X_4 + 99 X_5 + 24 X_6 - X_{14} \leq 0$
- 6)  $2 X_1 + 2 X_2 + 3 X_3 + 3 X_4 + 5 X_5 + 7 X_6 - X_{15} \leq 0$
- 7)  $12 X_1 + 12 X_2 + 7 X_3 + 8 X_4 + 8 X_5 - X_{16} \leq 0$
- 8)  $50 X_1 + 50 X_2 + 50 X_3 + 50 X_4 + 60 X_5 - X_{17} \leq 40$
- 9)  $118 X_1 + 130 X_2 + 60 X_3 + 60 X_4 + 53 X_5 + 85 X_6 - X_{18} \leq 0$
- 10)  $59 X_1 + 60 X_2 + 41 X_5 + 65 X_6 - X_{19} \leq 0$
- 11)  $54 X_1 + 62 X_2 + 32 X_3 + 34 X_4 + 60 X_5 + 35 X_6 - X_{20} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 100 X_6 \leq 140$
- 13)  $65 X_6 + 61 X_7 + 24 X_8 + 95 X_9 + 45 X_{10} + 15 X_{11} + 30 X_{12} - X_{21} \leq 0$
- 14)  $50 X_6 + 89 X_7 + 110 X_8 + 121 X_9 + 96 X_{10} + 60 X_{11} + 75 X_{12} - X_{22} \leq 0$
- 15)  $2 X_6 + 2 X_7 + 13 X_8 + 6 X_9 + 3 X_{10} + 3 X_{11} - X_{23} \leq 0$
- 16)  $6 X_6 + 12 X_7 + 5 X_8 + 5 X_9 + 3 X_{10} + 4 X_{11} + 4 X_{12} - X_{24} \leq 0$
- 17)  $150 X_6 + 65 X_7 + 80 X_9 + 40 X_{12} - X_{25} \leq 40$
- 18)  $80 X_6 + 110 X_7 + 88 X_8 + 92 X_9 + 32 X_{10} + 42 X_{11} + 63 X_{12} - X_{26} \leq 0$
- 19)  $56 X_6 + 57 X_7 + 37 X_9 + 22 X_{10} + 42 X_{11} - X_{27} \leq 0$
- 20)  $37 X_6 + 38 X_7 + 15 X_8 + 24 X_9 + 20 X_{12} - X_{28} \leq 0$
- 21)  $100 X_6 + 150 X_7 + 70 X_8 + 60 X_9 + 40 X_{10} + 25 X_{11} + 25 X_{12} \leq 112$
- 22)  $-55 X_1 + X_{29} \leq 0$
- 23)  $-59 X_2 + X_{30} \leq 0$
- 24)  $-15 X_3 + X_{31} \leq 0$
- 25)  $-16 X_4 + X_{32} \leq 0$
- 26)  $-23 X_5 + X_{33} \leq 0$
- 27)  $X_{34} - 108 X_6 \leq 0$
- 28)  $X_{35} - 62.5 X_7 \leq 0$
- 29)  $X_{36} - 16 X_8 \leq 0$
- 30)  $X_{37} - 19 X_9 \leq 0$
- 31)  $X_{38} - 15 X_{10} \leq 0$
- 32)  $X_{39} - 11 X_{11} \leq 0$
- 33)  $X_{40} - 7.7 X_{12} \leq 0$
- 34)  $2800 X_1 + 3000 X_2 + 1680 X_3 + 1590 X_4 + 2300 X_5 + 7500 X_6 + 45 X_{13} + 30 X_{14} + 150 X_{15} + 250 X_{16} + 25 X_{17} + 11 X_{18} + 15 X_{19} + 9 X_{20} - X_{41} + X_{44} \leq 10000$
- 35)  $X_{45} + 6000 X_6 + 3000 X_7 + 665 X_8 + 800 X_9 + 1500 X_{10} + 1400 X_{11} + 1100 X_{12} + 45 X_{21} + 30 X_{22} + 150 X_{23} + 250 X_{24} + 25 X_{25} + 11 X_{26} + 15 X_{27} + 9 X_{28} - 550 X_{29} - 560 X_{30} - 1620 X_{31} - 1680 X_{32} - 1700 X_{33} - X_{44} + 1.04 X_{42} = 0$
- 36)  $X_{41} \geq 0$
- 37)  $-X_{41} + X_{42} = 0$
- 38)  $X_{43} - X_{41} + X_{42} = 0$
- 39)  $X_1 + X_2 + X_7 \geq .8$
- 40)  $X_5 \leq .6$
- 41)  $X_8 \leq .6$
- 42)  $X_9 \leq .4$
- 43)  $X_6 \leq .6$

END





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,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

40

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,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<sub>1</sub>)

MAX 550 X29 + 1750 X30 + 1600 X31 + 2000 X32 - 1.08 X35 + X37

SUBJECT TO

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

END

SMALL FARMERS - TAIL REGION (TS<sub>2</sub>)

MAX 550 X<sub>29</sub> + 1750 X<sub>30</sub> + 1600 X<sub>31</sub> + 2000 X<sub>32</sub> - 1.08 X<sub>35</sub> + X<sub>37</sub>

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 \leq .93$
- 3)  $X_5 + X_6 + X_7 + X_8 \leq .93$
- 4)  $52 X_1 + 20 X_2 + 40 X_3 + 60 X_4 - X_9 \leq 50$
- 5)  $77 X_1 + 41 X_2 + 98 X_3 + 69 X_4 - X_{10} \leq 50$
- 6)  $6 X_1 + 3 X_2 + 6 X_3 + 7 X_4 - X_{11} \leq 15$
- 7)  $8 X_1 + 7 X_2 + 7 X_3 + 6 X_4 - X_{12} \leq 0$
- 8)  $45 X_1 + 40 X_2 + 50 X_3 + 60 X_4 - X_{13} \leq 40$
- 9)  $118 X_1 + 69 X_2 + 57 X_3 + 52 X_4 - X_{14} \leq 0$
- 10)  $59 X_1 + 46 X_3 + 68 X_4 - X_{15} \leq 0$
- 11)  $54 X_1 + 48 X_2 + 51 X_3 + 55 X_4 - X_{16} \leq 0$
- 12)  $125 X_1 + 45 X_2 + 45 X_3 + 55 X_4 \leq 67.5$
- 13)  $59 X_5 + 20 X_6 + 16 X_7 + 23 X_8 - X_{17} \leq 40$
- 14)  $89 X_5 + 102 X_6 + 59 X_7 + 71 X_8 - X_{18} \leq 40$
- 15)  $7 X_5 + 11 X_6 + 4 X_7 + 5 X_8 - X_{19} \leq 15$
- 16)  $6 X_5 + 6 X_6 + 2 X_7 + 2 X_8 - X_{20} \leq 0$
- 17)  $50 X_5 + 40 X_8 - X_{21} \leq 35$
- 18)  $111 X_5 + 92 X_6 + 35 X_7 + 63 X_8 - X_{22} \leq 0$
- 19)  $57 X_5 + 58 X_6 + 35 X_7 - X_{23} \leq 0$
- 20)  $38 X_5 + 21 X_6 + 23 X_8 - X_{24} \leq 0$
- 21)  $150 X_5 + 70 X_6 + 25 X_7 + 25 X_8 \leq 63$
- 22)  $- 53 X_1 + X_{25} \leq 0$
- 23)  $- 12 X_2 + X_{26} \leq 0$
- 24)  $- 20 X_3 + X_{27} \leq 0$
- 25)  $- 120 X_4 + X_{28} \leq 0$
- 26)  $X_{29} - 50 X_5 \leq 0$
- 27)  $X_{30} - 17 X_6 \leq 0$
- 28)  $X_{31} - 12 X_7 \leq 0$
- 29)  $X_{32} - 8 X_8 \leq 0$
- 30)  $2700 X_1 + 1600 X_2 + 5500 X_3 + 3380 X_4 + 50 X_9 + 30 X_{10} + 150 X_{11} + 300 X_{12} + 25 X_{13} + 10 X_{14} + 15 X_{15} + 9 X_{16} - X_{33} + X_{36} \leq 3500$
- 31)  $X_{37} + 2700 X_5 + 1450 X_6 + 895 X_7 + 1100 X_8 + 50 X_{17} + 30 X_{18} + 150 X_{19} + 300 X_{20} + 25 X_{21} + 10 X_{22} + 15 X_{23} + 9 X_{24} - 560 X_{25} - 1550 X_{26} - 1750 X_{27} - 300 X_{28} - X_{36} + 1.04 X_{34} = 0$
- 32)  $X_{33} \geq 0$
- 33)  $- X_{33} + X_{34} = 0$
- 34)  $X_{35} - X_{33} + X_{34} = 0$
- 35)  $X_1 + X_5 \geq .4$
- 36)  $X_6 \leq .4$
- 37)  $X_4 \leq .4$

END

**SMALL FARMERS - TAIL REGION (TS<sub>3</sub>)**

MAX 550 X<sub>29</sub> + 1750 X<sub>30</sub> + 1600 X<sub>31</sub> + 2000 X<sub>32</sub> - 1.08 X<sub>35</sub> + X<sub>37</sub>

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 \leq .93$
- 3)  $X_5 + X_6 + X_7 + X_8 \leq .93$
- 4)  $52 X_1 + 20 X_2 + 40 X_3 + 60 X_4 - X_9 \leq 50$
- 5)  $77 X_1 + 41 X_2 + 98 X_3 + 69 X_4 - X_{10} \leq 50$
- 6)  $6 X_1 + 3 X_2 + 6 X_3 + 7 X_4 - X_{11} \leq 15$
- 7)  $8 X_1 + 7 X_2 + 7 X_3 + 6 X_4 - X_{12} \leq 0$
- 8)  $45 X_1 + 40 X_2 + 50 X_3 + 60 X_4 - X_{13} \leq 40$
- 9)  $118 X_1 + 69 X_2 + 57 X_3 + 52 X_4 - X_{14} \leq 0$
- 10)  $59 X_1 + 46 X_3 + 68 X_4 - X_{15} \leq 0$
- 11)  $54 X_1 + 48 X_2 + 51 X_3 + 55 X_4 - X_{16} \leq 0$
- 12)  $125 X_1 + 45 X_2 + 45 X_3 + 55 X_4 \leq 60$
- 13)  $59 X_5 + 20 X_6 + 16 X_7 + 23 X_8 - X_{17} \leq 40$
- 14)  $89 X_5 + 102 X_6 + 59 X_7 + 71 X_8 - X_{18} \leq 40$
- 15)  $7 X_5 + 11 X_6 + 4 X_7 + 5 X_8 - X_{19} \leq 15$
- 16)  $6 X_5 + 6 X_6 + 2 X_7 + 2 X_8 - X_{20} \leq 0$
- 17)  $50 X_5 + 40 X_8 - X_{21} \leq 35$
- 18)  $111 X_5 + 92 X_6 + 35 X_7 + 63 X_8 - X_{22} \leq 0$
- 19)  $57 X_5 + 58 X_6 + 35 X_7 - X_{23} \leq 0$
- 20)  $38 X_5 + 21 X_6 + 23 X_8 - X_{24} \leq 0$
- 21)  $150 X_5 + 70 X_6 + 25 X_7 + 25 X_8 \leq 56$
- 22)  $- 53 X_1 + X_{25} \leq 0$
- 23)  $- 12 X_2 + X_{26} \leq 0$
- 24)  $- 20 X_3 + X_{27} \leq 0$
- 25)  $- 120 X_4 + X_{28} \leq 0$
- 26)  $X_{29} - 50 X_5 \leq 0$
- 27)  $X_{30} - 17 X_6 \leq 0$
- 28)  $X_{31} - 12 X_7 \leq 0$
- 29)  $X_{32} - 8 X_8 \leq 0$
- 30)  $2700 X_1 + 1600 X_2 + 5500 X_3 + 3380 X_4 + 50 X_9 + 30 X_{10} + 150 X_{11} + 300 X_{12} + 25 X_{13} + 10 X_{14} + 15 X_{15} + 9 X_{16} - X_{33} + X_{36} \leq 3500$
- 31)  $X_{37} + 2700 X_5 + 1450 X_6 + 895 X_7 + 1100 X_8 + 50 X_{17} + 30 X_{18} + 150 X_{19} + 300 X_{20} + 25 X_{21} + 10 X_{22} + 15 X_{23} + 9 X_{24} - 560 X_{25} - 1550 X_{26} - 1750 X_{27} - 300 X_{28} - X_{36} + 1.04 X_{34} = 0$
- 32)  $X_{33} \geq 0$
- 33)  $- X_{33} + X_{34} = 0$
- 34)  $X_{35} - X_{33} + X_{34} = 0$
- 35)  $X_1 + X_5 \geq .4$
- 36)  $X_6 \leq .4$
- 37)  $X_4 \leq .4$

END

**SMALL FARMERS - TAIL REGION (TS<sub>4</sub>)**

MAX 550 X<sub>29</sub> + 1750 X<sub>30</sub> + 1600 X<sub>31</sub> + 2000 X<sub>32</sub> - 1.08 X<sub>35</sub> + X<sub>37</sub>

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 \leq .93$
- 3)  $X_5 + X_6 + X_7 + X_8 \leq .93$
- 4)  $52 X_1 + 20 X_2 + 40 X_3 + 60 X_4 - X_9 \leq 50$
- 5)  $77 X_1 + 41 X_2 + 98 X_3 + 69 X_4 - X_{10} \leq 50$
- 6)  $6 X_1 + 3 X_2 + 6 X_3 + 7 X_4 - X_{11} \leq 15$
- 7)  $8 X_1 + 7 X_2 + 7 X_3 + 6 X_4 - X_{12} \leq 0$
- 8)  $45 X_1 + 40 X_2 + 50 X_3 + 60 X_4 - X_{13} \leq 40$
- 9)  $118 X_1 + 69 X_2 + 57 X_3 + 52 X_4 - X_{14} \leq 0$
- 10)  $59 X_1 + 46 X_3 + 68 X_4 - X_{15} \leq 0$
- 11)  $54 X_1 + 48 X_2 + 51 X_3 + 55 X_4 - X_{16} \leq 0$
- 12)  $125 X_1 + 45 X_2 + 45 X_3 + 55 X_4 \leq 52.5$
- 13)  $59 X_5 + 20 X_6 + 16 X_7 + 23 X_8 - X_{17} \leq 40$
- 14)  $89 X_5 + 102 X_6 + 59 X_7 + 71 X_8 - X_{18} \leq 40$
- 15)  $7 X_5 + 11 X_6 + 4 X_7 + 5 X_8 - X_{19} \leq 15$
- 16)  $6 X_5 + 6 X_6 + 2 X_7 + 2 X_8 - X_{20} \leq 0$
- 17)  $50 X_5 + 40 X_8 - X_{21} \leq 35$
- 18)  $111 X_5 + 92 X_6 + 35 X_7 + 63 X_8 - X_{22} \leq 0$
- 19)  $57 X_5 + 58 X_6 + 35 X_7 - X_{23} \leq 0$
- 20)  $38 X_5 + 21 X_6 + 23 X_8 - X_{24} \leq 0$
- 21)  $150 X_5 + 70 X_6 + 25 X_7 + 25 X_8 \leq 49$
- 22)  $- 53 X_1 + X_{25} \leq 0$
- 23)  $- 12 X_2 + X_{26} \leq 0$
- 24)  $- 20 X_3 + X_{27} \leq 0$
- 25)  $- 120 X_4 + X_{28} \leq 0$
- 26)  $X_{29} - 50 X_5 \leq 0$
- 27)  $X_{30} - 17 X_6 \leq 0$
- 28)  $X_{31} - 12 X_7 \leq 0$
- 29)  $X_{32} - 8 X_8 \leq 0$
- 30)  $2700 X_1 + 1600 X_2 + 5500 X_3 + 3380 X_4 + 50 X_9 + 30 X_{10} + 150 X_{11} + 300 X_{12} + 25 X_{13} + 10 X_{14} + 15 X_{15} + 9 X_{16} - X_{33} + X_{36} \leq 3500$
- 31)  $X_{37} + 2700 X_5 + 1450 X_6 + 895 X_7 + 1100 X_8 + 50 X_{17} + 30 X_{18} + 150 X_{19} + 300 X_{20} + 25 X_{21} + 10 X_{22} + 15 X_{23} + 9 X_{24} - 560 X_{25} - 1550 X_{26} - 1750 X_{27} - 300 X_{28} - X_{36} + 1.04 X_{34} = 0$
- 32)  $X_{33} \geq 0$
- 33)  $- X_{33} + X_{34} = 0$
- 34)  $X_{35} - X_{33} + X_{34} = 0$
- 35)  $X_1 + X_5 \geq .4$
- 36)  $X_6 \leq .4$
- 37)  $X_4 \leq .4$

END







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 <sub>1</sub> Y									
KPA <sub>9</sub> Y	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 <sub>1</sub> Y						<=	0
KPA <sub>9</sub> Y						<=	0
KSMY						<=	0
KSHY						<=	0
KGNY						<=	0
KBRY						<=	0
RPAY						<=	0
RCOY						<=	0
GGY						<=	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<sub>1</sub>)**

MAX 560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41

SUBJECT TO

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

END

**LARGE FARMERS - TAIL REGION (TL<sub>2</sub>)**

MAX 560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41  
SUBJECT TO

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

END

### LARGE FARMERS - TAIL REGION (TL<sub>3</sub>)

MAX 560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41

SUBJECT TO

- 2)  $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 \leq 2.01$
- 3)  $X_7 + X_8 + X_9 + X_{10} \leq 2.01$
- 4)  $55 X_1 + 64 X_2 + 22 X_3 + 24 X_4 + 45 X_5 + 65 X_6 - X_{11} \leq 0$
- 5)  $80 X_1 + 92 X_2 + 42 X_3 + 55 X_4 + 103 X_5 + 72 X_6 - X_{12} \leq 0$
- 6)  $2 X_1 + 3 X_2 + 3 X_3 + 3 X_4 + 5 X_5 + 6 X_6 - X_{13} \leq 0$
- 7)  $10 X_1 + 11 X_2 + 8 X_3 + 7 X_4 + 8 X_5 + 8 X_6 - X_{14} \leq 0$
- 8)  $50 X_1 + 55 X_2 + 45 X_3 + 50 X_4 + 55 X_5 + 80 X_6 - X_{15} \leq 40$
- 9)  $130 X_1 + 137 X_2 + 88 X_3 + 88 X_4 + 58 X_5 + 53 X_6 - X_{16} \leq 0$
- 10)  $78 X_1 + 79 X_2 + 52 X_5 + 68 X_6 - X_{17} \leq 0$
- 11)  $77 X_1 + 81 X_2 + 50 X_3 + 48 X_4 + 51 X_5 + 56 X_6 - X_{18} \leq 0$
- 12)  $125 X_1 + 125 X_2 + 45 X_3 + 45 X_4 + 45 X_5 + 55 X_6 \leq 145.6$
- 13)  $63 X_7 + 23 X_8 + 18 X_9 + 28 X_{10} - X_{19} \leq 0$
- 14)  $92 X_7 + 108 X_8 + 62 X_9 + 72 X_{10} - X_{20} \leq 0$
- 15)  $3 X_7 + 10 X_8 + 3 X_9 + 4 X_{10} - X_{21} \leq 0$
- 16)  $10 X_7 + 6 X_8 + 4 X_9 + 3 X_{10} - X_{22} \leq 0$
- 17)  $55 X_7 + 40 X_{10} - X_{23} \leq 35$
- 18)  $118 X_7 + 92 X_8 + 35 X_9 + 63 X_{10} - X_{24} \leq 0$
- 19)  $60 X_7 + 59 X_8 + 35 X_9 - X_{25} \leq 0$
- 20)  $38 X_7 + 21 X_8 + 23 X_{10} - X_{26} \leq 0$
- 21)  $150 X_7 + 70 X_8 + 25 X_9 + 25 X_{10} \leq 112$
- 22)  $-51 X_1 + X_{27} \leq 0$
- 23)  $-53 X_2 + X_{28} \leq 0$
- 24)  $-11 X_3 + X_{29} \leq 0$
- 25)  $-12 X_4 + X_{30} \leq 0$
- 26)  $-21 X_5 + X_{31} \leq 0$
- 27)  $-120 X_6 + X_{32} \leq 0$
- 28)  $X_{33} - 50 X_7 \leq 0$
- 29)  $X_{34} - 19 X_8 \leq 0$
- 30)  $X_{35} - 13 X_9 \leq 0$
- 31)  $X_{36} - 8 X_{10} \leq 0$
- 32)  $2300 X_1 + 2450 X_2 + 1250 X_3 + 1800 X_4 + 5200 X_5 + 3500 X_6 + 50 X_{11} + 30 X_{12} + 150 X_{13} + 300 X_{14} + 25 X_{15} + 10 X_{16} + 15 X_{17} + 9 X_{18} - X_{37} + X_{40} \leq 15000$
- 33)  $X_{41} + 2700 X_7 + 1500 X_8 + 1150 X_9 + 1200 X_{10} + 50 X_{19} + 30 X_{20} + 150 X_{21} + 300 X_{22} + 25 X_{23} + 10 X_{24} + 15 X_{25} + 9 X_{26} - 560 X_{27} - 580 X_{28} - 1600 X_{29} - 1700 X_{30} - 1750 X_{31} - 350 X_{32} - X_{40} + 1.04 X_{38} = 0$
- 34)  $X_{37} \geq 0$
- 35)  $-X_{37} + X_{38} = 0$
- 36)  $X_{39} - X_{37} + X_{38} = 0$
- 37)  $X_1 + X_2 \geq .6$
- 38)  $X_7 \geq .4$
- 39)  $X_5 \leq .6$
- 40)  $X_6 \leq .3$
- 41)  $X_8 \leq .9$

END

**LARGE FARMERS - TAIL REGION (TL<sub>4</sub>)**

MAX 560 X33 + 1750 X34 + 1600 X35 + 2100 X36 - 1.08 X39 + X41  
 SUBJECT TO

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

END

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