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Water allocation among competing uses in Zawia and Zahra areas of Libya

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by

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CHAPTER I

INTRODUCTION

Water scarcity in Libya is an important factor in determining the kinds of crops farmers can grow and the amounts of land utilized in each crop. The problem of water scarcity accelerates with the lack of sufficient rainfall which recharges underground reservoirs. Allocation of the available supply of water appears to be inefficient. Possible reasons for this inefficiency include: (1) customary farming practices whereby water becomes either underused or overused, and (2) farmer's lack of adequate information about water allocation and use. Improving the extension techniques and demonstrating to farmers the proper ways of farming could help solve the above problems. Basically however, the problems are how to find adequate sources of water and how to allocate the available supply between uses and users in a manner that maximizes the value product of water.

The general goal of this study is to develop a model for the allocation of the available supply of water in the area of study and to determine how many hectares of each crop could be grown under this allocation.

The Libyan Economy and Importance of Water

Libya is an independent country located on the north-central coast of Africa. The Mediterranean borders Libya on the north, Tunisia and Algeria on the west, Sudan on the southeast, Niger and Chad on the south, and Egypt on the east (Figure 1). The area of Libya is 679,360 square miles and the population is about 2.20 million with an annual growth rate of 3.7 percent (26). The capital of Libya is Tripoli with a population of 247,000 (26).

Most of the cultivated land is located on the coastal area. However, there are new agricultural projects located in the eastern and southern areas. The main crops grown in the coastal area are barley, wheat, vegetables, and fruit trees including olives, figs, dates, grapes, almonds, and peaches.

The coastal climate is generally mild with a minimum temperature in winters of 5° C and a maximum of 41° C in summers (Mediterranean climate) (11). Rainfall is not enough for intensive agriculture but generally is enough for grain crops and some drought resistant trees including olive, palm, and fig. The rainfall is generally about 14 inches per year on the coastal area, 12 inches per year on the western area, 18 inches per year on the Green Mountains in the eastern area, and decreasing towards south (11). Although underground water is relatively scarce when compared with some other areas in the world, all farming in the coastal area and agricultural projects depends primarily on this source.

The Libyan economy depends heavily on water. The process of oil pumping uses considerable water presently and will use more water in the future when most of the wells reach the secondary recovery stage when water or gas become necessary. With the reclamation of thousands

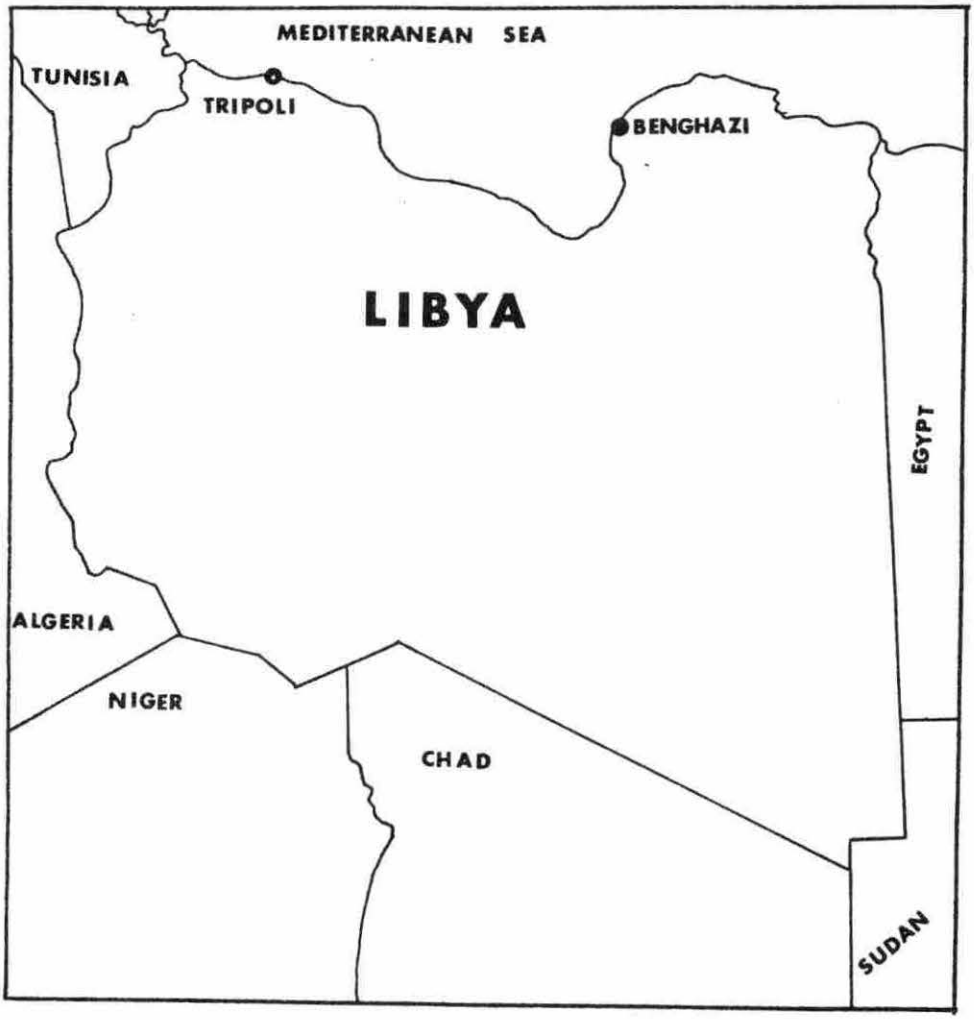

Figure 1. International borders of Libya

of hectares of land, demand for water will increase rapidly. The increase in construction also demands large quantities of water. Industry and manufacturing require huge amounts of water and with anticipated rapid industrial development, demand for water will increase sharply. Besides all the above water-consuming sectors, the population is increasing 3.7 percent annually which means higher demands for water in homes. The government, through the Ministry of Water and Dams, is spending considerable amounts of money in surveying the entire country for the possibility of finding new sources of water. As a result, a large underground reservoir of water has been discovered in the eastern part of the country near the border of Egypt. That reservoir is believed to be an extension of a similar one which has been found in the western area of Egypt with the help of an American company. Most of the oil revenue is being used in developing the Libyan agriculture and industry which are believed to be the two sound foundations for further development of the country in the post-petroleum period.

Water is generally suitable for agricultural use except in the coastal areas where the interference of the salty sea water with the water table is increasing. Such areas are Janzour, the north part of Zawia, and the north part of Tajoura (10). The Ministry of Agriculture is engaged in (1) limiting the amounts of crops farmers can grow in those areas and (2) prohibiting the growing of certain crops including tomatoes and potatoes. The ultimate purpose of this program is water conservation.

The uses of water can be divided into two main categories: (1) production uses and (2) consumption uses. Production uses include navigation, power, and manufacturing uses while consumption uses include domestic, agriculture, and petroleum.

The Problem of Water Allocation

Water allocation and conservation are essential criteria especially for areas experiencing water scarcity. The decisions of water allocation are very important but before making those decisions, three facts have to be understood.

"First, are the objectives to be achieved. Second, are the means available for achieving the desired objectives. Third, are the consequences of the several alternative means (practices or policies) in terms of achievement of the stated objectives" (23).

There are two closely related levels of allocative decisions within the process of decision making. The first level involves decisions among competitive uses. The second level involves decisions among competitive users. In the first level, decisions must be made concerning the amount of physical supply of water that is to be made available for particular uses. In the second level, decisions must be made on how the available water is to be allocated among competing uses. Use and user decisions are closely related and should be understood (23).

The problem within agriculture

There is little scientific water allocation in the area of study where some farmers probably use too much water for crops with low water requirements and some use too little water for crops with high water requirements in relation to optimum allocation. The lack of information, farmers' education, and extension people are the main reasons behind the misallocation of available water in the area. One of the main purposes of the linear programming model used in this report is to demonstrate how water may be allocated among the competing crops grown in the area.

The problem among sectors

As mentioned earlier, all sectors of the economy are competing for water use. Most of the competition is among agriculture, industry, petroleum, construction, and home use. Those sectors of the economy can be treated like crops within agriculture,and different theories of water allocation can be successfully applied. The attention in this report is given to allocating water among competing crops without attempting to deal with the other economic sectors. Eventually, studies concerned with intersectional allocation must be undertaken to resolve water allocation problems between sectors.

Objectives of Study

The objectives of this study are:

1. To develop a model for allocating water among different uses (crops) in the area of study.
2. To apply the model in the study area in demonstrating how many hectares of each crop should be grown under varying amounts of water supplies.

3. To suggest further research on procedures with improved data for achieving objectives.

The Method Used in Pursuing Objectives

A linear programming model is used to achieve the stated objectives. This model includes information needed from the area of study qualified by the serious limitations which will be stated later.

Thus, some of the data used are regarded as proxy data for purposes of testing application of the model. Improved data will be obtained in the future and will replace the proxy data with appropriate changes in the conclusions.

Organization of Report

This report is organized as follows:

In Chapter I the introduction, the problem, the objectives of study, the procedures used in pursuing objectives, and the organization of report are presented.

In Chapter II theory of water allocation among competing uses is explained.

In Chapter III the study model is developed in relation to conditions in the area of study.

In Chapter IV the results of the model application and data analysis are presented.

In Chapter V the interpretation of results and recommendations are included.

Finally, in Chapter VI the summary is presented.

CHAPTER II

THEORY OF WATER ALLOCATION AMONG COMPETING USES

Two simple diagrams are used in presenting the analytical framework for water allocation among several competing uses (crops) (Figures 2 and 3).

"The underlying assumptions in this model are (1) a given supply of water, and (2) two alternative competing uses for the given supply" (23). In order to present the idea only two competing crops are shown (alfalfa and tomato). Of course, many alternative crops may be competing for the use of a given amount of water.

The budgeting curve AE shows all possible allocations to two crops of a given supply of water. The total supply of water could be placed in alfalfa. This extreme allocation of the given water supply to alfalfa would be represented by point A. Another alternative allocation would be point E, wherein use of the entire water supply would be allocated to tomato. Besides these extreme allocations of water, numerous possible combinations of uses could be selected. For example, point B represents 8 units of alfalfa and 2 units of tomato which could be produced; point D represents 2 units of alfalfa and 8 units of tomato; point C represents 5 units of alfalfa and 5 units of tomato; or any other of the numerous combinations along the curve AE. But the important thing is which one of these numerous alternative combinations is the optimum.

The answer cannot be given unless we are able to place values on the products and factors. The selection of alternative uses should

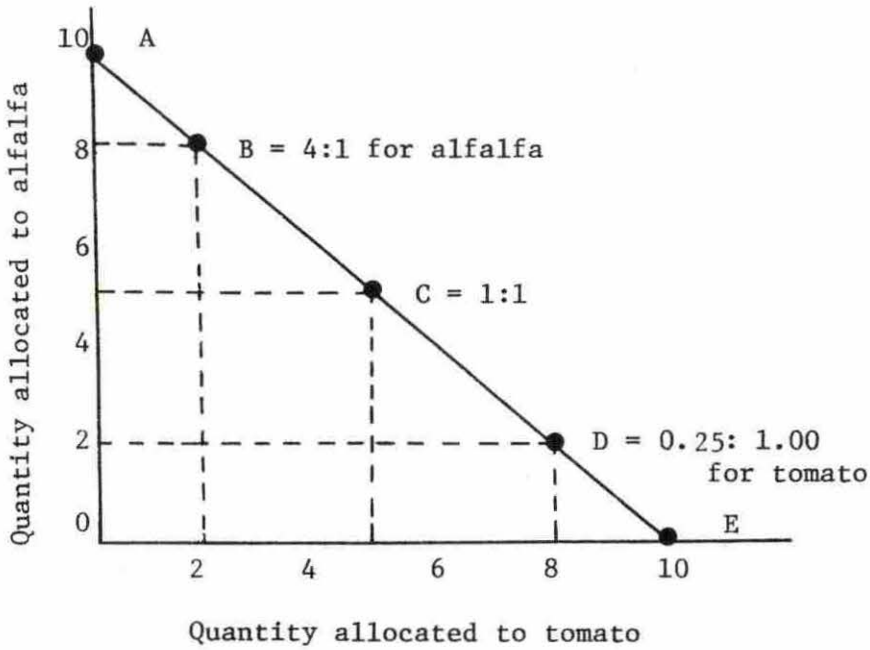

Figure 2. Hypothetical water allocation between two uses

be based on a flexible choice criterion reflecting the changing desires of consumers. The choice criterion usually employed in specifying how resources should be used is the pricing mechanism. If the sacrifice ratio among products (resource uses) is equal to the product price ratio, taking in account the production costs, then profit is at a maximum; i.e., the substitution ratio among production possibilities must be equal to the price ratio.

This principle is illustrated in the diagram below. Assume that from a fixed supply of one resource (such as water), or a fixed supply of bundle of resources (such as water, capital and land), the following combination of products can be produced: all of alfalfa and none of tomato; 90 of alfalfa and 10 of tomato; 70 of alfalfa and 20 of tomato;

etc. as illustrated in the figure below. The production possibility curve presents the substitutional relationship. For example, in a change from a combination of 100 alfalfa and no tomato, to 90 alfalfa and 10 tomato, we sacrifice one unit from the former for each one unit gain in the latter. Under a third combination, wherein 70 alfalfa and 20 tomato are produced, two units of alfalfa are lost for each one of tomato gained. Under a fourth combination, 40 alfalfa and 30 tomato are produced resulting in a gain of one unit of tomato for each three units of alfalfa sacrificed. Generally, increasing shifting water for one use entails increasing sacrifices in other uses to the degree water is scarce in relation to total demand.

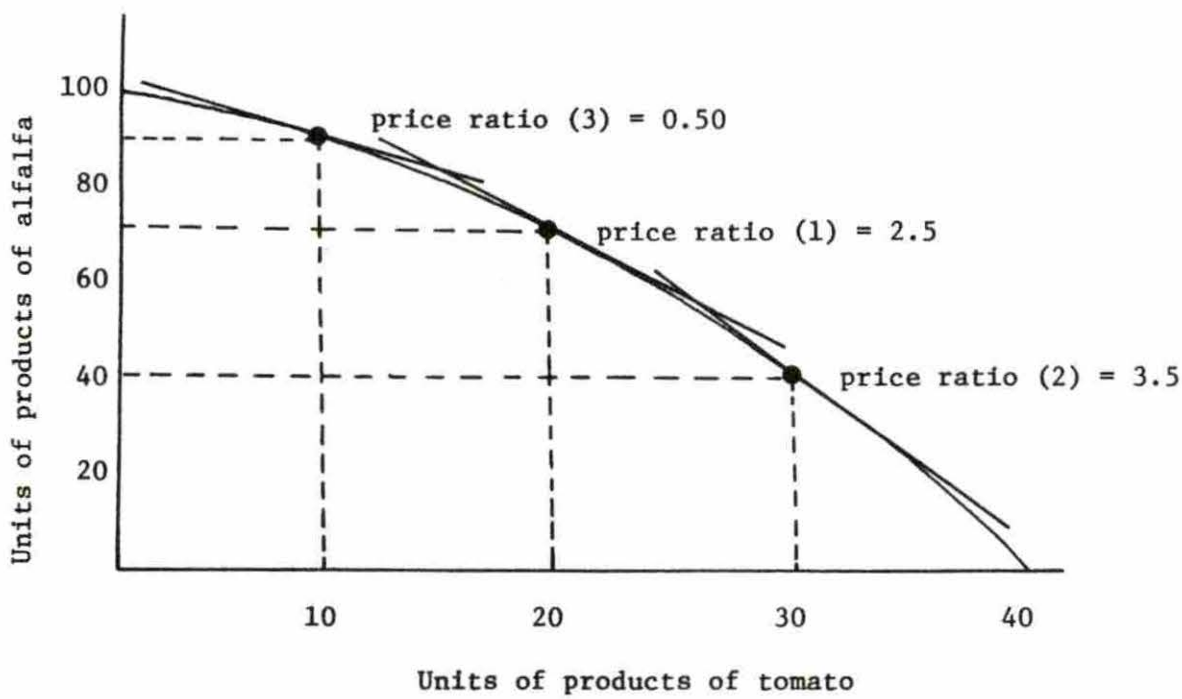

Figure 3. Production decisions in relation to production possibilities and relative product prices

Now suppose that the consuming society says that it likes both products alfalfa and tomato but that it places a per unit price on tomato which is 2.5 times the unit price of alfalfa (Figure 3). This price ratio, a price for tomato that is 2.5 times the price of alfalfa, is the choice criterion, the expression of relative importance by the consuming society that serves to indicate the optimum use of resources. The farmer growing the two crops can increase his profits by expanding tomato production at the expense of alfalfa production as long as the substitution ratio of tomato for alfalfa (i.e., the amount of alfalfa sacrificed to gain one more unit of tomato) is less than the price ratio, expressed in terms of the quotient of price of tomato divided by price of alfalfa.

Hence, since the substitution ratio, between the first two combinations of crops, is only one, and is less than the price ratio of 2.5, the second combination is preferrable to the first (Figure 3). The third combination (70 alfalfa and 20 tomato) also is preferrable to the second since the substitution ratio of 2.0, in going between the second and third combinations, is still less than the price ratio of 2.5. However, the fourth combination is not preferrable to the third, since the relative amount of alfalfa sacrificed to gain one more unit of tomato is more than proportional to the greater weight placed on tomato by consumers.

Hence, a general principle has been indicated for attainment of our first major condition. It is necessary to determine the production possibilities in the use of water and determine the rate at which one use must be sacrificed to allow attainment of another use. Then, these production possibilities and substitution ratios must be related to the relative importance that consumers attach to the different uses. Water laws alone are not capable of optimum allocation of water but with the above principle water can be allocated efficiently.

The above idea can be applied to all crops (uses) within the agricultural sector. The most efficient crops in water use should be expanded and the inefficient ones should be reduced. For example, if crop A uses five units of water and yields ten units of output, and if crop B uses the same five units of water and yields only six units of output, then crop A should be expanded in production and crop B should be limited in production. Taking into account the prices of outputs, the costs of inputs, and the need for the product is very important when making a decision like the one above.

Allocating water among different sectors of the economy is crucial. It has been shown before that all sectors of the economy consume water and the demands for it are increasing at an increasing rate. These sectors of the economy can be treated the same way as the crops treated in the agricultural sector above. The same idea used to allocate water among the crops can be used to allocate water among the sectors of the economy. The most efficient sectors in water use -- taking into account the kind of policy, the prices of the products, the costs of the factors, and the need for the output -- should be enhanced and the deficient sectors in water use should be limited.

CHAPTER III

STUDY PROCEDURE AND DEVELOPMENT OF THE MODEL

Linear Programming as a Tool for Resource Allocation

Use of linear programming

Linear programming is one of the most frequently and successfully applied mathematical approaches by decision makers. The objective in using linear programming is to develop a model to aid decision makers in determining the optimal allocation of scarce resources among competing uses. Since resources used on farms have economic values and outputs of farms lead to profits and costs, the linear programming problem becomes that of allocating the scarce resources in a manner such that revenue is a maximum for particular levels of costs or costs are minimum for particular levels of products. Two factors give rise to the allocation problem. First, resources available to farmers have a cost and are limited in supply; therefore, farmers as decision makers must determine how limited resources will be used. Second, the allocation of the resources must be made in accordance with some overall objective. In the farming sector, this objective is normally the maximization of profit or the minimization of cost.

Components of a linear programming model

The three necessary components of a linear programming model are: (1) the objective function, (2) the alternative methods of meeting the requirements of the objective function, and (3) the restraints on the quantity of resources available.

The usual goal of any farmer is assumed to be profit maximization; however, additional goals of the farmer may be included in the linear programming model. For example, the farmer may eliminate hiring any labor, maintain a minimum amount of land in wheat, or take a certain number of days of vacation per month.

If a farmer has only one method of producing a crop, such as barley, the problem of maximizing farm income is relatively simple; he should produce as much barley as possible up to the point where marginal cost equals marginal revenue taking the relevant constraints into account. However, if there are numerous ways, that is, different combinations of inputs called a process or an activity, to produce barley and numerous ways to produce other crops and/or livestock, then the problem of determining optimal production becomes very difficult. Linear programming becomes a useful tool in determining optimal resource allocation under those conditions.

A linear programming problem does not exist unless there are resources of limited quantity. Thus, if the farmer who irrigates does not have a limited quantity of water for irrigation, and/or limited land, and/or limited capital, and/or a limit on some other resources, then he has no problem amenable to linear programming application. If there are only a few resource restrictions, then either arithmetic or graphics may be used to solve for the optimal combinations of products to produce. However, on most farms there are numerous resource restrictions and processes; thus, linear programming is a useful analytical tool.

Assumptions of linear programming

Heady and Candler list the four major assumptions made in the application of linear programming as:

1. Additivity and linearity. The activities must be additive in the sense that when two or more are used; their total product must be the sum of their individual products.
2. Divisibility. It is assumed that factors can be used and commodities can be produced in quantities which are fractional units.
3. Finiteness. It is assumed that there is a limit to the number of alternative activities and to the resource restrictions which need be considered.
4. Single value expectations. In general (the assumption is made) that resource supplies, input-output coefficients, and prices are known with certainty (13, p. 17).

These assumptions are not as restrictive as it may appear. It has been demonstrated (6) that the linear programming model is a logical extension of linear economic theory which is itself a restatement of the conventional theory of competitive equilibrium. In fact, "linear programming is marginal analysis, appropriately tailored to a finite number of activities" (6, p. 133).

If the assumption of a homogenous production function is acceptable, it is difficult to argue with the linearity assumption employed in programming (19, p. 84). However, because of resource indivisibilities variable proportions may have to be accepted in some cases. Fortunately, such a situation may be approximated by means of a series of linear segments (3).

The divisibility assumption is a necessary mathematical requirement in the simplex method and can be adapted to a particular empirical problem. Thus, if the solution specifies that 74,000.31 hectares of barley be grown, we may reasonably ignore the decimal figure. For other programming problems where a fractional answer is totally meaningless and unacceptable, a modification known as integer programming may be used (9). Thus, the divisibility assumption is not as restrictive as it may first appear.

The additivity assumption may impose certain limitations. It does not permit, for example, a complementary relationship between any two activities but we can get around this problem by dealing with products as joint products like the case of raising dairy cows for milk and calves.

The finiteness assumption also, while a necessary mathematical requirement, does not impose restrictions in empirical investigations. It is true that water, for example, may be applied in increasingly small amounts on a farm. A farmer, however, is far from interested in considering this number of alternatives. We may, therefore, only include three or four discrete levels in an analysis.

The assumption of single valued expectations while certainly unrealistic for some farming situations may be partially overcome by the use of parametric techniques as in the case when a proposed available water supply is allowed to vary (see application of the model, next chapter). This modification, however, does not explicitly consider the effects of, for example, weather variability or risk aversion.

We have now found that in empirical analysis the assumptions of linear programming are not so restrictive as to limit the usefulness of the technique.

Development of the Programming Model

A linear programming optimization model is developed to suit the area of study. This model consists of 76 rows (restraints) and 73 columns (activities). Among the activities there are a dairy cow raising activity and a feed buying activity (APPENDIX B). The model has a right hand side column which contains the total amounts of resources available for production. That is, a column consists of as many rows as the number of rows in the matrix. Also, the model has an objective function which is called a "c" row and contains all the prices and variable costs of a unit of the activity.

Multiple right hand side columns are used to find the effect of different levels of resource availability. Also, multiple objective function rows are used to see the effect of different prices and variable costs on the solution. The A_{ij} coefficients, that is the ith row and the jth column will be plugged into the model. Although some of the A_{ij} coefficients are not accurate the model can be used as a framework and when the accurate coefficients become available they can easily replace the inaccurate ones. The A_{ij} coefficients which are not accurate are labor needed per hectare for picking green peppers, onions, potatoes, tomatoes, and watermelon, labor needed per year for mowing alfalfa, and tomatoes yield per hectare.

Description of the model

A single period linear programming model based on the restraints and possible activities is designed. The program objective is to maximize income over all variable costs taking into account the restraints imposed.

List of activities (columns of matrix by type and number)

1. Crop producing and growing activities. These activities include seedbed preparation, planting, fertilizer spread, chemicals, spraying, and machinery used for seedbed preparation. (The unit of activity for every activity listed below is one hectare.)

   P01 Producing and growing barley.

   P02 Producing and growing corn.

   P03 Producing and growing wheat.

   P04 Producing and growing peanuts.

   P05 Producing and growing tomatoes.

   P06 Producing and growing potatoes.

   P07 Producing and growing onions.

   P08 Producing and growing green peppers.

   P09 Producing and growing watermelon.

   P10 Producing and growing alfalfa.

   P11 Producing and growing millet for forage.

P12 Producing and growing faba-beans.

P13 Producing and growing oats for forage.

2. Crop watering activities. (Included here are only the costs of watering).

P14 An activity which permits irrigating one hectare of barley.

P15 An activity which permits irrigating one hectare of corn.

P16 An activity which permits irrigating one hectare of wheat.

P17 An activity which permits irrigating one hectare of peanuts.

P18 An activity which permits irrigating one hectare of tomatoes.

P19 An activity which permits irrigating one hectare of potatoes.

P20 An activity which permits irrigating one hectare of onions.

P21 An activity which permits irrigating one hectare of green peppers.

P22 An activity which permits irrigating one hectare of watermelon.

P23 An activity which permits irrigating one hectare of alfalfa.

P24 An activity which permits irrigating one hectare of millet for forage.

P25 An activity which permits irrigating one hectare of faba-beans.

P26 An activity which permits irrigating one hectare of oats for forage.

3. Crop harvesting activities. Included here are the costs of harvesting only. (The activity unit is one hectare).

   P27 An activity which has barley custom-combined and the hay put up by farmers.

   P28 An activity which has corn custom-combined and hauling.

   P29 An activity which has wheat custom-combined and the hay put up by farmers.

   P30 An activity which has peanuts manually picked.

   P31 An activity which has tomatoes manually picked.

   P32 An activity which has potatoes manually picked.

   P33 An activity which has onions manually picked.

   P34 An activity which has green peppers manually picked.

   P35 An activity which has watermelon manually picked.

   P36 An activity which has alfalfa mowed 50 times per year by farmers.

   P37 An activity which contains millet custom harvested and baled.

   P38 An activity which includes faba-beans manually picked.

   P39 An activity which has oats custom-harvested and baled.

4. Buying and selling activities.

   P40 Barley selling. The activity unit is one metric ton (2240 lb).

   P41 Corn selling. The activity unit is one metric ton.

   P42 Wheat selling. The activity unit is one metric ton.

   P43 Peanuts selling. The activity unit is one long ton.

   P44 Tomato selling. The activity unit is one metric ton.

   P45 Potato selling. The activity unit is one metric ton.

P46 Onion selling. The activity unit is one metric ton.

P47 Green pepper selling. The activity unit is one metric ton.

P48 Watermelon selling. The activity unit is one metric ton.

P49 Alfalfa selling. The activity unit is one metric ton.

P50 Millet selling. The activity unit is one metric ton.

P51 Faba-beans selling. The activity unit is one metric ton.

P52 Oats selling. The activity unit is one metric ton.

P53 Fertilizer buying. The activity unit is one pound.

P54 Feed supplement buying. The unit of activity is one metric ton.

P55 Water buying in Jan. 1 - Feb. 28. The unit of activity is one cubic meter.

P56 Water buying in Mar. 1 - Apr. 30. The unit of activity is one cubic meter.

P57 Water buying in May 1 - June 30. The unit of activity is one cubic meter.

P58 Water buying in July 1 - Aug. 30. The unit of activity is one cubic meter.

P59 Water buying in Sept. 1 - Oct. 31. The unit of activity is one cubic meter.

P60 Water buying in Nov. 1 - Dec. 31. The unit of activity is one cubic meter.

5. Livestock production activities.

P61 Dairy cow raising and selling. Selling the culled cow and the milk. The activity unit is one cow.

6. Capital activities.

P62 Capital borrowing. The activity unit is one dollar.

7. Labor hiring activities. (The activity unit is one hour.)

P63 Labor hiring in Jan. 1 - Feb. 28.

P64 Labor hiring in Mar. 1 - Mar. 15.

P65 Labor hiring in Mar. 16 - Mar. 31.

P66 Labor hiring in Apr. 1 - Apr. 30.

P67 Labor hiring in May 1 - May 30.

P68 Labor hiring in May 31 - Aug. 30.

P69 Labor hiring in Sept. 1 - Oct. 31.

P70 Labor hiring in Nov. 1 - Nov. 30.

P71 Labor hiring in Dec. 1 - Dec. 31.

The reason for arranging the labor periods as shown above is because the crops are either grown or harvested in those periods. So this arrangement eases the process of calculating labor and other inputs required by the crops.

8. Machinery custom-hiring activities.

P72 Custom-combine hiring. The activity unit is one hour.

P73 Custom-tractor hiring. The activity unit is one hour.

List of restraints (rows of matrix)

By type and number. All restraints are maximum restraints (equal to or less than the total amount of resource available in the B column of each restraint).

1. Land restraints.

R01 A restraint on land. The land is homogenous. The B column unit is hectare.

2. Labor restraints. These restraints are on the labor provided by the farmers in the area without hiring outside labor. The restraint unit is one hour.

R02 A restraint on labor in Jan. 1 - Feb. 28.

R03 A restraint on labor in Mar. 1 - Mar. 15.

R04 A restraint on labor in Mar. 16 - Mar. 31.

R05 A restraint on labor in Apr. 1 - Apr. 30.

R06 A restraint on labor in May 1 - May 30.

R07 A restraint on labor in May 31 - Aug. 30.

R08 A restraint on labor in Sept. 1 - Oct. 31.

R09 A restraint on labor in Nov. 1 - Nov. 30.

R10 A restraint on labor in Dec. 1 - Dec. 31.

3. Capital restraints.

R11 A restraint on head space of cows (capital accounting). The restraint unit is one head space.

R12 A restraint on operating capital. The restraint unit is one dollar.

4. Water requirement restraints. The restraint unit is one cubic meter.

R13 A restraint on water demanded by the crops in Jan. 1 - Feb. 28.

R14 A restraint on water in Mar. 1 - Apr. 30.

R15 A restraint on water in May 1 - June 30.

R16 A restraint on water in July 1 - Aug. 30.

R17 A restraint on water in Sept. 1 - Oct. 31.

R18 A restraint on water in Nov. 1 - Dec. 31.

5. Fertilizer availability restraints.

   R19 A restraint on the fertilizer available for the crops. The restraint unit is one pound.

6. Machinery supply restraints.

   R20 A restraint on custom-combine hire. The restraint unit is hour.

   R21 A restraint of custom-tractor hire. The restraint unit is hour.

7. Grown crops transfer rows. Every hectare grown has to be transferred through the crop transfer rows to be watered. (The restraint unit is one watered hectare.)

   R22 A grown barley transfer rows.

   R23 A grown corn transfer row.

   R24 A grown wheat transfer row.

   R25 A grown peanut transfer row.

   R26 A grown tomato transfer row.

   R27 A grown potato transfer row.

   R28 A grown onion transfer row.

   R29 A grown green pepper transfer row.

   R30 A grown watermelon transfer row.

   R31 A grown alfalfa transfer row.

   R32 A grown millet transfer row.

   R33 A grown Faba-beans transfer row.

   R34 A grown oats transfer row.

8. Water maximum restraints. These quantities of water were chosen high enough and parametric analysis was used on them to

find the effect of different levels of water on variables including income, production, labor, capital, etc. (The unit of restraint is one cubic meter.)

R35 A restraint on water in Jan. 1 – Feb. 28.

R36 A restraint on water in Mar. 1 - Apr. 30.

R37 A restraint on water in May 1 – June 30.

R38 A restraint on water in July 1 - Aug. 30.

R39 A restraint on water in Sept. 1 - Oct. 31.

R40 A restraint on water in Nov. 1 - Dec. 31.

9. Harvest transfer rows. Every watered hectare has to be transferred into harvesting. (The transferred unit is one hectare of crop.)

R41 A harvested hectare of barley transfer.

R42 A harvested hectare of corn transfer.

R43 A harvested hectare of wheat transfer.

R44 A harvested hectare of peanuts transfer.

R45 A harvested hectare of tomato transfer.

R46 A harvested hectare of potato transfer.

R47 A harvested hectare of onion transfer.

R48 A harvested hectare of green pepper transfer.

R49 A harvested hectare of watermelon transfer.

R50 A harvested hectare of alfalfa transfer.

R51 A harvested hectare of millet transfer.

R52 A harvested hectare of Faba-beans transfer.

R53 A harvested hectare of oats transfer.

10. Yield transfer rows. Every yield of a harvested hectare has to be transferred into its selling activity. (The unit of the transferred row is one metric ton.)

R54 A barley transfer row.

R55 A corn transfer row.

R56 A wheat transfer row.

R57 A peanuts transfer row.

R58 A tomato transfer row.

R59 A potato transfer row.

R60 An onions transfer row.

R61 A green peppers transfer row.

R62 A watermelon transfer row.

R63 An alfalfa transfer row.

R64 A millet transfer row.

R65 A Faba-beans transfer row.

R66 An oats transfer row.

11. Feed supplement transfer row.

R67 Feed supplement transfer row. The unit is one pound.

12. Labor hiring maximum restraints. (The unit is one hour.)

R68 A restraint on hiring labor in Jan. 1 - Feb. 28.

R69 A restraint on hiring labor in Mar. 1 - Mar. 15.

R70 A restraint on hiring labor in Mar. 16 - Mar. 31.

R71 A restraint on hiring labor in Apr. 1 - Apr. 30.

R72 A restraint on hiring labor in May 1 - May 30.

R73 A restraint on hiring labor in May 31 - Aug. 30.

R74 A restraint on hiring labor in Sept. 1 - Oct. 31.

R75 A restraint on hiring labor in Nov. 1 - Nov. 30.

R76 A restraint on hiring labor in Dec. 1 - Dec. 30.

Development of coefficients

Most of the coefficients were obtained from the farmers in the area of study. A sample of fourteen farmers were interviewed in the summer of 1977. The coefficients obtained were either taken from the farmers'records or based on their past experience in farming. The price expectations and cost figures (APPENDIX A) used are the same as those which prevail in the area. Some biased coefficients were replaced by others which are obtained from the Agricultural Research Center (10). Most of the labor coefficients for dairy cows activity were based on past experience of the farmers. The C row coefficients are the net returns over variable costs not accounted for in the model of one unit of activity.

The B column coefficients for labor requirements were divided into periods over the year according to the times of growing and harvesting the different crops (APPENDIX A). The labor, capital, and other coefficients for the crop growing and harvesting activities were developed for a set of small sized machinery (European machinery) using information from the farmers in the area.

The six B column coefficients for the maximum amounts of water available were set arbitrarily at high levels, and parametric analysis was applied since the actual data are not available. A second set of C row coefficients was developed to examine the effect of price and variable cost changes on the solution. Two more B columns were included to study the effects of different quantities of resources on the optimal solution. Six different solutions will be obtained in this model and will be explained later.

Assumptions and points to observe

1. Labor included in the B columns is the farmer's own labor only and hiring activities are included in the model.
2. Capital included in the B columns is the farmer's own capital and borrowing more capital at 8% in C_1 or 5% in C_2 is possible.
3. All harvesting other than alfalfa, barley, oats, millet and wheat is done manually.
4. Harvesting barley, oats, millet and wheat is done by hiring a custom harvestor. Alfalfa is mowed by the farmer's own machinery.
5. Barley growing activity, tomato growing activity, potato growing activity, and oats growing activity are bound at 75,000, 10,000, 11,000 and 20,000 hectares, respectively. Those bounds are the requirements for the area based on the agricultural research center information.
6. The fixed cost of land, machines, wells, and the irrigation systems are not included and can be subtracted to get net income.

Data Needs of Model

The specified model with the availability of accurate data can help solve the problems of resource allocation in the area of study. The data needed are numerous and can be stated as follows: (1) The amount and cost of inputs (per unit) used in production. For example, the amount of seed or fertilizer needed for cultivating one hectare of land and the cost per unit of that input. (2) The total area of land suitable for cultivation. (3) The expected yield and market prices of the products. The unit of yield is a kilogram or a ton and the market prices are referred to that unit of production. (4) amount of capital required for production. (5) Amount of labor needed for finishing the agricultural practices. The amounts of labor in different periods and the labor required per one hectare are stated. (6) Machinery and other implements used in production. The total amount of machinery available is stated as a constraint and the amount needed per one hectare (expressed in time) is given in APPENDIX A.

The gross amounts of all the inputs needed for production are listed in the left hand side of the programming tableau. The row column coefficients are in terms of one unit of production, i.e. if there is a coefficient in the intersection of wheat growing column and the labor row, then that coefficient is hours of labor needed for growing one hectare of wheat.

CHAPTER IV

APPLICATION OF MODEL TO STUDY AREA AND RESULTS

Study Area

The area of study is a farming area located 30 kilometers to the west of the capital, Tripoli (Figure 4). This area is characterized by a homogenous type of soil, same weather conditions, and similar agricultural practices. All farms in the area are irrigated from aquifers. Every farm has its own water well. All farms in the area are privately owned and range in size from one to forty hectares. The area is characterized by relatively level land without any major mountains or hills. There is not any specific design or shape for the farms in the area. The borders between the farms are simply wind shelter trees or some kinds of spiky wind-shelter shrubs. There is an important need for agrarian reform with emphasis on land reform for the area to make production more efficient. The most commonly grown crops in the area are alfalfa, barley, corn, faba-beans, green peppers, millet, oats, onions, peanuts, potatoes, tomatoes, watermelon, and wheat. Dairy cows are the most common livestock raised in this area.

The area of study is about 40 by 50 kilometers, or 200,000 hectares. Approximately twenty-five percent of the area is covered with timber which can be removed and the land can be used for cultivation. One hundred and fifty thousand hectares are used as land restraint in B_1 column, one hundred and twenty thousand in B_2 column, and one hundred and eighty thousand in B_3 column.

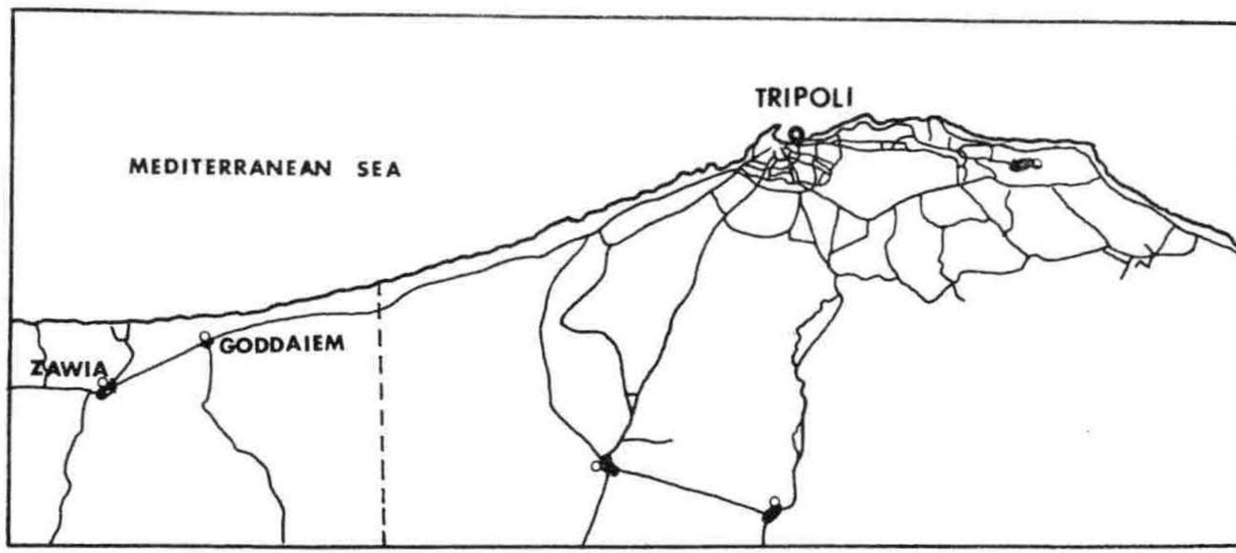

Figure 4. A cross section of study area

The capital structure of the area appears to be relatively low compared to the neighboring areas. The land fertility is poor and the feed space for dairy cows is insufficient. The capital supply is limited, water is scarce, and labor provided by the farmers in the area is not enough for cultivating the land.

Data Collection with Limitations

Detailed accurate data for any linear programming model are very important. When accurate data are available, the results can be meaningful and explain in detail the amount of land which could be utilized, the kinds of crops which could be grown, and the amounts of other resources which could be used.

Twenty randomly chosen farmers were intended to be interviewed from the area of study. The questionnaires were prepared and designed to cover all types of activities and practices farmers in the area pursue. For example, the kinds of crops they grow, the amounts and costs of inputs they use, and the amounts and prices of outputs they obtain. The major objective of the questionnaires was to find the effect of irrigation on farm return, i.e., to study the way farmers allocate water and to find the best alternative way to allocate this resource. Some agricultural information was to be obtained from the experts in the Agricultural Research Center, Ministry of Agricultural Development, Ministry of Water and Dams, Ministry of Planning, and El-Fateh University in Tripoli.

Because of the limitations stated in the following pages only fourteen interviews were made and only limited data were obtained. No significant information was obtained from any ministry mentioned above except Ministry of Agricultural Development.

There were a number of obstacles which prevented obtaining the needed information as planned. These obstacles were due to factors beyond the control of the author.

While the author was in Libya in July, 1977, the war started between Egypt and Libya which caused many problems. Most of the people including the farmers were either drafted or volunteered into the army. Because there were not enough farmers to interview the author had to interview some farmers' wives. Many answers from the women were not correct because of the lack of knowledge and the fear from taxing.

During the time the author was in the country, there were not enough people in the ministries to answer his questions concerning the research because they were in the army.

The author was given a governmental marked car to use in his travel from ministry to ministry or farm to farm. At the same time, the similar governmental marked cars were used by the army, which led to the following problem. The soldiers guarding the roads to the study area or even in the city stopped the car frequently and ordered the author (driver) to bring or deliver certain things like food to them from different places, or give rides to other soldiers. Although the author knew obeying the orders in these kinds of situations was part of his duty he lost a great deal of time, especially when the car was given to him for 25 days only.

As a result of the war, insufficient reliable data were obtained. Consequently, the data originating from the interviews and other sources were used as proxies in the linear programming model in order to demonstrate application of the model. When the accurate data becomes available, it can replace the proxy data.

Application of the Model

The linear programming model stated in the previous chapter could be applied to the area of study. The activities, restraints, and coefficients are shown on the matrix (APPENDIX B). The detailed data are shown in APPENDIX A).

A restraint is a limitation imposed on a resource, or hiring labor, or use of capital, or producing a certain quantity of output, or etc. Restraints can be maximum or minimum or equality.

A maximum restraint is like:

$$3x_1 + 2x_2 + x_3 \leq 8$$

A minimum restraint is like:

$$3x_1 + 2x_2 + x_3 \geq 8$$

An equality restraint is like:

$$3x_1 + 2x_2 + x_3 = 8$$

An activity can be producing corn with a certain level of fertilizer or producing a combination of alfalfa and weed with a certain level of water. Buying or selling can also be called activities. A farmer can have more than one activity in producing a single or combinations of crops.

Since the total amount of water available in the area is not exactly known, parametric range analysis is applied to find the effect of different levels of water on the crops and amount of land each crop uses.

The control cards and the data deck are set up to give six solutions and the parametric range analysis is applied to six periods of proposed maximum amounts of water available. Many relationships between the parametrized water and some other variables are shown in a later section.

Every solution of the five parametric solutions obtained gives different amounts of water allocated to each crop. Finally, the possibilities of more research and study and the expansion of model are discussed later.

Results of Application

The following table shows the major resources used in solution one and their marginal value products. The highest marginal value product is on the last hectare of land.

Table 1. Major resources used and their marginal value products

Major Resources	Total Amount Available	Amount Used	Marginal Value Product $
R01, Land	150,000 ha	150,000 ha	$699.35
R02, Owned labor Jan. 1-Feb. 28	19,874 hr	19,874 hr	6.72
R03, Owned labor Mar. 1-Mar. 15	10,674 hr	10,674 hr	8.40
R04, Owned labor Mar. 16-Mar. 31	11,356 hr	11,356 hr	110.45
R05, Owned labor Apr. 1-Apr. 30	21,293 hr	21,293 hr	70.66
R06, Owned labor May 1-May 30	21,293 hr	21,293 hr	13.44
R07, Owned labor May 31-Aug. 30	65,300 hr	65,300 hr	42.55
R08, Owned labor Sept. 1-Oct. 31	44,006 hr	44,006 hr	10.08
R09, Owned labor Nov. 1-Nov. 30	21,293 hr	21,293 hr	10.08
R10, Owned labor Dec. 1-Dec. 31	22,003 hr	15,471.92 hr	0.0
R12, Operating capital	$20,460,000	$20,460,000	0.08
R20, Combine supply	30,000 hr	30,000 hr	13.40
R21, Tractor supply	105,000 hr	105,000 hr	12.30
R68, Hired labor Jan. 1-Feb. 28	60,000 hr	48,651 hr	0.0
R69, Hired labor Mar. 1-Mar. 15	20,000 hr	10,584 hr	0.0
R70, Hired labor Mar. 16-Mar. 31	40,000 hr	40,000 hr	102.05
R71, Hired labor Apr. 1-Apr. 30	120,000 hr	120,000 hr	62.26
R72, Hired labor May 1-May 30	25,000 hr	15,681 hr	00.00

Table 1. (continued)

Major Resources	Total Amount Available	Amount Used	Marginal Value Product ($)
R73, Hired labor May 31-Aug. 30	150,000 hr	150,000 hr	29.11
R74, Hired labor Sept. 1-Oct. 31	30,000 hr	22,144 hr	00.00
R75, Hired labor Nov. 1-Nov. 30	170,000 hr	132,582 hr	00.00
R76, Hired labor Dec. 1-Dec. 31	1,000 hr	0 hr	00.00

The following table shows the major activities in solution one and their penalty costs,i.e., the loss as a result of forcing one more unit into the optimum solution.

Table 2. Major activities in solution and their penalty costs

Activity	Level of Activity	Shadow Price (penalty costs) ($)
P01, Barley growing	75,000 ha	$24,94
P03, Wheat growing	12,719 ha	00.00
P05, Tomato growing	10,000 ha	213.90
P06, Potato growing	11,000 ha	868.06
P07, Onion growing	8,737 ha	00.00
P08, Green pepper growing	1,667 ha	00.00
P12, Faba-bean growing	10,875 ha	00.00
P13, Oats growing	20,000 ha	00.00

Table 2. (continued)

Activity	Level of Activity	Shadow Price (penalty costs)
P40, Selling barley	187,500 metric ton	00.00
P42, Selling wheat	24,166 metric ton	00.00
P44, Selling tomato	300,000 metric ton	00.00
P45, Selling potato	225,500 metric ton	00.00
P46, Selling onion	183,487 metric ton	00.00
P47, Selling green pepper	17,007 metric ton	00.00
P51, Selling Faba-bean	100,058 metric ton	00.00
P53, Buying fertilizer	28,869 metric ton	00.00

Three B columns (total amount of each resource available) and two C rows (rows show the variable costs and the prices of inputs and outputs) are shown in the matrix (APPENDIX B). Some changes in columns B_2 and B_3 and also in row C_2 are made (APPENDIX B). Those changes will be discussed in the next chapter.

CHAPTER V

INTERPRETATION OF RESULTS AND RECOMMENDATIONS

This chapter gives the interpretation of the information obtained from applying the linear programming model developed in the previous chapter. All the six solutions are examined and answers to the issues raised under the objective of the study are given. Given the situation of low capital, scarce water, and the need for more labor, the following questions could be answered during the interpretation:

1. Is hiring more labor desirable?
2. Would raising more dairy cows be feasible?
3. Is borrowing more capital desirable?

The Solutions

Table 3 gives the six solutions in the "row numbers" from the computer printout.

Some shadow prices are relatively high compared to the rest. The reason for this variation is because the use of those resources is profitable and output prices of the activities connected with them are high. The highest total revenue per hectare is from potato ($2066.3) APPENDIX A. Thus, compared to this total revenue those relatively high shadow prices are acceptable.

Table 4 shows the crop activities in solution and their optimum levels.

Wheat production is not feasible in solutions two and five because the variable costs of producing wheat are high compared to barley and

Table 3. Major marginal value products in the six solutions

	Solution One ($)	Solution Two ($)	Solution Three ($)	Solution Four ($)	Solution Five ($)	Solution Six ($)
Major rows (resources) at limit level (numbers are the major shadow prices)						
R01, Land	699.35	739.87	509.77	597.45	616.68	522.50
R03, Labor Mar. 1-15			1160.63			
R22, Watering barley	842.39	845.67				
R24, Watering wheat	835.67	838.95				
R25, Watering peanuts					915.52	785.25
R26, Watering tomato	1413.16	1431.34	878.68		957.42	789.27
R27, Watering potato	1802.13	1802.13	1287.47	1069.69	1069.69	
R28, Watering onion	1257.95	1275.43		1031.92	1040.21	842.39
R29, Watering green pepper	1167.27	1183.31		918.69	926.30	
R30, Watering watermelon	1177.12	1198.40		972.58		802.16
R31, Watering alfalfa	911.32	949.13		807.00	824.94	786.72
R32, Watering millet	868.38	912.59	848.09			
R33, Watering Faba-bean	888.76	927.10	1066.75		813.18	850.45
R34, Watering oats	868.38	868.40	848.10			
R41, Barley transfer for harvest	1023.92	1025.70	975.71	952.78	953.61	936.61
R42, Corn transfer for harvest						
R43, Wheat transfer for harvest	1017.20	1018.95	968.99	966.21	971.33	950.05

Table 3. (continued)

	Solution One ($)	Solution Two ($)	Solution Three ($)	Solution Four ($)	Solution Five ($)	Solution Six ($)
R44, Peanuts transfer for harvest						
R45, Tomato transfer for harvest	1617.27	1686.98	1238.61	813.93	821.38	
R46, Potato transfer for harvest	1938.05	1938.05	1430.05	1239.26	1239.26	906.22
R47, Onion tranfer for harvest	1440.34	1454.93	1038.58	1227.62	1234.54	1092.90
R48, Green pepper transfer for harvest	1442.46	1435.93	1079.42	1208.73	1215.12	1084.38
R49, Watermelon transfer for harvest	1385.96	1456.66	1097.74	1266.74	841.64	
R50, Alfalfa transfer for harvest	1641.86	1664.97	1337.11	1518.71	1529.63	1711.12
R51, Millet transfer for harvest	1039.87	1084.08	1039.87	989.16	993.23	
R52, Faba-bean transfer for harvest	1085.77	1121.60	1459.35	1016.03	1033.04	1141.27
R53, Oats transfer for harvest	1039.87	1039.87	1039.87	940.54		
R69, Hired labor Mar. 1-15			1152.24			

Table 4. Crop activities in solution and their optimum levels

	Solution One (ha)	Solution Two (ha)	Solution Three (ha)	Solution Four (ha)	Solution Five (ha)	Solution Six (ha)
Crop activities in solution (numbers are activity units)						
P01, Growing barley	75,000.00	55,077.98	75,000.00	75,000.00	74,242.60	75,000.00
P03, Growing wheat	12,719.20	-	62,520.62	31,883.82	-	71,813.35
P05, Growing tomato	10,000.00	10,000.00	10,000.00	-	-	-
R06, Growing potato	11,000.00	11,000.00	11,000.00	11,000.00	11,000.00	10,400.35
R07, Growing onions	8,737.48	9,777.11	4,870.23	8,923.29	9,962.92	8,670.71
P08, Growing green pepper	1,667.41	4,650.41	-	11,636.23	14,619.23	6,885.80
P12, Growing Faba-beans	10,875.92	9,494.50	5,264.50	11,556.67	10,175.25	7,229.10
P13, Growing oats	20,000.00	20,000.00	11,344.56	-	-	-

per unit output prices of other crops are higher than that for wheat. Thus, resources are more profitable in producing crops other than wheat. Tomato production is not feasible in solutions four, five, and six because of low per unit output price of tomatoes in C_2 row. Green pepper production is not feasible in solution three because the resources are more efficient in producing more wheat and barley because of low variable costs compared to that in green pepper production. Oats production is not feasible in solutions four, five, and six because of low per unit output price and resources are more efficient in producing other crops. Some activities are in the basis at zero levels and are ignored. For the rest of activities in solution see APPENDIX C.

It is clear from Table 4 that most of the land should go to barley production in all solutions. Barley appears to be the most efficient crop in resource use, It uses less water and less labor compared to vegetable crops in these solutions. Oats production seems to be the second most efficient crop in solutions one and two. In solutions three, four, and six, wheat appears to be the second most efficient crop in resource use. The general idea that efficiency is based upon in these solutions, is when the crop (like barley) grown on most of the land this means the crop is efficient in resource use because the model is an optimization model. Naturally, barley, oats, and wheat use less labor and water than vegetable crops in these solutions (APPENDIX A). Thus, in the area of study most of the land should be allocated to barley, oats, and wheat. More of these conclusions are given under each solution later.

Table 5 shows the major income penalties in the six solutions. In that table the penalty costs for raising dairy cows (P61) are very high because of high resource requirements especially labor. The dairy cows raised in the area are Frisian cows which are not native. Those kinds of dairy cows require more labor, specific kinds of shelter, and expensive equipment.

Solution One

This solution reports the optimum plan using prices and variable costs in C_1 row and available resources in B_1 column. For the coefficients of C_1 row and B_1 column, see the matrix (APPENDIX B).

Crop activities

Barley for grain (P01)	75,000.00 hectares
Wheat for grain (P03)	12,719.20 hectares
Tomatoes (P05)	10,000.00 hectares
Potatoes (P06)	11,000.00 hectares
Onions (P07)	8,737.48 hectares
Green peppers (P08)	1,667.41 hectares
Faba-beans (P12)	10,875.92 hectares
Oats for forage (P13)	20,000.00 hectares

All the land available (150,000 ha) is used.

Table 5. Major income penalties in the six solutions

	Solution One ($)	Solution Two ($)
Activities not in solution (numbers are income penalties)		
P02, Growing corn	615.37	648.24
P03, Growing wheat	-	24.94
P04, Growing peanuts	734.08	742.13
P05, Growing tomato	-	-
P09, Growing watermelon	-	-
P10, Growing alfalfa	-	-
P11, Growing millet	19.70	-
P15, Watering corn	-	-
P17, Watering peanuts	-	-
P18, Watering tomato	-	-
P22, Watering watermelon	52.32	-
P24, Watering millet	-	-
P26, Watering oats	-	-
P36, Harvesting alfalfa	857.17	-
P39, Harvesting oats	-	-
P42, Selling wheat	-	-
P47, Selling green peppers	-	-
P48, Selling watermelon	-	5.72
P49, Selling alfalfa	-	106.62
P50, Selling millet	-	7.37
P54, Selling May 1-Jun. 30	358.40	358.40
P61, Raising dairy cows	3,302.01	3,705.72
P69, Labor hire Sept. 1-Oct. 31	-	-
P71, Labor hire Dec. 1-Dec. 31	6.72	6.72
P73, Custom-tractor hire	-	12.30
Returns over variable costs (C row value)	145,021,625.7	123,847,395.3

Table 5. (continued)

Solution Three ($)	Solution Four ($)	Solution Five ($)	Solution Six ($)
-	611.40	627.00	577.73
-	-	-	-
753.95	586.91	-	-
-	429.58	-	-
-	431.49	433.82	-
871.17	-	-	-
50.00	-	358.63	-
542.81	-	-	-
262.32	-	590.73	672.19
-	-	428.51	450.30
-	-	433.82	440.23
-	-	-	341.85
-	-	310.02	293.23
-	-	1,111.93	-
-	305.95	-	293.24
-	-	2.25	-
2.72	-	-	-
8.26	43.15	-	-
111.77	134.61	135.60	173.96
-	59.09	59.77	-
358.40	-	-	-
11,247.95	3,090.15	3,038.88	5,771.91
-	-	-	11.76
6.72	8.40	8.40	8.40
12.30	-	13.40	13.40
164,175,053.8	105,585,805.7	87,834,962.5	124,732,500.3

Livestock activity

Dairy cow (P61). It is not profitable to raise any dairy cows and if one cow raised the penalty cost (the loss) is $3,302.61.

Raising dairy cow is not feasible in all of the solutions because of the reasons mentioned before. Thus, it will be dropped from the interpretation.

Resources completely used

	Amount used	Value to solution of last unit (MVP)
Jan. 1-Feb. 28 labor, R02	19,874.00 hrs	$ 6.72
Mar. 1-Mar. 15 labor, R03	10,647.00 hrs	8.40
Mar. 16-Mar. 31 labor, R04	11,356.00 hrs	110.45
Apr. 1-Apr. 30 labor, R05	21,293.00 hrs	70.66
May 1-May 30 labor, R06	21,293.00 hrs	13.44
May 31-Aug. 30 labor, R07	65,300.00 hrs	42.55
Sept. 1-Oct. 31 labor, R08	44,000.00 hrs	10.08
Nov. 1-Nov. 30 labor, R09	21,293.00 hrs	10.08
Machinery supply for grain crops harvest, R20	30,000.00 hrs	13.40
Tractor for plowing, R21	105,000.00 hrs	12.30
Mar. 16-Mar. 31 maximum labor hire, R70	40,000.00 hrs	102.05
Apr. 1-Apr. 30 maximum labor hire, R71	120,000.00 hrs	62.26
May 31-Aug. 30 maximum labor hire, R73	150,000.00 hrs	29.11
Operating capital, R12	$20,460.00	0.08

Commodity buying and selling

Sell barley, P40	187,500.00 MT[1]
Sell wheat, P42	24,166.47 MT
Sell tomatoes, P44	300,000.00 MT
Sell potatoes, P45	225,500.00 MT
Sell onions, P46	183,487.00 MT
Sell green peppers, P47	17,007.57 MT
Sell Faba-beans, P51	100,058.45 MT
Sell oats, P52	120,000.00 MT
Buy fertilizer, P53	28,869.49 MT
Jan. 1-Feb. 28 water buy P55	125,648,381.03 cubic meter
Mar. 1-Apr. 30 water buy P56	169,856,404.18 cubic meter
May 1-Jun. 30 water buy P57	194,007,852.83 cubic meter
Jul. 1-Aug. 30 water buy P58	34,548,352.67 cubic meter
Sept. 1-Oct. 31 water buy P59	53,073,000.00 cubic meter
Nov. 1-Dec. 31 water buy P60	123,046,276.29 cubic meter
Capital borrow at 8%, P62	$25,962,687.12

[1]MT = metric ton (2,240 lbs.)

Based on this solution, most of the land available should be allocated to barley, oats, and wheat production because of their low intake of resources especially water. The five other feasible crops in this solution (Faba-beans, green peppers, onions, potatoes, and tomatoes) should be grown up to the optimum amount of land of each crop given by this solution. As an answer to the questions raised at the beginning of this chapter, hiring labor is feasible in all of the nine periods. Raising any dairy cows is not profitable for the reasons stated before. Borrowing more capital at 8% interest rate is desirable.

Stability of the solution (range analysis)

Range analysis expands the information provided in the optimum solution. It makes the interpretation of shadow prices more useful by providing the range over which a shadow price is relevant (APPENDIX C). The range output contains four sections as follows:

Section 1 -- Rows at limit level The resources in the rows of this section are being at limit levels that is, all resources are completely used in the plan.

The last hour of March 16 - March 31 labor period (R04) added $110.45 to the value of the program. Each hour reduction in labor from 11,355.99 to zero would reduce the value of the program by $110.45. Each hour added from 11,355.99 to 17,837.49 would add $110.45 to the value of the program. Onions harvest (P33) which is now in the basis will drop out of the basis when the lower limit is reached. Green peppers harvest (P34) which is now in the basis will drop out of the basis when the upper limit is reached.

The last ton of green pepper yield transferred for sale (R61) added $168.00 to the value of the program. Although it is not reasonable, each ton from zero to infinity would add $168.00 to the value of the program. This indicates that with combination of resources green pepper sale is profitable. Of course, if more resource or subjective restraints are imposed the range will change. Selling green peppers (P47) which is now in the basis will drop out of the basis when none of the green peppers is produced.

There are seven restraints in this section which are highly stable in the solution because their ranges are very wide and their levels in the solution are very far from the upper limits of their ranges. Those restraints are labor in January 1 - February 28 (R02), labor in March 1 - March 16 (R03), labor in April 1 - April 30 (R05), labor in May 31 - August 30 (R07), labor in November 1 - November 30 (R09), operating capital (R12), custom-combine hire supply (R20). The restraints above are stable because of the assumption of stability of owned labor and profitability to hire more, the profitability to borrow capital with 8% interest rate, and the profitability of hiring a custom-combine for harvesting crops. The remaining restraints are unstable because of the narrow range and the closeness of the levels of resources in plan to upper ranges boundaries.

Section 2 -- Columns at limit level In this section the attention is given to those real activities which did not enter the plan. They are at their lower limit of zero or the upper bounded limits.

Range analysis indicates that barley growing activity (P01) is at its upper limit (because it is bounded). The solution will decrease by

\$24.94 per every hectare decreased and this continues down to zero hectares level. Each hectare increase from 75,000 up to 87,719.16 will increase the objective function by \$24.94. Thus, the range of \$24.94 extends from zero to 87,719.16 hectares. If the variable cost for growing barley in the C_1 row increased beyond \$66.372 80, then the level of barley growing activity (P01) in the optimum plan goes to zero. Note that barley growing activity is in solution but not in the basis because it is bounded. The penalty cost (shadow prices) signs of growing barley (P01), growing tomatoes (P05), growing potatoes (P06), and growing oats (P13) are positive because they are upper bounds. The upper quantity bounds stated above are based on information from the Agricultural Research Center.

The penalty cost for alfalfa harvest (P36) is \$857.17 per one hectare harvested. This penalty cost applies over the range of zero to 2,627.54 hectare of alfalfa. The penalty cost might increase after that.

Corn growing activity (P02) is not in solution and its shadow price (penalty cost) is \$615.37. If one hectare of corn is forced into the plan, the objective function will decrease by \$615.37 over the range of zero to 3081.16 hectares.

There is only one activity which is relatively stable in solution if compared to the rest. This activity is growing oats (P13). It is stable because its level in solution is not close to the upper boundary of its range.

<u>Section 3 -- Rows at intermediate level</u> This section deals with those restraints which are not limiting; i.e., some resources are left

as slacks.

The restraint of owned labor in the period from December 1 - December 31 (R10) is in the basis at a level of 15,471.92 hours. The C_1 row value ($6.72) will be the loss per hour if the program is forced to use less labor down from 15,471.92 to 14,471.92 hours. That is, $6.72 is the marginal value product of the last unit used. If the program is forced to use more labor from 15,471.92 up to 16,789.72, the loss per hour would be $108.72. Labor hiring in December 1 - December 31 (P71) which is not in the basis will enter the basis when the lower limit (14,471.92) is reached. Growing millet (P11) which is not in the basis will enter the basis when the upper limit (16,789.92) is reached.

There are seven highly stable restraints in this section because of their wide ranges and their levels in solution are very far from the upper boundaries of their ranges. The restraints are water available in July 1 - August 30 (R38), water available in November 1 - December 31 (R40), hiring labor in January 1 - February 28 (R68), hiring labor in March 1 - March 15 (R69), hiring labor in May 1 - May 30 (R72), hiring labor in Sept. 1 - Oct. 31 (R74), and hiring labor in Nov. 1 - Nov. 30 (R75).

The reasons for those wide ranges appear to be the availability of both labor and water under this solution (with the prices used) in those specific periods. Note that the total amount of water in every period of the six periods is arbitrary and assumed to be 300,000,000 cubic meters. All the remaining restraints have narrow ranges because of the insufficient resources available; i.e., these restraints are not stable in solution.

<u>Section 4 -- Columns at intermediate level</u> This section reports on the real activities which entered the plan. Because the plan is optimum, divergence from it will cause a decrease in the value of the program.

Wheat growing activity (P03) is in the basis at a level of 12,719.20 hectares and diverging from this optimum will cause a decrease in the value of the program. An income penalty of $19.93 arises for each hectare the activity is decreased below 12,719.20 hectares. The same penalty applies till the land is decreased to 5529.81 hectare. Below this the penalty will increase. If (P03) is pushed beyond 12,719.20, the penalty is $24.94 per hectare. The same penalty applies up to 87,719.17 hectares. If the variable cost of producing one hectare of wheat is increased beyond $78.23, then the optimum level of land in wheat in the new plan is 5529.81 hectare. If the variable cost is reduced beyond $33.36 rather than $58.30, then 87,719.17 hectares could be raised.

There are 13 activities in this section which are very stable because of their wide ranges. These wide ranges indicate that all the activities involved in the ranges can be produced profitably over the ranges. The activities are wheat growing (P03), green peppers growing (P08), irrigating a hectare of wheat (P16), irrigating a hectare of green peppers (P21), wheat harvest (P29), green peppers harvest (P34), selling wheat (P42), selling green peppers (P47), fertilizer buying (P53), water buying in July 1 - August 30 (P58), capital borrow (P62), custom-combine hire (P72), custom-tractor hire (P73). All remaining activities have narrow ranges which means they are not stable in solution.

All restraints and activities in the four sections of the range analysis can be interpreted like the samples given under every section above. Those samples are the most important ones to illustrate the meaningful interpretation of range analysis. For more information, see APPENDIX C.

Parametric analysis of water

The arbitrary amount of water to start with is 300,000,000 cubic meters in every period. Then there are five decreasing parametric increments which result in five solutions, one at every increment. The average of six watering periods in each solution is taken and these averages are used on the abscissas of Figures 5 and 6.

Figure 5 shows the relationship between the parametrized periods and income, the parametrized periods and owned capital, and the parametrized periods and borrowed captial. The three curves are increasing. The income curve shows that when less water is available, less production occurs and income is low. The capital curves show when less water is needed less capital is needed also to pay for that water. Figure 6 shows the relationships between the parametrized periods and hired and owned labor. Hiring labor is increasing and owned labor is slightly increasing up to increment three. Owned labor curve is constant from increment three to increment five. Hired labor curve shows that when more water is available more labor is needed because more land went into vegetable production which requires high rates of labor. The difference between the two curves is the amount of labor

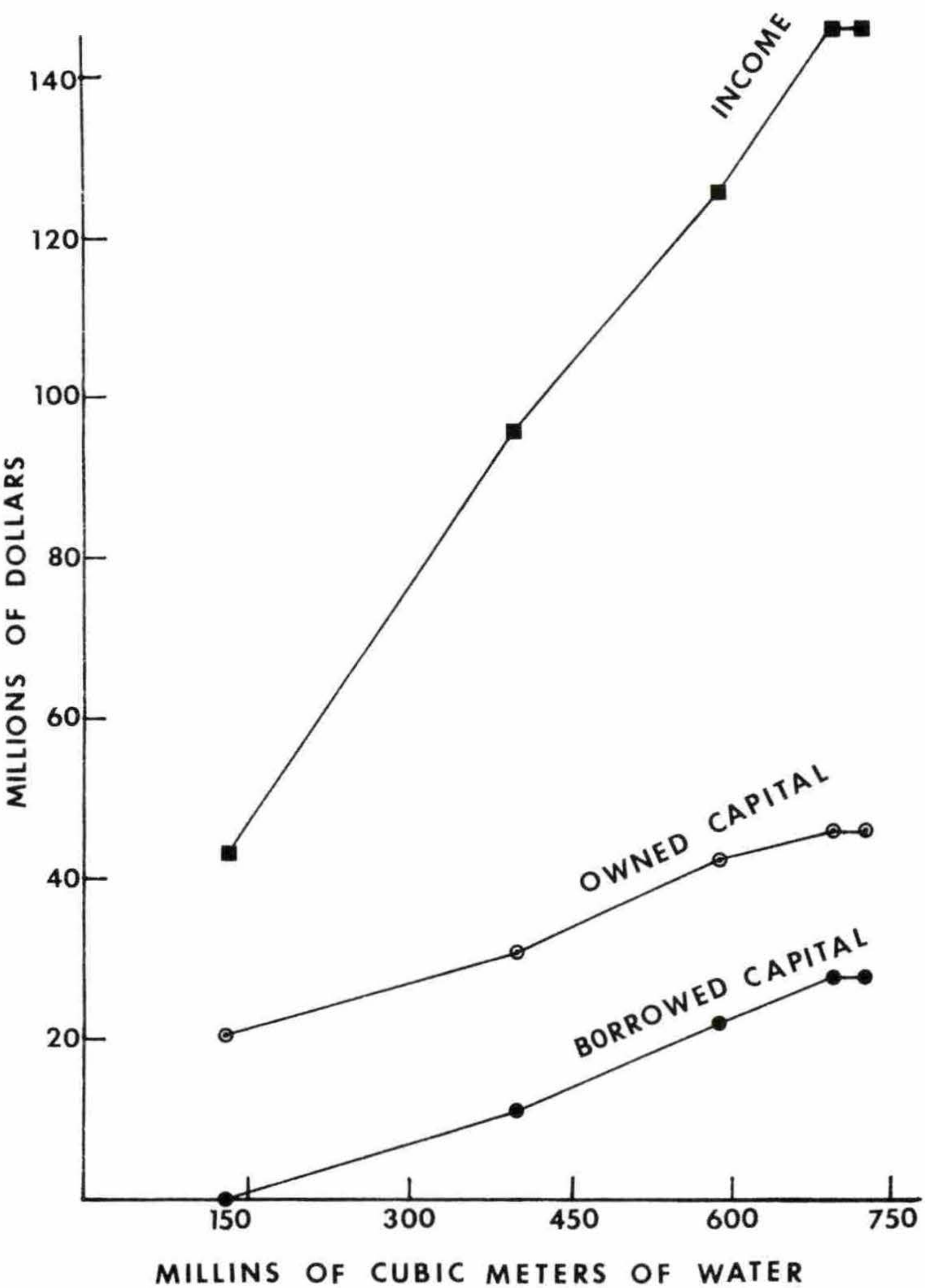

Figure 5. A relationship between parametric increments of water and income, owned capital, and borrowed capital

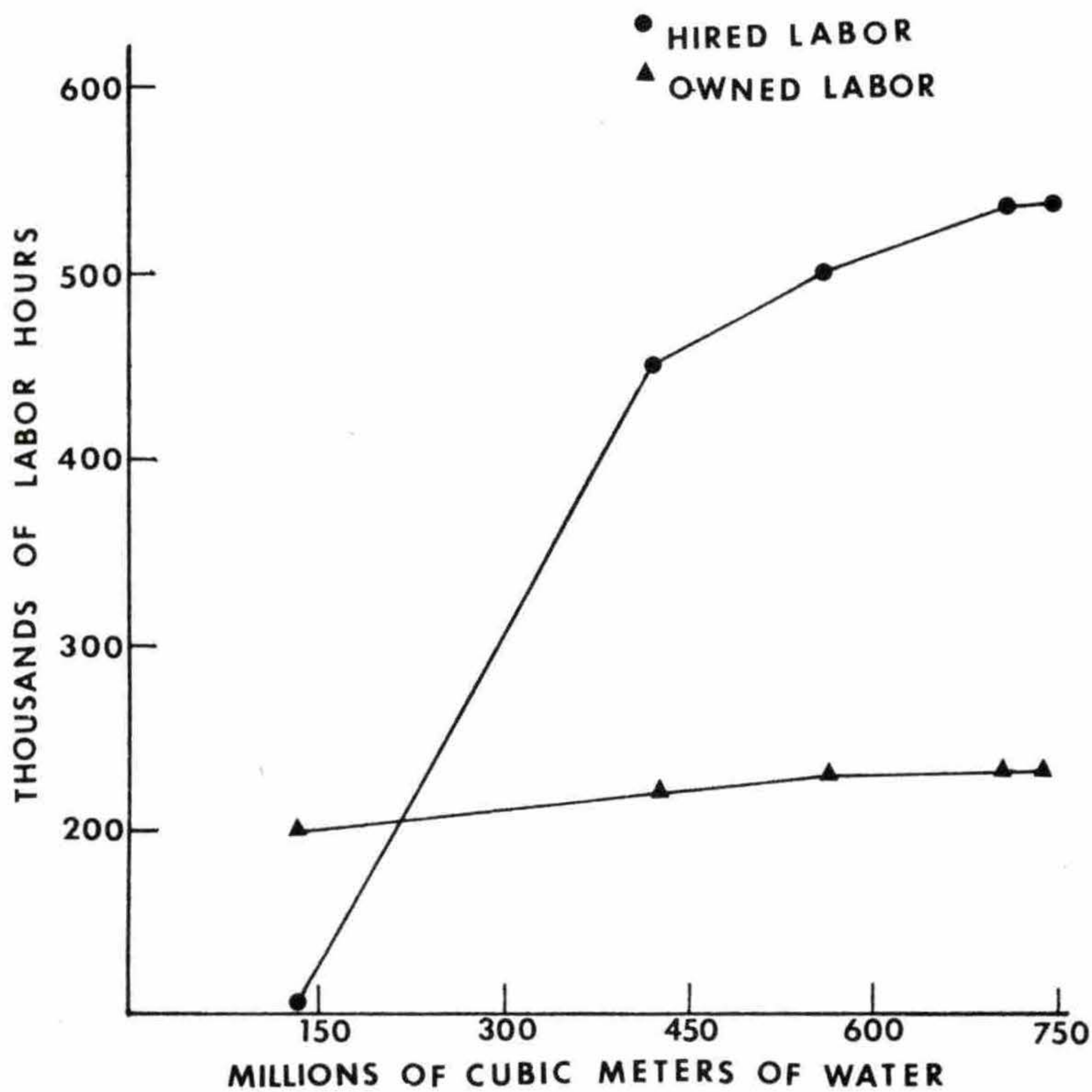

Figure 6. A relationship between parametric increments of water and owned labor and hired labor

Table 6. The relationship between water parametric range and nine crops grown in the area

Parametric Range (Mil M^3)	Barley (ha)	Green Pepper (ha)	Faba-beans (ha)	Oats (ha)	Onions (ha)	Millet (ha)	Potato (ha)	Tomato (ha)	Wheat (ha)
700	75,000	1,667	10,875	20,000	8,737	0	11,000	10,000	12,719
690	75,000	1,878	10,638	20,000	8,732	2,709	11,000	10,000	10,041
590	51,737	2,151	10,482	20,000	9,121	15,888	8,702	10,000	0
390	7,620	8,810	7,213	20,000	11,039	7,274	11,000	10,000	0
140	0	0	1,982	7,795	13,382	0	7,838	1,508	0

hired over all periods of the five (solutions) increments.

Table 6 shows the relationship between the parametrized increments of water and nine crops grown in the area. Those nine crops are the crops feasible in the five solutions of the parametric range of water. Barley, oats, potato, and tomato are bounded at 75,000, 20,000, 11,000, and 10,000 hectares of land respectively. Wheat production is not feasible in solution three, four, and five because most of the resources went into barley production. Variable cost of producing barley is less than that of producing wheat.

As water amount decreases the number of hectares of land in Faba-beans and wheat decrease. As water amount decreases the number of hectares of land in green pepper and onions increase too. As water amount decreases the number of hectares of land in millet increase up to increment three then drop after that. Finally, barley, oats, potatoes, and tomato are bounded so the effect of water at every increment is not clear.

Solution Two

A B_2 column is introduced which is similar to the B_1 column except that five restraints are changed. Land (R01) is decreased from 150,000 to 120,000 hectares. Operating capital (R12) is increased from \$20,460,000 to \$25,500,000. Combine supply time (R20) is increased from 30,000 to 50,000 hours. Tractor supply time (R21) is increased from

105,000 to 115,000 hours. Labor from March 1 - March 16 (R69) is decreased from 20,000 to 10,000 hours. The reasons for the changes are to see the effects on the objective function and on the crops in solution.

Crop activities

Barley for grain, P01	55,077.98 hectares
Tomatoes, P05	10,000.00 hectares
Potatoes, P06	11,000.00 hectares
Onions, P07	9,777.11 hectares
Green peppers, P08	4,650.41 hectares
Faba-beans, P12	9,494.50 hectares
Oats for forage, P13	20,000.00 hectares

All the land available has been used.

Resources completely used

The same as solution one except that tractor supply time (R21) is not completely used.

Commodity buying and selling

Sell barley, P40	187,694.95 MT
Sell tomatoes, P44	300,000.00 MT
Sell potatoes, P45	225,500.00 MT
Sell onions, P46	205,319.36 MT
Sell green peppers, P47	47,434.15 MT
Sell Faba-beans, P51	87,349.42 MT
Sell oats, P52	120,000.00 MT
Buy fertilizer, P53	22,757.36 MT

Jan. 1 - Feb. 28 water buy P55	99,455,348.87 cubic meters
Mar. 1 - Apr. 30 water buy P56	128,330,348.11 cubic meters
May 1 - Jun. 30 water buy P57	147,885,375.68 cubic meters
July 1 - Aug. 30 water buy P58	43,587,397.33 cubic meters
Sept. 1 - Oct. 31 water buy P59	53,073,000.00 cubic meters
Nov. 1 - Dec. 31 water buy P60	93,669,180.66 cubic meters
Capital borrow at 8%, P62	$13,895,897.62

Range analysis

The marginal value product on land was higher in this solution than in solution one. The same idea of interpreting the range analysis used in solution one can be followed here (APPENDIX C).

As a result of introducing the B_2 column (see matrix APPENDIX B) with the new five restraint levels mentioned before, the value of the program decreased by 15 percent from that of solution one. Wheat growing dropped out of the plan because most of the resources went to vegetable production. Levels of growing onions and green peppers are higher than those in solution one because resources are more efficient in producing those crops. Levels of growing barley and Faba-beans are lower than those in solution one because producing more vegetables is profitable in this situation. Remaining crops have equal levels in both solutions because of the upper bounds. For more information see APPENDIX C.

Solution Three

This solution reports the optimum plan using prices and variable costs in C_1 row and available resources in B_3 column. The B_3 column is similar to B_1 column except that four restraints are changed. Land (R01) is increased from 150,000 to 180,000 hectares. Operating capital (R12) is increased from \$20,460,000 to \$30,500,000. Combine supply time (R20) is increased from 30,000 to 100,000 hours. Tractor supply time (R21) is increased from 105,000 to 150,000 hours. The reasons for the changes are to find the effects on the objective function and on the crops in solution.

Crop activities

Barley for grain, P01	75,000.00 hectares
Wheat for grain, P03	62,520.62 hectares
Tomatoes, P05	10,000.00 hectares
Potatoes, P06	11,000.00 hectares
Onions, P07	4,870.23 hectares
Faba-beans, P12	5,264.50 hectares
Oats for forage, P13	11,344.56 hectares

All the land available (180,000 ha) was used.

Resources completely used

All the resources available are used except the farmers' own labor in period nine (R10); tractor time supply (R21), and maximum labor hire in rows (R68, R70, R71, R74, and R76) were not completely used.

Commodity buying and selling

Sell barley and tomatoes are the same as solutions one and two.

Sell wheat, P42	118,789.18 MT
Sell potatoes, P45	225,500.00 MT
Sell onions, P46	102,274.76 MT
Sell Faba-beans, P51	48,433.36 MT
Sell oats, P52	68,067.95 MT
Buy fertilizer, P53	36,084.90 MT
Jan. 1 - Feb. 28 water buy P55	132,917,271.84 cubic meters
Mar. 1 - Apr. 30 water buy P56	212,392,287.90 cubic meters
May 1 - Jun. 30 water buy P57	268,018,438.79 cubic meters
Jul. 1 - Aug. 30 water buy P58	26,137,371.74 cubic meters
Sept. 1 - Oct. 31 water buy P59	42,591,381.69 cubic meters
Nov. 1 - Dec. 31 water buy P60	154,823,958.18 cubic meters
Capital borrow at 8%, P62	$22,222,347.65

Range analysis

The marginal value product on land is less than solution one and solution two. The reason for that is that more land is available than in solution one or solution two. The same idea of interpreting the range analysis used in solution one can be followed here (APPENDIX C).

Because of introducing the B_3 column (see matrix APPENDIX B) with the new four restraint levels mentioned before, the value of the program increased by 30 percent over that of solution two. Wheat production came to this solution while it is not in solution two. The reasons are because more of the new resources went to wheat and more barley production. Also, more resources shifted from vegetable to grain crop production, levels of growing barley, onions, and Faba-beans are higher than those in solution two because more of the available resources shifted to production of those crops. Level of growing oats is lower than that in solution two because resources are more efficient in barley and wheat production. Remaining activities have equal levels in both solutions because of the upper bounds. For more information, see APPENDIX C.

Solution Four

This solution reports the optimum plan using C_2 row and B_1 column. The prices and variable costs in C_2 row are either higher or lower than those in C_1 row. The reasons for this change are to examine the effects of price change on the number of activities in solution and their levels, and to find the effect on the objective function.

All the land is used and the marginal value product is $597.45/ hectare.

Crop activities

Barley for grain, P01	75,000.00 hectares
Wheat for grain, P03	31,883.81 hectares
Potatoes, P06	11,000.00 hectares

Onions, P07	8,923.28 hectares
Green peppers, P08	11,636.23 hectares
Faba-beans, P12	11,556.67 hectares

Resources completely used

All the resources are used except the farmers' own labor in period nine (R10) and maximum labor hire in rows (R68, R69, R72, R74, R75, and R76) are not completely utilized.

Commodity buying and selling

Sell barley, P40	187,500.00 MT
Sell wheat, P42	60,579.25 MT
Sell potatoes, P45	225,500.00 MT
Sell onions, P46	187,389.00 MT
Sell green peppers, P47	118,689.52 MT
Sell Faba-beans, P51	106,321.37 MT
Buy fertilizer, P53	30,731.04 MT
Jan. 1 - Feb. 28 water buy P55	99,139,346.45 cubic meters
Mar. 1 - Apr. 30 water buy P56	193,432,949.79 cubic meters
May 1 - Jun. 30 water buy P57	223,456,794.72 cubic meters
Jul. 1 - Aug. 30 water buy P58	40,234,869.51 cubic meters
Sept. 1 - Oct. 31 water buy P59	28,852,999.99 cubic meters
Nov. 1 - Dec. 31 water buy P60	110,154,434.66 cubic meters

Range analysis

The highest marginal value product was on alfalfa transfer for harvest (R50) and the shadow price for the last hectare was $1518.71. For more information see APPENDIX C.

As a result of introducing the C_2 row which contains different variable costs and prices and the B_1 column (see matrix APPENDIX B), the value of the program decreased by 36 percent from that of solution three. Tomato and oats production dropped out of the plan because the output sale price of tomatoes is very low and resources are more efficient in producing other crops like Faba-beans, green peppers, and onions. Green peppers came into solution. Growing onions level increased in this solution compared to solution three, while growing wheat level decreased in this solution compared to solution three because resources are more profitable in producing some vegetable production than wheat. Growing barley and potato have the same levels in solutions three and four because of the upper bound. For more information see APPENDIX C.

Solution Five

This solution reports the optimum plan between C_2 row and B_2 column. The land is completely used and its marginal value product is higher than the last solution $616.68 for the last hectare used.

Crop activities

Barley for grain, P01	74,242.60 hectares
Potatoes for grain, P03	11,000.00 hectares
Onions, P07	9,962.93 hectares
Green pepper, P08	14,619.23 hectares

Faba-beans, P12	10,175.25 hectares

Resources completely used

All the available resources are used except farmers' own labor in period nine (R10), tractor supply time (R21), and maximum labor hire in rows (R68, R69, R72, R74, R75, and R76) are not completely used.

Commodity buying and selling

Sell barley, P40	185,606.50 MT
Sell potatoes, P45	225,500.00 MT
Sell onions, P46	209,221.36 MT
Sell green peppers, P47	149,116.10 MT
Sell Faba-beans, P51	93,612.34 MT
Buy fertilizer, P53	24,618.91 MT
Jan. 1 - Feb. 28 water buy P55	72,946,314.29 cubic meters
Mar. 1 - Apr. 30 water buy P56	151,906,893.72 cubic meters
May 1 - Jun. 30 water buy P57	177,334,317.57 cubic meters
Jul. - Aug. 30 water buy P58	49,273,914.18 cubic meters
Sept. 1 - Oct. 31 water buy P59	28,852,999.99 cubic meters
Nov. 1 - Dec. 31 water buy P60	80,777,339.02 cubic meters

Range analysis

The highest marginal value product is on onion transfer for harvest (R47) and the shadow price for the last hectare is $1234.54. For more information see APPENDIX C.

As a result of introducing the C_2 row and the B_2 column (see matrix APPENDIX B), the value of the program decreased by 17 percent from that of solution four. Growing wheat and tomato are not in solution because resources are more efficient in producing onions, and green peppers because of high sale prices. Levels of growing onions and green peppers are higher in this solution compared to the one before. Levels of growing barley and Faba-beans are lower than those in solution four because of low prices in C_2 row, and level of growing potato is the same in both solutions (APPENDIX C).

Solution Six

This solution reports the optimum plan between C_2 row and B_3 column. All land available is used and the marginal value product for the last hectare is $522.50.

Crop activities

Barley for grain, P01	75,000.00 hectares
Wheat for grain, P03	71,813.14 hectares
Potatoes, P06	10,400.35 hectares
Onions, P07	8,670.71 hectares
Green peppers, P08	6,885.80 hectares
Faba-beans, P12	7,229.50 hectares

Resources completely used

All resources are used except farmers' own labor in periods seven and nine (R08 and R10), tractor supply time (R21), and maximum labor hire in rows (R68, R71, R72, R74, and R76) are not all used.

Commodity buying and selling

Sell barley, P40	187,500,00 MT
Sell wheat, P42	136,444.96 MT
Sell potatoes, P45	213,207.20 MT
Sell onions, P46	182,085.00 MT
Sell green peppers, P47	70,235.18 MT
Sell Faba-beans, P51	66,515.99 MT
Buy fertilizer, P53	37,041.93 MT
Jan. 1 - Feb. 28 water buy P55	119,743,310.55 cubic meters
Mar. 1 - Apr. 30 water buy P56	228,190,983.49 cubic meters
May 1 - Jun. 30 water buy P57	278,716,791.65 cubic meters
Jul. 1 - Aug. 30 water buy P58	27,274,103.00 cubic meters
Sept. 1 - Oct. 31 water buy P59	27,280,120.78 cubic meters
Nov. 1 - Dec. 31 water buy P60	145,329,866.54 cubic meters

Range analysis

The highest marginal value product is on Faba-beans transfer for harvest (R52) and the shadow price for the last hectare is $1141.27. For more information see APPENDIX C.

As a result of using C_2 row and B_3 column (see matrix APPENDIX B), the value of the program increased by 47 percent over that of solution five. Growing tomato is not in the solution because of low product price and the high inputs requirement of the crop. Growing wheat came into solution because the resources are more efficient in wheat than tomato growing. Growing barley level increased in this solution compared to solution five because of more resources from B_3 column. Levels of growing potato, onions, green peppers, and Faba-beans decreased compared to solution four because resources are more efficient in growing wheat and barley. For more information see APPENDIX C.

So far most of the interpretation was given on a technical basis but now attention is given to practical ones. The following part of interpretation is of a great concern to decision makers and farmers in the area of study. As mentioned before, most of the land available in the area should go to barley, oats, and wheat production. Those are the major crops consumers demand in the area. Those crops use less water and labor compared to all vegetable crops grown in the area. If advanced mechanization and modern irrigation systems are introduced to the area, production of row crops like peanuts and corn may become profitable. To demonstrate that barley production is more efficient than tomato production, for example, this comparison can be given.

Table 7. A comparison between barley and tomato in resources use

Item	Barley	Tomato
1. Total water requirement per hectare per season	4,500.00 M^3 [a]	6,300.00 M^3
2. Number of irrigations per hectare per season	23.00	39.00
3. Time for planting one hectare	0.55 hour	10.00 hour

[a]Cubic meter.

Table 7. (continued)

Item	Barley	Tomato
4. Time for harvesting one hectare	0.73 hour	5.00 hour
5. Time for other field operations per hectare per season	6.00 hour	13.50 hour
6. Capital requirement per hectare per season	$41.43	$137.00

From the table above it is clear that tomato uses more resources than barley. This can be generalized to say that vegetable production requires more resources than grain crops. Of course, farmers in the area will base their production on the anticipated output prices without giving much attention to resource conservation. The role of extension people and decision makers is to direct the farmers by demonstrating to them that production of grain crops is more efficient in the long run than production of vegetables if resource conservation is taken into account.

The model in this report is used as a methodology to demonstrate the approximate allocation of resources available in the area. Some of the data are not accurate and can be replaced when the true ones become available.

Possibilities of More Research and Expansion of Model

More research could be done on the area of study to solve the numerous problems existing in the area. For example, more research on water allocation and raising the efficiency of labor are the most important problems to deal with. The total amount of water in the area and the recharge rate could be found to replace the parametric range analysis used in this report.

The model itself could be extended in many different ways. For example, labor requirement periods could be broken into shorter periods or maybe even on a day-by-day basis. Water requirement periods could be broken into shorter periods also. Different activities for buying and using every type of fertilizer could be used. Finally, more research is still needed to accomplish the best results and advice to give to the decision makers and farmers in the area. In order to have accurate research data, the cooperation of all concerned sectors in the Libyan government is needed.

Recommendations

Several recommendations may be developed from results of two models' application and visits to the area of study. These recommendations include further studies and improved data. Also, tentative recommendations are suggested by the findings but the current data base does not permit their validations because of data qualifications stated earlier in this report. Through further improvement in data quality, these tentative recommendations can be tested and revised accordingly. Until such testing has been performed, the tentative recommendations may be viewed as hypotheses to be tested.

1. Initiate studies of the entire area to identify demands for different crops and to predict the anticipated percentage increase in demands per year. After this is done, land allotment for highly resource consuming crops, especially water consuming, could be applied.
2. With more accurate data the theory and model discussed in previous chapters can be applied successfully to the area of study to solve the problems of resource allocations.
3. Water available in the area can be allocated among crops by a policy which restricts the amounts used for each crop based on the optimum amount needed. A gradual increase in taxes could be levied on extra water used beyond optimum needs of crops.
4. Expand growing barley, oats, and wheat to the upper limits obtained from optimizing the model. Other crops should be grown to the limits indicated in the solutions.
5. Reduce dairy cow production to a minimum because of their huge resource requirements, especially labor.
6. Obtain more information about water and other resource allocations in the area of study.
7. Develop an agricultural education program to suit farmers in the area and to help them pursue their practices efficiently.
8. Introduce a new Agrarian Reform Program with emphasis on land development and improvement to raise the productivity of the area.

9. Introduce the idea of induced technology and induced institutions to help develop the agricultural sector. Induced technology is the kind of technology which is designed to specifically deal with a certain problem. Induced institutions are institutions specifically designed to suit a process of solving a problem or enhancing development.
10. Train more extension people to help the farmers in the area through providing information about efficient agricultural techniques.
11. Demonstrate to farmers on their farms the efficient ways of production and optimum resource allocation particularly water.

CHAPTER VI

SUMMARY

The first chapter of this report is an introduction which deals with water scarcity, the role of water in the Libyan economy, the problem of water allocation among competing uses, objectives of study, the method used in pursuing objectives, and organization of report. Water scarcity is mentioned as an important factor in determining the kinds of crops farmers can grow and the amounts of land used in each crop. Conservation and better allocation are the main two solutions for this problem. The role of water in the Libyan economy is very important. Although all sectors of the economy consume water, some sectors like agriculture, petroleum, construction, industry, and home use are the most demanding sectors.

The available water in the area of study is not efficiently used and the model developed can help in allocating the available supply of water efficiently among the competing crops. The objectives of this study are shown in detail in chapter one but the main ones are to develop a model whereby water can be allocated efficiently and to apply the model in the study area. The report is organized systematically in which every chapter is based on the previous one and every section is based on the previous one also.

Chapter two deals with the theory of water allocation among competing uses. The uses in this study are the crops grown in the area. A hypothetical example of allocating water between two crops is illustrated and that could be extended to many crops competing for water use.

Chapter three deals with study procedure and development of the model. Linear programming is the technique used in this study to allocate water and some other resources among different activities in the model. A general idea about the use of linear programming, components of linear programming, and assumptions behind using linear programming are stated in this chapter. The model which consists of 73 activities and 76 restraints is developed to fully deal with the situation and to achieve the goals stated before. All restraints and activities are stated in detail in this chapter. Data needs of the model are discussed at the end of this chapter.

Some coefficients used in this model are not accurate enough for use in programs because of the lack of the accurate data. In these instances, proxy data are used. This model serves as a methodology whereby the exact results can be found when the accurate data are used instead of proxy data.

Chapter four deals with the application of the model developed in chapter three. Study area, data collection with limitations, application of the model and results of application are discussed in this chapter. The study area is relatively homogenous and farmers pursue similar agricultural practices. Other data about study are are given in this chapter.

Most of the data were collected during the summer of 1977, but the limitations stated in this section prevented the author from acquiring accurate data for this model. The model is applied using coefficients obtained from the area of study or Ministries of Development, Planning, Agriculture, Water and Dams, or El-Fateh University. The whole matrix is shown in APPENDIX B. Parametric range analysis is applied to water because the exact supply available in the area is not known. Major results from applying the model are shown in this chapter.

Chapter five states the interpretation of results obtained from running the linear programming model. The interpretations attempt to answer the questions raised and to meet the objectives stated in Chapter 1. A general interpretation of the six solutions is given, then details on each solution are stated. Possibilities of more study and extension of the model are given in this chapter. Possible types of recommendations for the public and the farmers in the area are mentioned at the end of Chapter four.

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APPENDIX A

THE COST - OUTPUT DATA

PERIODS WHERE THE CROPS SHOW THE GREATEST DEMAND FOR LABOR

Crop	Planting	Harvesting
Barley & wheat	Nov. 1 - Nov. 30	June 15 - July 15
Millet	Oct. 15 - Oct. 31	Jan. 2 - Feb. 28
Corn	Apr. 1 - Apr. 15	July 15 - July 31
Peanuts	Apr. 1 - Apr. 15	July 15 - Aug. 15
Tomatoes	Apr. 1 - Apr. 15	May 31 - Aug. 15
Potatoes	Sept. 1 - Sept. 15	Nov. 15 - Nov. 30
Faba-beans	Feb. 1 - Feb. 15	Apr. 1 - Apr. 30
Alfalfa	Planting usually in spring and harvesting all the year around (perennial).	
Oats	Oct. 15 - Oct. 31	Jan. 2 - Feb. 28
Onions	Mar. 2 - Mar. 15	July 1 - July 31
Green peppers	Apr. 1 - Apr. 15	May 31 - Aug. 30
Watermelons	Mar. 1 - Mar. 15	June 15 - July 31

Based on those periods, the nine labor restraint periods (shown below) were designed:

Periods	Days Per Period	Total Labor per Period (hours)
Jan. 1 - Feb. 28	28	19,874
Mar. 1 - Mar. 15	15	10,647
Mar. 16 - Mar. 31	16	11,356
Apr. 1 - Apr. 30	30	21,293
May 1 - May 30	30	21,293
May 31 - Aug. 30	92	65,300

Periods	Days Per Period	Total Labor per Period (hours)
Sept. 2 - Oct. 31	62	44,006
Nov. 1 - Nov. 30	30	21,293
Dec. 1 - Dec. 31	31	22,003

The average amount of labor available for the area per day = 709.78 hours.

LABOR REQUIREMENTS FOR FIELD PRACTICES PER HECTARE

Practice	Average Amount of Labor Per Hectare (hours)	Number of Men
Seeding and plowing	.55	1 (using tractor)
Irrigating	.25	1
Fertilizer spreading or chemical spray	.21	1 (using a machine)
Harvesting corn, oats, barley, millet	.73	1 (using tractor)
Harvesting tomatoes, green peppers, beans	5.0[1]	3
Harvesting potatoes, peanuts	7.0[1]	5
Harvesting water-melon	4.0[1]	4
Harvesting alfalfa	10.0	
Harvesting onions	5.5[1]	4

[1] Those crops are harvested manually

PRICE EXPECTATIONS AS OBTAINED FROM THE AREA

	Selling Price		Buying Price	
	LD[1]	$	LD	$
Barley	130/MT	436.8/MT	______	______
Corn	32.8/MT	110.24/MT	______	______
Wheat	170/MT	571.2/MT	______	______
Peanuts	120/MT	403.2/MT	______	______
Tomatoes	20/MT	67.2/MT	______	______
Potatoes	30/MT	100.8/MT	______	______
Onions	25/MT	84.0/MT	______	______
Green peppers	50/MT	168.9/MT	______	______
Watermelons	30/MT	100.8/MT	______	______
Alfalfa	35/MT	117.6/MT	______	______
Millet	53.6/MT	180.0/MT	______	______
Faba-beans	50/MT	168.0/MT	______	______
Oats	53.6/MT	180.0/MT	______	______
Feed supplement	______	______	106.7/MT	358.4/MT
Fertilizer	______	______	80.0/MT	268.8/MT
Custom combining rent for barley, wheat, millet and oats	______	______	5.89/ha	19.8/ha
Custom combining rent for corn	______	______	6.55/ha	22.0/ha
Harvesting one hectare of peanuts or potatoes	______	______	15/ha	50.4/ha
Harvesting one hectare of tomatoes, onions, or watermelon	______	______	12/ha	40.3/ha

PRICE EXPECTATIONS AS OBTAINED FROM THE AREA (continued)

	Selling Price		Buying Price	
	LD[1]	$	LD	$
Harvesting one hectare of green pepper and beans	______	______	9/ha	30.24/ha
Harvesting one hectare of alfalfa	______	______	18/ha	60.48/ha

[1]one LD (Libyan Dinar) = 3.36 American dollars

DAIRY COWS ACTIVITY - COSTS AND RETURNS (C-ROW COEFFICIENTS)

The requirements per head:

Item		Cost in Dollars
Veterinary and Medical		100.5
Machinery, equipment, power, etc.		215.0
Breeding charges		60.0
Miscellaneous		20.5
	Total	395.0

Receipts

	Kg/cow	Lb/cow	Revenue $	Price/ lb
Average milk production per cow	4,898	12,000	987.4	8.23
Average cow weight	512	1,254	37.8[1]	
Total			1025.2	
C_1 - Row Coefficient			630.2	8.23¢
C_2 - Row Coefficient			570.2	7.72¢

[1]Assuming the cow will continue production for 8 years on the average. Note: Average days in milk is 302 days.

FERTILIZER REQUIREMENTS

Type of Crop	Amount of all Types of Fertilizer (Lb/ha)
Barley	462
Corn	485
Wheat	462
Peanuts	490
Tomatoes	480
Potatoes	495
Onions	460
Green peppers	479
Watermelon	375
Alfalfa	350
Millet	250
Faba-beans	375
Oats	250

The average price/lb of different types of fertilizer is 12¢ in C_1 14¢ in C_2.

VARIABLE COST AND FIELD OPERATION REQUIREMENTS

Barley

Item	Cost/ha	
Seed	$ 31.45	yield/ha = 2.5 MT
Plowing	1.19	
Planting	0.99	
Fert. spread	4.90	
Machinery	1.05	
Cultivating	1.85	
Total	$ 41.43	

Corn

Seed	$ 24.53	yield/ha = 4.02 MT
Plowing	1.25	
Planting	1.10	
Fert. spread	4.84	
Machinery	1.05	
Cultivating	1.85	
Total	$ 34.62	

Wheat

Seed	$ 48.36	yield/ha = 1.9 MT
Plowing	1.19	
Planting	0.99	
Fert. spread	4.90	
Machinery	1.05	
Cultivating	1.85	
Total	$ 58.34	

Peanuts

Seed	$134.40[c]	yield/ha = 2.4 MT
Plowing	1.19	
Planting	1.10	
Fert. spread	4.90	
Machinery	2.30	
Cultivating	4.35	
Total	$148.24	

[c]This is on unshelled basis.

VARIABLE COST AND FIELD OPERATION REQUIREMENTS (Continued)

Tomatoes

Item	Cost/ha	
Plants	$ 56.96	yield/ha = 30 MT
Plowing	1.19	
Planting	23.99	
Fert. spread	4.90	
Machinery	2.30	
Cultivating	3.35	
Spraying	4.25	
Chemicals	40.08	
Total	$137.02	

Potatoes

Seed	$ 60.48	yield/ha = 20.5 MT
Plowing	1.19	
Planting	19.80	
Fert. spread	4.90	
Machinery	2.30	
Cultivating	3.35	
Spraying	4.25	
Chemicals	30.08	
Total	$126.35	

Onions

Plants	$ 33.60	yield/ha = 21 MT
Plowing	1.19	
Planting	25.68	
Fert. spread	4.90	
Machinery	2.30	
Cultivating	3.35	
Spraying	4.25	
Chemicals	20.08	
Total	$ 95.35	

VARIABLE COST AND FIELD OPERATION REQUIREMENTS (continued)

Green Pepper

Item	Cost/ha	
Plants	$ 36.50	yield/ha = 10.2 MT
Plowing	1.19	
Planting	24.91	
Fert. spread	4.90	
Machinery	2.30	
Cultivating	3.35	
Spraying	4.25	
Chemicals	30.08	
Total	$107.48	

Watermelon

Seed	$ 13.44	yield/ha = 10 MT
Plowing	1.19	
Planting	21.32	
Fert. spread	4.90	
Machinery	2.30	
Cultivating	3.35	
Spraying	4.25	
Chemicals	40.08	
Total	$ 90.83	

Alfalfa

Seed	$ 83.16	yield/ha = 8.2 MT
Plowing	1.19	
Planting	2.22	
Fert. spread	4.90	
Machinery	2.60	
Spraying	4.25	
Chemicals	10.08	
Total	$108.40	

Millet

Seed	$ 63.84	yield/ha = 6 MT
Plowing	1.19	
Planting	0.99	
Fert. spread	4.90	
Machinery	1.05	
Cultivating	1.85	
Total	$ 73.82	

VARIABLE COST AND FIELD OPERATION REQUIREMENTS (continued)

Faba-beans

Item	Cost/ha	
Seed	$ 32.26	yield/ha = 9.2 MT
Plowing	1.19	
Planting	1.52	
Fert. spread	4.90	
Machinery	1.05	
Chemicals	30.08	
Spraying	1.85	
Total	$ 72.85	

Oats

Item	Cost/ha	
Seed	$ 17.47	yield/ha = 6 MT
Plowing	1.19	
Planting	0.99	
Fert. spread	4.90	
Machinery	1.05	
Cultivating	1.85	
Total	$ 27.45	

WATER REQUIREMENTS FOR THE CROPS PER SEASON

Crop	Water (cubic meter)/hectare
Alfalfa	12,800
Barley	4,500
Corn	6,250
Faba-beans	4,599
Green pepper	6,205
Millet	4,800
Oats	4,800
Onion	4,800
Peanuts	5,599
Potatoes	3,892
Tomatoes	6,300
Watermelon	6,205
Wheat	4,500

The distribution over the season is arbitrary taking into account the temperature, i.e., more water in hot periods than in cold periods. (Lack of detailed data over the season.)

The total water requirement for each crop is right but the distribution is arbitrary, so the coefficients can be replaced later when the actual ones are obtained.

Budgeting of Every Crop

Barley

Growing	VC	$ 41.43	TR = $1092/ha
Water	VC	185.35	
Fert.	VC	55.44	NR = $ 786.23/ha
Harvest	VC	19.80	
Labor	VC	3.75	NR = # 318.31/acre
		$305.77	

Corn

Growing	VC	$ 34.62	TR = $ 443.16/ha
Water	VC	178.20	
Fert.	VC	58.29	NR = $ 146.53/ha
Harvest	VC	22.00	
Labor	VC	3.61	NR = $ 59.32/acre
		$296.63	

Wheat

Growing	VC	$ 58.30	TR = $1085/ha
Water	VC	185.35	
Fert.	VC	55.44	NR = $ 762.64/ha
Harvest	VC	19.80	
Labor	VC	3.75	NR = $ 308.76/acre
		$322.64	

Peanuts

Growing	VC	$148.24	TR = $ 967.68/ha
Water	VC	279.95	
Fert.	VC	58.80	NR = $ 414.33/ha
Harvest	VC	50.40	
Labor	VC	15.96	NR = $ 167.74/acre
		$553.35	

Tomatoes

Growing	VC	$137.00	TR = $2016/ha
Water	VC	314.55	
Fert.	VC	57.60	NR = $1446.22/ha
Harvest	VC	40.30	
Labor	VC	20.33	NR = $585.51/acre
		$569.78	

<u>Potatoes</u>

Growing	VC	$126.40	TR = $2066/ha
Water	VC	194.60	
Fert.	VC	59.40	NR = $1616.78/ha
Harvest	VC	50.40	
Labor	VC	18.82	NR = $ 654.57/acre
		$449.62	

<u>Onions</u>

Growing	VC	$ 95.40	TR = $1764/ha
Water	VC	194.65	
Fert.	VC	55.20	NR = $1359.63/ha
Harvest	VC	40.30	
Labor	VC	18.82	NR = $ 550.46/acre
		$404.37	

<u>Green pepper</u>

Growing	VC	$107.50	TR = $1713.60/ha
Water	VC	310.25	
Fert.	VC	57.48	NR = $1189.52/ha
Harvest	VC	30.20	
Labor	VC	18.65	NR = $ 481.59/acre
		$524.08	

<u>Watermelon</u>

Growing	VC	$ 90.89	TR = $1008/ha
Water	VC	310.25	
Fert.	VC	33.00	NR = $ 516.60/ha
Harvest	VC	40.30	
Labor	VC	17.05	NR = $ 209.15/acre
		$491.40	

<u>Alfalfa</u>

Growing	VC	$108.35	TR = $ 964.32/ha
Water	VC	639.95	
Fert.	VC	42.00	NR = $ 90.51/ha
Harvest	VC	60.50	
Labor	VC	22.81	NR = $ 36.64/acre
		$873.81	

Millet

Growing	VC	$ 73.80	TR = $1080/ha
Water	VC	240.00	
Fert.	VC	30.00	NR = $ 708.82/ha
Harvest	VC	19.80	
Labor	VC	7.58	NR = $ 286.97/acre
		$371.18	

Beans

Growing	VC	$ 72.90	TR = $1545.60/ha
Water	VC	229.95	
Fert.	VC	45.00	NR = $1149.66/ha
Harvest	VC	30.20	
Labor	VC	17.89	NR = $ 465.45/acre
		$395.94	

Oats

Growing	VC	$ 27.50	TR = $1080/ha
Water	VC	240.00	
Fert.	VC	30.00	NR = $ 755.12/ha
Harvest	VC	19.80	
Labor	VC	7.58	NR = $ 305.72/acre
		$324.88	

APPENDIX B

DATA MATRIX WITH THE COEFFICIENTS, PRICES OF OUTPUTS, VARIABLE COSTS, AND THE RESOURCES AVAILABLE

List of Activities

From P01 to P39 the activity unit is one hectare.

P01 Producing and growing barley

P02 Producing and growing corn

P03 Producing and growing wheat

P04 Producing and growing peanuts

P05 Producing and growing tomatoes

P06 Producing and growing potatoes

P07 Producing and growing onions

P08 Producing and growing green peppers

P09 Producing and growing watermelon

P10 Producing and growing alfalfa

P11 Producing and growing millet for forage

P12 Producing and growing Faba-beans

P13 Producing and growing oats for forage

P14 An activity which permits irrigating one hectare of barley

P15 An activity which permits irrigating one hectare of corn

P16 An activity which permits irrigating one hectare of wheat

P17 An activity which permits irrigating one hectare of peanuts

P18 An activity which permits irrigating one hectare of tomatoes

P19 An activity which permits irrigating one hectare of potatoes

P20 An activity which permits irrigating one hectare of onions

P21 An activity which permits irrigating one hectare of green peppers

P22 An activity which permits irrigating one hectare of watermelon

P23 An activity which permits irrigating one hectare of alfalfa.

P24 An activity which permits irrigating one hectare of millet for forage.

P25 An activity which permits irrigating one hectare of Faba-beans.

P26 An activity which permits irrigating one hectare of oats for forage.

P27 An activity which has barley custom-combined and the hay put up by farmers.

P28 An activity which has corn custom-combined and hauling.

P29 An activity which has wheat custom-combined and the hay put up by farmers.

P30 An activity which has peanuts manually picked.

P31 An activity which has tomatoes manually picked.

P32 An activity which has potatoes manually picked.

P33 An activity which has onions manually picked.

P34 An activity which has green peppers manually picked.

P35 An activity which has watermelon manually picked.

P36 An activity which has alfalfa mowed 50 times per year by farmers.

P37 An activity which contains millet custom harvested and baled.

P38 An activity which includes Faba-beans manually picked.

P39 An activity which has oats custom harvested and baled.

P40 Barley selling. The activity unit is one metric ton (2240 lb).

P41 Corn selling. The activity unit is one metric ton.

P42 Wheat selling. The activity unit is one metric ton.

P43 Peanuts selling. The activity unit is one long ton.

P44 Tomato selling. The activity unit is one metric ton.

P45 Potato selling. The activity unit is one metric ton.

P46 Onion selling. The activity unit is one metric ton.

P47 Green pepper selling. The activity unit is one metric ton.

P48 Watermelon selling. The activity unit is one metric ton.

P49 Alfalfa selling. The activity unit is one metric ton.

P50 Millet selling. The activity unit is one metric ton.

P51 Faba-beans selling. The activity unit is one metric ton.

P52 Oats selling. The activity unit is one metric ton.

P53 Fertilizer buying. The activity unit is one pound.

P54 Feed supplement buying. The unit of activity is one metric ton.

P55 Water buying in Jan. 1 - Feb. 28. The unit of activity is one cubic meter.

P56 Water buying in Mar. 1 - Apr. 30. The unit of activity is one cubic meter.

P57 Water buying in May 1 - June 30. The unit of activity is one cubic meter.

P58 Water buying in July 1 - Aug. 30. The unit of activity is one cubic meter.

P59 Water buying in Sept. 1 - Oct. 31. The unit of activity is one cubic meter.

P60 Water buying in Nov. 1 - Dec. 31. The unit of activity is one cubic meter.

P61 Dairy cow raising and selling. Selling the culled cow and the milk. The activity unit is one cow.

P62 Capital borrowing. The activity unit is one dollar.

The activity unit is one hour.

P63 Labor hiring in Jan. 1 — Feb. 28.

P64 Labor hiring in Mar. 1 - Mar. 15.

P66 Labor hiring in Mar. 16 — Mar. 31.

P67 Labor hiring in May 1 — May 30.

P68 Labor hiring in May 31 — Aug. 30.

P69 Labor hiring in Sept. 1 — Oct. 31.

P70 Labor hiring in Nov. 1 — Nov. 30.

P71 Labor hiring in Dec. 1 — Dec. 31.

P72 Custom-combine hiring. The activity unit is one hour.

P73 Custom-tractor hiring. The activity unit is one hour.

List of restraints

R01 A restraint on land. The B column unit is hectare.

From R02 to R10 the restraint unit is one hour.

R02 A restraint on labor in Jan. 1 - Feb. 28.

R03 A restraint on labor in Mar. 1 - Mar. 15.

R04 A restraint on labor in Mar. 16 - Mar. 31.

R05 A restraint on labor in Apr. 1 - Apr. 30.

R06 A restraint on labor in May 1 - May 30.

R07 A restraint on labor in May 31 - Aug. 30.

R08 A restraint on labor in Sept. 1 - Oct. 31.

R09 A restraint on labor in Nov. 1 - Nov. 30.

R10 A restraint on labor in Dec. 1 - Dec. 31.

R11 A restraint on head space of cows (capital accounting). The restraint unit is one head space.

R12 A restraint on operating capital. The restraint unit is one dollar.

From R13 to R18 the restraint unit is one cubic meter.

R13 A restraint on water demanded by the crops in Jan. 1 - Feb. 28.

R14 A restraint on water in Mar. 1 - Apr. 30.

R15 A restraint on water in May 1 - June 30.

R16 A restraint on water in July 1 - Aug. 30.

R17 A restraint on water in Sept. 1 - Oct. 31.

R18 A restraint on water in Nov. 1 - Dec. 31.

R19 A restraint on the fertilizer available for the crops. The restraint unit is one pound.

R20 A restraint on custom-combine hire. The restraint unit is hour.

R21 A restraint of custom-tractor hire. The restraint unit is hour.

From R22 to R34 the restraint unit is one watered hectare.

R22 A grown barley transfer row.

R23 A grown corn transfer row.

R24 A grown wheat transfer row.

R25 A grown peanut transfer row.

R26 A grown tomato transfer row.

R27 A grown potato transfer row.

R28 A grown onion transfer row.

R29 A grown green pepper transfer row.

R30 A grown watermelon transfer row.

R31 A grown alfalfa transfer row.

R32 A grown millet transfer row.

R33 A grown Faba-beans transfer row.

R34 A grown oats transfer row.

From R35 to R40 the restraint unit is one cubic meter.

R35 A restraint on water in Jan. 1 - Feb. 28.

R36 A restraint on water in Mar. 1 - Apr. 30.

R37 A restraint on water in May 1 - June 30.

R38 A restraint on water in July 1 - Aug. 30.

R39 A restraint on water in Sept. 1 - Oct. 31.

R40 A restraint on water in Nov. 1 - Dec. 31.

From R41 to R57 the restraint unit is one hectare.

R41 A harvested hectare of barley transfer.

R42 A harvested hectare of corn transfer.

R43 A harvested hectare of wheat transfer.

R44 A harvested hectare of peanuts transfer.

R45 A harvested hectare of tomato transfer.

R46 A harvested hectare of potato transfer.

R47 A harvested hectare of onion transfer.

R48 A harvested hectare of green pepper transfer.

R49 A harvested hectare of watermelon transfer.

R50 A harvested hectare of alfalfa transfer.

R51 A harvested hectare of millet transfer.

R52 A harvested hectare of Faba-beans transfer.

R53 A harvested hectare of oats transfer.

From R54 to R66 the restraint unit is one metric ton.

R54 A barley transfer row.

R55 A corn transfer row.

R56 A wheat transfer row.

R57 A peanuts transfer row.

R58 A tomato transfer row.

R59 A potato transfer row.

R60 An onions transfer row.

R61 A green peppers transfer row.

R62 A watermelon transfer row.

R63 An alfalfa transfer row.

R64 A millet transfer row.

R65 A Faba-beans transfer row.

R66 An oats transfer row.

R67 Feed supplement transfer row. The unit is one pound.

From R68 to R76 the restraint unit is one hour.

R68 A restraint on hiring labor in Jan. 1 - Feb. 28.

R69 A restraint on hiring labor in Mar. 1 - Mar. 15.

R70 A restraint on hiring labor in Mar. 16 - Mar. 31.

R71 A restraint on hiring labor in Apr. 1 - Apr. 30.

R72 A restraint on hiring labor in May 1 - May 30.

R73 A restraint on hiring labor in May 31 - Aug. 30.

R74 A restraint on hiring labor in Sept. 1 - Oct. 31.

R75 A restraint on hiring labor in Nov. 1 - Nov. 30.

R76 A restraint on hiring labor in Dec. 1 - Dec. 30.

Table B-1. The data matrix

	B_1	B_2	B_3	P01	P02	P03	P04
C_1				-41.43	-34.62	-58.3	-198.3
C_2				-51.43	-44.62	-68.3	-158.3
R01	150,000	120,000	180,000				
R02	19,874	19,874	19,874				
R03	10,647	10,647	10,647				
R04	11,356	11,356	11,356				
R05	21,293	21,293	21,293		0.55		2
R06	21,293	21,293	21,293		0.10		0.6
R07	65,300	65,300	65,300				
R08	44,006	44,006	44,006				
R09	21,293	21,293	21,293	0.55		0.55	
R10							
R11							
R12	20,460,000	25,500,000	30,000,000	42.35	35.71	59.21	152.69
R13							
R14							
R15							
R16							
R17							
R18							
R19				462	485	462	490
R20	30,000	50,000	100,000				

P05	P06	P07	P08	P09	P10	P11	P12	P13
-137	-126.9	-95.4	-107.5	-90.8	-108.4	-73.8	-72.9	-27.5
-147	-136.4	-105.4	-117.5	-100.8	-118.4	-83.8	-82.9	-37.5
					0.55		3.5	
					0.10	0.20	0.35	0.20
		3.5		2.9	0.10	0.15	0.35	0.15
4.1		0.15	4.1	0.15	0.10	0.35		0.35
0.3		0.20	0.3	0.25	0.10	0.25		0.25
					0.10	0.30		0.30
	0.38				0.10	0.73		0.73
					0.10			
					0.10			
144.39	132.73	101.82	114.87	96.37	110.67	77.15	79.96	30.83
480	495	460	479	375	350	250	375	250

Table B-1. (continued)

	P14	P15	P16	P17	P18	P19	P20	P21
C_1	-.02	-.02	-.02	-.02	-.02	-.02	-.02	-.02
C_2	-.02	-.02	-.02	-.02	-.02	-.02	-.02	-.02
R01								
R02	0.10		0.10					
R03	0.10	0.10	0.10	0.10	0.10		0.15	0.10
R04	0.10	0.10	0.10	0.10	0.10		0.15	0.10
R05	0.15	0.25	0.15	0.25	0.25		0.25	0.25
R06	0.20	0.45	0.20	0.45	0.45		0.45	0.45
R07		0.20		0.20	0.20		0.20	0.20
R08						0.25		
R09	0.25		0.25			0.10		
R10	0.10		0.10			0.10		
R11								
R12	186.69	179.4	186.7	281.1	315.7	195.2	196.1	311.4
R13	722		722					
R14	1295	876	1295	1269	1370		1319	1041
R15	1690	1782	1690	2100	2805		1552	2490
R16		906		2230	2116		1022	2674
R17						2623		
R18	900		900			1269		
R19								
R20								

P22	P23	P24	P25	P26	P27	P28	P29	P30
-.02	-.02	-.02	-.02	-.02	-19.8	-22	-19.8	-50.4
-.02	-.02	-.02	-.02	-.02	-20.8	-23	-20.8	-51.4
	.05	0.25	0.10	0.25				
0.15	0.28		0.20					
0.15	0.28		0.25					
0.25	0.28		0.15					
0.45	1.66							
0.20	5.01							
	0.28	0.35		0.35				
	0.28	0.28		0.28				
	0.28	0.28		0.28				
311.7	654.1	242.9	230.7	242.9	21.11	23.34	21.11	94.04
	1448	2082	1901	2082				
1979	1679		2698					
2474	2674							
1752	3381							
	2099	1211	1211					
	1518	1507		1507				

Table B-1. (continued)

	P31	P32	P33	P34	P35	P36	P37	P38
C_1	-40.3	-50.4	-40.5	-30.2	-40.3	-60.5	-19.8	-30.7
C_2	-41.3	-51.4	-41.3	-31.2	-41.3	-61.5	-20.8	-31.7
R01								
R02						0.25	0.78	
R03						0.30		
R04						0.20		
R05						0.50		
R06						0.80		
R07	7		8.5	6	6	0.78		
R08						0.40		
R09						0.30		
R10						0.30		
R11								
R12	82.36	92.36	84.9	70.6	80.7	81.4	21.11	70.6
R13								
R14								
R15								
R16								
R17								
R18								
R19								
R20								

P39	P40	P41	P42	P43	P44	P45	P46	P47	P48
-19.8	436.8	110.2	571.2	403.2	67.2	100.8	84	168	100.8
-20.8	403.2	84	537.6	336	33.6	67.2	67.4	134.4	67.2

0.78

21.14

Table B-1. (continued)

	P49	P50	P51	P52	P53	P54	P55	P56	P57
C_1	117.6	180	168	180	-.12	-358.4	-.03	-.03	-.03
C_2	67.2	113.3	134.4	113.3	-.14	-336	-.04	-.04	-.04
R01									
R02									
R03									
R04									
R05									
R06									
R07									
R08									
R09									
R10									
R11									
R12									
R13							-1		
R14								-1	
R15									-1
R16									
R17									
R18									
R19					-1				
R20									

P58	P59	P60	P61	P62	P63	P64	P65	P66
-.03	-.03	-.03	630.2	-.08	-6.72	-8.4	-8.4	-8.4
-.04	-.04	-.04	570.2	-.05	-8.4	-10.08	-10.08	-10.08
			.002					
			8.82		-1			
			6.71			-1		
			6.71				-1	
			9.41					-1
			7.42					
			10.26					
			6.82					
			4.42					
			4.42					
			1					
			10.35					
-1								
	-1							
		-1						

Table B-1. (continued)

	P67	P68	P69	P70	P71	P72	P73
C_1	-13.4	-13.4	-10.08	-10.08	-6.72	-13.4	-12.3
C_2	-13.4	-13.4	-11.76	-11.76	-8.4	-16.8	-13.4
R01							
R02							
R03							
R04							
R05							
R06	-1						
R07		-1					
R08			-1				
R09				-1			
R10					-1		
R11							
R12							
R13							
R14							
R15							
R16							
R17							
R18							
R19							
R20							

Table B-1. (continued)

	B_1	B_2	B_3	P01	P02	P03	P04	P05
R21	105,000	115,000	150,000	1		1		
R22				-1				
R23					-1			
R24						-1		
R25							-1	
R26								-1
R27								
R28								
R29								
R30								
R31								
R32								
R33								
R34								
R35	300,000,000	300,000,000	300,000,000					
R36	"	"	"					
R37	"	"	"					
R38	"	"	"					
R39	"	"	"					
R40	"	"	"					
R41								

P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17
-1					1		1				
	-1							1			
		-1							1		
			-1							1	
				-1							1
					-1						
						-1					
							-1				
								-1			

Table B-1. (continued)

	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29
R21												
R22												
R23												
R24												
R25												
R26	1											
R27		1										
R28			1									
R29				1								
R30					1							
R31						1						
R32							1					
R33								1				
R34									1			
R35												
R36												
R37												
R38												
R39												
R40												
R41										1		

P30	P31	P32	P33	P34	P35	P36	P37	P38	P39	P40	P41

Table B-1. (continued)

	P42	P43	P44	P45	P46	P47	P48	P49	P50	P51	P52
R21											
R22											
R23											
R24											
R25											
R26											
R27											
R28											
R29											
R30											
R31											
R32											
R33											
R34											
R35											
R36											
R37											
R38											
R39											
R40											
R41											

P53	P54	P55	P56	P57	P58	P59	P60	P61	P62	P63	P64
		1									
			1								
				1							
					1						
						1					
							1				

Table B-1. (continued)

	P65	P66	P67	P68	P69	P70	P71	P72	P73
R21									-1
R22									
R23									
R24									
R25									
R26									
R27									
R28									
R29									
R30									
R31									
R32									
R33									
R34									
R35									
R36									
R37									
R38									
R39									
R40									
R41									

Table B-1. (continued)

	B_1	B_2	B_3	P01	P02	P03	P04	P05	P06	P07	P08	P09
R42												
R43												
R44												
R45												
R46												
R47												
R48												
R49												
R50												
R51												
R52												
R53												
R54												
R55												
R56												
R57												
R58												
R59												
R60												
R61												
R62												

P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
					-1						
						-1					
							-1				
								-1			
									-1		
										-1	
											-1

Table B-1. (continued)

	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31	P32
R42											
R43											
R44											
R45											
R46											
R47											
R48											
R49	-1										
R50		-1									
R51			-1								
R52				-1							
R53					-1						
R54						-2.5					
R55							-4.02				
R56								-1.9			
R57									-2.4		
R58										-30	
R59											-20.5
R60											
R61											
R62											

P33	P34	P35	P36	P37	P38	P39	P40	P41	P42	P43	P44
1											
	1										
		1									
			1								
				1							
					1						
						1					
							1				
								1			
									1		
										1	
											1

Table B-1. (continued)

	P45	P46	P47	P48	P49	P50	P51	P52	P53	P54	P55
R42											
R43											
R44											
R45											
R46											
R47											
R48											
R49											
R50											
R51											
R52											
R53											
R54											
R55											
R56											
R57											
R58											
R59	1										
R60		1									
R61			1								
R62				1							

P56	P57	P58	P59	P60	P61	P62	P63	P64	P65	P66	P67

0.49

Table B-1. (continued)

	P68	P69	P70	P71	P72	P73
R42						
R43						
R44						
R45						
R46						
R47						
R48						
R49						
R50						
R51						
R52						
R53						
R54						
R55						
R56						
R57						
R58						
R59						
R60						
R61						
R62						

Table B-1. (continued)

	B_1	B_2	B_3	P01	P02	P03	P04	P05	P06	P07
R63										
R64										
R65										
R66										
R67										
R68	60,000	60,000	60,000							
R69	20,000	10,000	10,000							
R70	40,000	40,000	40,000							
R71	120,000	120,000	120,000							
R72	25,000	25,000	25,000							
R73	150,000	150,000	150,000							
R74	30,000	30,000	30,000							
R75	170,000	170,000	170,000							
R76	1000	1000	1000							
R77										
R78										
R79										
R80										

P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19

Table B-1. (continued)

	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30
R63											
R64											
R65											
R66											
R67											
R68											
R69											
R70											
R71											
R72											
R73											
R74											
R75											
R76											
R77											
R78											
R79											
R80											

P31	P32	P33	P34	P35	P36	P37	P38	P39	P40	P41	P42
					-8.2						
						-6					
							-9.2				
								-6			

Table B-1. (continued)

	P43	P44	P45	P46	P47	P48	P49	P50	P51	P52	P53
R63											
R64								1			
R65									1		
R66										1	
R67											
R68											
R69											
R70											
R71											
R72											
R73											
R74											
R75											
R76											
R77											
R78											
R79											
R80											

P54	P55	P56	P57	P58	P59	P60	P61	P62	P63	P64	P65
							4.75				
							2.50				
							2.56				
-1							1.10				
									1		
										1	
											1

Table B-1. (continued)

	P66	P67	P68	P69	P70	P71	P72	P73
R63								
R64								
R65								
R66								
R67								
R68								
R69								
R70								
R71	1							
R72		1						
R73			1					
R74				1				
R75					1			
R76						1		
R77								
R78								
R79								
R80								

APPENDIX C

SUMMARIZED RESULTS OF THE LINEAR PROGRAMMING COMPUTER OUTPUT

Table C-1. Resources (rows) used in solution one

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	C1	BS	145021625.675	145021625.675-	NONE	NONE	1.00000
2	C2	BS	95171064.8511	95171064.8511-	NONE	NONE	.
3	R01	UL	150000.00000	.	NONE	150000.00000	699.34928-
4	R02	UL	19874.00000	.	NONE	19874.00000	6.72000-
5	R03	UL	10647.00000	.	NONE	10647.00000	8.40000-
6	R04	UL	11356.00000	.	NONE	11356.00000	110.44760-
7	R05	UL	21293.00000	.	NONE	21293.00000	70.66357-
8	R06	UL	21293.00000	.	NONE	21293.00000	13.44000-
9	R07	UL	65300.00000	.	NONE	65300.00000	42.54823-
10	R08	UL	44006.00000	.	NONE	44006.00000	10.08000-
11	R09	UL	21293.00000	.	NONE	21293.00000	10.08000-
12	R10	BS	15471.91959	6531.08041	NONE	22003.00000	.
13	R11	BS	.	1000.00000	NONE	1000.00000	.
14	R12	UL	20460000.0000	.	NONE	20460000.0000	.08000-
15	R13	UL	.	.	NONE	.	.03000-
16	R14	UL	.	.	NONE	.	.03000-
17	R15	UL	.	.	NONE	.	.03000-
18	R16	UL	.	.	NONE	.	.03000-
19	R17	UL	.	.	NONE	.	.03000-
20	R18	UL	.	.	NONE	.	.03000-
21	R19	UL	.	.	NONE	.	.12000-
22	R20	UL	30000.00000	.	NONE	30000.00000	13.40000-
23	R21	UL	105000.00000	.	NONE	105000.00000	12.30000-
24	R22	UL	.	.	NONE	.	842.39408-
25	R23	UL	.	.	NONE	.	219.86032-
26	R24	UL	.	.	NONE	.	835.67408-
27	R25	UL	.	.	NONE	.	333.97226-
28	R26	UL	.	.	NONE	.	1413.15689-
29	R27	UL	.	.	NONE	.	1802.12800-
30	R28	UL	.	.	NONE	.	1257.94903-
31	R29	UL	.	.	NONE	.	1167.27152-
32	R30	UL	.	.	NONE	.	1177.11646-
33	R31	UL	.	.	NONE	.	911.32435-
34	R32	UL	.	.	NONE	.	868.38720-
35	R33	UL	.	.	NONE	.	888.76275-
36	R34	UL	.	.	NONE	.	868.38480-
37	R35	BS	125648381.027	174351618.972	NONE	299999999.999	.
38	R36	BS	169856404.182	130143595.817	NONE	299999999.999	.
39	R37	BS	194007852.831	105992147.169	NONE	299999999.999	.
40	R38	BS	34548352.6660	265451647.333	NONE	299999999.999	.
41	R39	BS	53073000.0000	246926999.999	NONE	299999999.999	.
42	R40	BS	123046276.293	176953723.706	NONE	299999999.999	.
43	R41	UL	.	.	NONE	.	1023.92359-
44	R42	UL	.	.	NONE	.	335.25902-
45	R43	UL	.	.	NONE	.	1017.20359-
46	R44	UL	.	.	NONE	.	569.37096-
47	R45	UL	.	.	NONE	.	1071.27359-
48	R46	UL	.	.	NONE	.	1539.05120-
49	R47	UL	.	.	NONE	.	1440.34610-

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	R48	UL	.	.	NONE	.	1422.46422-
51	R49	UL	.	.	NONE	.	1385.95622-
52	R50	UL	.	.	NONE	.	1641.65771-
53	R51	UL	.	.	NONE	.	1039.86960-
54	R52	UL	.	.	NONE	.	1085.77218-
55	R53	UL	.	.	NONE	.	1039.86720-
56	R54	UL	.	.	NONE	.	436.80000-
57	R55	UL	.	.	NONE	.	110.24000-
58	R56	UL	.	.	NONE	.	571.20000-
59	R57	UL	.	.	NONE	.	403.20000-
60	R58	UL	.	.	NONE	.	67.20000-
61	R59	UL	.	.	NONE	.	100.80000-
62	R60	UL	.	.	NONE	.	84.00000-
63	R61	UL	.	.	NONE	.	168.00000-
64	R62	UL	.	.	NONE	.	168.80000-
65	R63	UL	.	.	NONE	.	117.60000-
66	R64	UL	.	.	NONE	.	180.00000-
67	R65	UL	.	.	NONE	.	168.00000-
68	R66	UL	.	.	NONE	.	180.00000-
69	R67	BS	.	.	NONE	.	.
70	R68	BS	48651.22719	11348.77281	NONE	60000.00000	.
71	R69	BS	10584.03726	9415.96274	NONE	20000.00000	.
72	R70	UL	40000.00000	.	NONE	40000.00000	102.04760-
73	R71	UL	120000.00000	.	NONE	120000.00000	62.26357-
74	R72	BS	15680.75556	9319.24444	NONE	25000.00000	.
75	R73	UL	150000.00000	.	NONE	150000.00000	29.10823-
76	R74	BS	22144.00000	7856.00000	NONE	30000.00000	.
77	R75	BS	132582.35671	37417.64329	NONE	170000.00000	.
78	R76	BS	.	1000.00000	NONE	1000.00000	.

Table C-2. Activities (columns) used in solution one

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
79	P01	UL	75000.00000	41.43000-	.	75000.00000	24.94280
80	P02	LL	.	34.62000-	.	NONE	615.37473-
81	P03	BS	12719.19588	58.30000-	.	NONE	.
82	P04	LL	.	148.30000-	.	NONE	734.08176-
83	P05	UL	10000.00000	137.00000-	.	10000.00000	213.90377
84	P06	UL	11000.00000	126.40000-	.	11000.00000	868.05632
85	P07	BS	8737.47623	95.40000-	.	NONE	.
86	P08	BS	1667.40911	107.50000-	.	NONE	.
87	P09	BS	.	90.80000-	.	NONE	.
88	P10	BS	.	105.35000-	.	NONE	.
89	P11	LL	.	73.80000-	.	NONE	19.69634-
90	P12	BS	10875.91878	72.90000-	.	NONE	.
91	P13	UL	20000.00000	27.50000-	.	20000.00000	30.30686
92	P14	BS	75000.00000	.02000-	.	NONE	.
93	P15	BS	.	.02000-	.	NONE	.
94	P16	BS	12719.19583	.02000-	.	NONE	.
95	P17	BS	.	.02000-	.	NONE	.
96	P18	BS	10000.00000	.02000-	.	NONE	.
97	P19	BS	11000.00000	.02000-	.	NONE	.
98	P20	BS	8737.47623	.02000-	.	NONE	.
99	P21	BS	1667.40911	.02000-	.	NONE	.
100	P22	LL	.	.02000-	.	NONE	52.31532-
101	P23	BS	.	.02000-	.	NONE	.
102	P24	BS	.	.02000-	.	NONE	.
103	P25	BS	10875.91878	.02000-	.	NONE	.
104	P26	BS	20000.00000	.02000-	.	NONE	.
105	P27	BS	75000.00000	19.80000-	.	NONE	.
106	P28	BS	.	22.00000-	.	NONE	.
107	P29	BS	12719.19588	19.80000-	.	NONE	.
108	P30	BS	.	50.40000-	.	NONE	.
109	P31	BS	10000.00000	40.30000-	.	NONE	.
110	P32	BS	11000.00000	50.40000-	.	NONE	.
111	P33	BS	8737.47623	40.30000-	.	NONE	.
112	P34	BS	1667.40911	30.20000-	.	NONE	.
113	P35	BS	.	40.30000-	.	NONE	.
114	P36	LL	.	60.50000-	.	NONE	857.16903-
115	P37	BS	.	19.80000-	.	NONE	.
116	P38	BS	10875.91878	30.20000-	.	NONE	.
117	P39	BS	20000.00000	19.80000-	.	NONE	.
118	P40	BS	187500.00000	436.80000	.	NONE	.
119	P41	BS	.	110.24000	.	NONE	.
120	P42	BS	24166.47218	571.20000	.	NONE	.
121	P43	BS	.	403.20000	.	NONE	.
122	P44	BS	300000.00000	67.20000	.	NONE	.
123	P45	BS	225500.00000	100.80000	.	NONE	.
124	P46	BS	183487.00079	84.00000	.	NONE	.
125	P47	BS	17007.57293	168.00000	.	NONE	.
126	P48	BS	.	168.80000	.	NONE	.
127	P49	BS	.	117.60000	.	NONE	.

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
128	P50	BS	.	180.00000	.	NONE	.
129	P51	BS	100058.45277	168.00000	.	NONE	.
130	P52	BS	120000.00000	180.00000	.	NONE	.
131	P53	BS	64667666.0687	.12000-	.	NONE	.
132	P54	LL	.	358.40000-	.	NONE	358.40000-
133	P55	BS	125648381.027	.03000-	.	NONE	.
134	P56	BS	169856404.182	.03000-	.	NONE	.
135	P57	BS	194007852.831	.03000-	.	NONE	.
136	P58	BS	34548352.6661	.03000-	.	NONE	.
137	P59	BS	53073000.0000	.03000-	.	NONE	.
138	P60	BS	123046276.293	.03000-	.	NONE	.
139	P61	LL	.	630.20000	.	NONE	3302.00954-
140	P62	BS	25962687.1172	.08000-	.	NONE	.
141	P63	BS	48651.22719	6.72000-	.	NONE	.
142	P64	BS	10584.03726	8.40000-	.	NONE	.
143	P65	BS	40000.00000	8.40000-	.	NONE	.
144	P66	BS	120000.00000	8.40000-	.	NONE	.
145	P67	BS	15680.75556	13.44000-	.	NONE	.
146	P68	BS	150000.00000	13.44000-	.	NONE	.
147	P69	BS	22144.00000	10.08000-	.	NONE	.
148	P70	BS	132582.35671	10.08000-	.	NONE	.
149	P71	LL	.	6.72000-	.	NONE	6.72000-
150	P72	BS	77719.19588	13.40000-	.	NONE	.
151	P73	BS	2719.19588	12.30000-	.	NONE	.

Table C-3. Range analysis for solution one (rows at limit level)

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
3	R01	UL	149999.95718	.	NONE	147500.78950	699.34901-		P73	LL
					149999.95718	166769.08011	699.34901		P34	LL
4	R02	UL	19873.99681	.	NONE	8525.22491	6.72000-		R68	UL
					19873.99681	68525.19503	6.72000		P63	LL
5	R03	UL	10646.99190	.	NONE	1231.03328	8.40000-		R69	UL
					10646.99190	21231.02136	8.40000		P64	LL
6	R04	UL	11355.99258	.	NONE	22531.19364-	110.44757-		P33	LL
					11355.99258	17837.49277	110.44757		P34	LL
7	R05	UL	21292.99217	.	NONE	19113.15116-	70.66357-		P34	LL
					21292.99217	38251.95472	70.66357		P73	LL
8	R06	UL	21292.98753	.	NONE	11973.74411	13.44000-		R72	UL
					21292.98753	36973.73446	13.44000		P67	LL
9	R07	UL	65299.98416	.	NONE	54367.90703	42.54822-		P34	LL
					65299.98416	110429.26764	42.54822		P73	LL
10	R08	UL	44005.98609	.	NONE	36149.98760	10.08000-		R74	UL
					44005.98609	66149.96950	10.08000		P69	LL
11	R09	UL	21292.98589	.	NONE	16124.63129-	10.08000-		R75	UL
					21292.98589	153875.22022	10.08000		P70	LL
14	R12	UL	20459994.2382	.	NONE	INFINITY-	.08000-		NONE	
					20459994.2382	46422673.0380	.08000		P62	LL
15	R13	UL	.	.	NONE	174351592.255-	.03000-		R35	UL
					.	125648353.467	.03000		P55	LL
15	R14	UL	.	.	NONE	130143549.977-	.03000-		R36	UL
					.	169856332.059	.03000		P56	LL
17	R15	UL	.	.	NONE	105992054.781-	.03000-		R37	UL
					.	194007688.865	.03000		P57	LL
18	R16	UL	.	.	NONE	265451547.604-	.03000-		R38	UL
					.	34548321.2471	.03000		P58	LL
19	R17	UL	.	.	NONE	246926979.750-	.03000-		R39	UL
					.	53072968.5066	.03000		P59	LL
20	R18	UL	.	.	NONE	176953692.625-	.03000-		P40	UL
					.	123046255.883	.03000		P60	LL

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
21	R19	UL	.	.	NONE .	INFINITY- 64667618.3544	.12000- .12000	NONE	 P53	 LL
22	R20	UL	29999.99462	.	NONE 29999.99462	INFINITY- 107719.16880	13.40000- 13.40000	NONE	 P72	 LL
23	R21	UL	104999.98504	.	NONE 104999.98504	INFINITY- 107719.17991	12.30000- 12.30000	NONE	 P73	 LL
24	R22	UL	.	.	NONE .	30885.69996- 16769.11525	842.39412- 842.39412		P73 P34	LL LL
25	R23	UL	.	.	NONE .	. 12160.62629	219.86033- 219.86033		P28 P34	LL LL
26	R24	UL	.	.	NONE .	11689.98854- 16769.11525	835.67413- 835.67413		P16 P34	LL LL
27	R25	UL	.	.	NONE .	. 1349.81015	333.97225- 333.97225		P43 P34	LL LL
28	R26	UL	.	.	NONE .	5539.18635- 1529.95199	1413.15696- 1413.15696		P73 P34	LL LL
29	R27	UL	.	.	NONE .	10999.98927- 5270.08643	1802.12884- 1802.12884		P19 R75	LL LL
30	R28	UL	.	.	NONE .	5794.51104- 1678.07803	1257.94925- 1257.94925		P73 P34	LL LL
31	R29	UL	.	.	NONE .	6314.19237- 1792.44651	1167.27154- 1167.27154		P73 P08	LL LL
32	R30	UL	.	.	NONE .	4760.30729- .	1177.11649- 1177.11649		P73 P09	LL LL
33	R31	UL	.	.	NONE .	2678.99487- .	911.32441- 911.32441		P73 P10	LL LL
34	R32	UL	.	.	NONE .	. 11018.21844	868.38732- 868.38732		P50 R68	LL UL
35	R33	UL	.	.	NONE .	2643.66871- 8800.23898	888.76266- 888.76266		P73 P34	LL LL
36	R34	UL	.	.	NONE .	19999.98794- 11019.21844	868.38494- 868.38494		P39 R68	LL LL
43	R41	UL	.	.	NONE .	57856.08329- 14015.48035	1023.92364- 1023.92364		P73 P34	LL LL

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
44	R42	UL	.	.	NONE	.	385.25907-		P29	LL
					.	13665.08967	385.25907		P34	LL
45	R43	UL	.	.	NONE	12148.25134-	1017.20356-		P42	LL
					.	14015.48025	1017.20356		P34	LL
46	R44	UL	.	.	NONE	.	569.37101-		P43	LL
					.	1366.50963	569.37101		P34	LL
47	R45	UL	.	.	NONE	6447.04361-	1671.27359-		P73	LL
					.	1561.72546	1671.27359		P34	LL
48	R46	UL	.	.	NONE	10999.98927-	1938.05060-		P45	LL
					.	5345.37235	1938.05060		R75	UL
49	R47	UL	.	.	NONE	6942.96923-	1440.34630-		P73	LL
					.	1681.85805	1440.34630		P34	LL
50	R48	UL	.	.	NONE	7521.55059-	1422.46428-		P73	LL
					.	1822.01291	1422.46428		P08	LL
51	R49	UL	.	.	NONE	.	1385.95626-		P48	LL
					.	1822.01267	1385.95626		P34	LL
52	R50	UL	.	.	NONE	3051.40980-	1641.85794-		P34	LL
					.	.	1641.85794		P10	LL
53	R51	UL	.	.	NONE	.	1039.86977-		P50	LL
					.	14549.69685	1039.86977		R68	UL
54	R52	UL	.	.	NONE	2826.49480-	1085.77217-		P73	LL
					.	6734.35624	1085.77217		P34	LL
55	R53	UL	.	.	NONE	19999.98794-	1039.86739-		P52	LL
					.	14549.69685	1039.86739		R68	UL
56	R54	UL	.	.	NONE	187499.85265-	436.80025-		P40	LL
					.	INFINITY	436.80025		NONE	
57	R55	UL	.	.	NONE	.	110.24002-		P41	LL
					.	INFINITY	110.24002		NONE	
58	R56	UL	.	.	NONE	24166.46711-	571.19996-		P42	LL
					.	INFINITY	571.19996		NONE	
59	R57	UL	.	.	NONE	.	403.19988-		P43	LL
					.	INFINITY	403.19988		NONE	
60	R58	UL	.	.	NONE	299999.83511-	67.19998-		P44	LL
					.	INFINITY	67.19998		NONE	

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
61	R59	UL	.	.	NONE .	225499.86442- INFINITY	100.80001- 100.80001		P45 NONE	LL
62	R60	UL	.	.	NONE .	183486.89381- INFINITY	83.99998- 83.99998		P46 NONE	LL
63	R61	UL	.	.	NONE .	17007.56337- INFINITY	167.99997- 167.99997		P47 NONE	LL
64	R62	UL	.	.	NONE .	. INFINITY	168.79999- 168.79999		P48 NONE	LL
65	R63	UL	.	.	NONE .	. INFINITY	117.60000- 117.60000		P49 NONE	LL
66	R64	UL	.	.	NONE .	. INFINITY	179.99995- 179.99995		P50 NONE	LL
67	R65	UL	.	.	NONE .	100058.42723- INFINITY	167.99998- 167.99998		P51 NONE	LL
68	R66	UL	.	.	NONE .	119999.92740- INFINITY	179.99998- 179.99998		P52 NONE	LL
72	R70	UL	39999.96608	.	NONE 39999.96608	6112.77629 46481.46553	102.04759- 102.04759		P46 P34	LL LL
73	R71	UL	119999.97007	.	NONE 119999.97007	79593.84989 136958.93939	62.26356- 62.26356		P34 P73	LL LL
75	R73	UL	149999.98652	.	NONE 149999.98652	139067.90895 195129.26822	29.10822- 29.10822		P34 P73	LL LL

Table C-4. Range analysis for solution one (columns at limit level)

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT. / ..UPPER LIMIT.	LOWER ACTIVITY / UPPER ACTIVITY	...UNIT COST.. / ...UNIT COST..	..UPPER COST.. / ..LOWER COST..	LIMITING PROCESS.	AT / AT
79	P01	UL	74999.97152	41.43000-	.	.	24.94280-	66.37280-	P27	LL
					74999.99326	87719.15921	24.94280	INFINITY	P16	LL
80	P02	LL	.	34.61999-	.	.	615.37469	INFINITY-	P28	LL
					NONE	3081.15817	615.37469-	590.75471	P73	LL
82	P04	LL	.	148.30000-	.	.	734.08169	INFINITY-	P43	LL
					NONE	1368.53433	734.08169-	585.78170	P34	LL
83	P05	UL	9999.99843	137.00001-	.	.	213.90379-	350.90380-	P44	LL
					9999.99915	11446.74274	213.90379	INFINITY	P34	LL
84	P06	UL	10999.99866	126.40000-	.	5532.24603	868.05615-	994.45616-	P69	LL
					10999.99892	12539.75147	868.05615	INFINITY	R74	UL
89	P11	LL	.	73.79999-	.	.	19.69634	INFINITY-	P50	LL
					NONE	7274.07232	19.69634-	54.10365-	R74	UL
91	P13	UL	19999.99734	27.50000-	.	.	30.30685-	57.80685-	P52	LL
					19999.99820	27274.06565	30.30685	INFINITY	R74	UL
100	P22	LL	.	.02000-	.	.	52.31532	INFINITY-	P48	LL
					NONE	10429.85727	52.31532-	52.29532	P46	LL
114	P36	LL	.	60.50000-	.	.	857.16890	INFINITY-	P49	LL
					NONE	2627.53876	857.16890-	796.66890	P34	LL
132	P54	LL	.	358.40004-	.	.	358.40004	INFINITY-	P67	UL
					NONE	INFINITY	358.40004-	.	NONE	
139	P61	LL	.	630.20010	.	832.83628-	3302.00977	INFINITY-	P73	LL
					NONE	.	3302.00977-	3932.20986	P67	UL
149	P71	LL	.	6.72000-	.	6531.07547-	6.72000	INFINITY-	R10	UL
					NONE	999.99989	6.72000-	.	R76	UL

Table C-5. Range analysis for solution one (rows at intermediate level)

NUMBER	...ROW...	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
12	R10	BS	15471.91593	6531.07591	NONE	14471.91679	6.72000-		P71	LL
					22002.99184	16789.71701	108.72096-		P11	LL
13	R11	BS	.	999.99984	NONE	.	INFINITY-		NONE	
					999.99984	.	3302.00977-		P61	LL
37	R35	BS	125648223.072	174351601.572	NONE	101615861.141	.02522-		P13	UL
					299999824.644	134398884.586	.01639-		P11	LL
38	R36	BS	169856239.047	130143585.597	NONE	159396899.145	.01370-		P11	LL
					299999824.644	196614093.428	.02108-		P13	UL
39	R37	BS	194007685.937	105992138.706	NONE	183247659.219	.01332-		P11	LL
					299999824.644	223592274.527	.02049-		P13	UL
40	R38	BS	34548207.6735	265451616.970	NONE	29920561.9674	.06876-		R73	UL
					299999824.644	INFINITY	.03000-		R16	UL
41	R39	BS	53072871.3067	246926953.337	NONE	28852895.1074	.02503-		P13	UL
					299999824.644	61881770.6392	.01626-		P11	LL
42	R40	BS	123046122.031	176953702.613	NONE	110696573.516	.04908-		P13	UL
					299999824.644	INFINITY	.03000-		R18	UL
69	R67	BS	.	.	NONE	INFINITY-	358.40004-		P54	LL
					.	.	2001.82692-		P61	LL
70	R68	BS	48651.22542	11348.77117	NONE	36344.95801	49.25430-		P13	UL
					59999.99660	INFINITY	6.72000-		R02	UL
71	R69	BS	10584.03779	9415.96096	NONE	9375.39184	501.50062-		P13	UL
					19999.99875	INFINITY	8.40000-		R03	UL
74	R72	BS	15680.75299	9319.24374	NONE	14454.45077	259.49014-		R73	UL
					24999.99672	INFINITY	13.44000-		R06	UL
76	R74	BS	22143.99686	7855.99940	NONE	544.02557	28.06191-		P13	UL
					29999.99627	INFINITY	10.08000-		R08	UL
77	R75	BS	132582.34438	37417.63170	NONE	128867.57750	38.56838-		P11	LL
					169999.97608	INFINITY	10.08000-		R09	UL
78	R76	BS	1670.97	999.99989	NONE	.	INFINITY-		NONE	
					999.99989	INFINITY	6.72000-		P71	LL

Table C-6. Range analysis for solution one (column at intermediate level)

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT. / ..UPPER LIMIT.	LOWER ACTIVITY / UPPER ACTIVITY	...UNIT COST.. / ...UNIT COST..	..UPPER COST.. / ..LOWER COST..	LIMITING PROCESS.	AT / AT
81	P03	BS	12719.19353	58.29999-	.	5529.80984	19.92835-	78.22835-	P11	LL
					NONE	87719.16505	24.94280-	33.35719-	P01	UL
85	P07	BS	8737.47459	95.40000-	.	.01203	62.44870-	157.84870-	P22	LL
					NONE	8737.47459	2304.20610-	2208.80610	R25	UL
86	P08	BS	1667.40885	107.49999-	.	.00190	190.84320-	298.34320-	R73	UL
					NONE	13192.63991	185.59595-	78.09596	P05	UL
87	P09	BS	.	90.79999-	.	.	INFINITY-	INFINITY-	NONE	
					NONE	10429.89407	52.31533-	38.48466-	P22	LL
88	P10	BS	.	108.34999-	.	.	INFINITY-	INFINITY-	NONE	
					NONE	2627.53784	857.16865-	748.81865	P36	LL
90	P12	BS	10875.91576	72.90000-	.	10237.71629	224.49505-	297.39506-	P11	LL
					NONE	12049.99100	271.03318-	198.13319	R73	LL
92	P14	BS	74999.99395	.02000-	.	.	24.94280-	24.96280-	P01	UL
					NONE	74999.99395	INFINITY-	INFINITY	NONE	
93	P15	BS	.	.02000-	.	.	219.86033-	219.88033-	R23	UL
					NONE	3081.15698	615.37485-	615.35485	P02	LL
94	P16	BS	12719.18820	.02000-	.	5529.80462	19.92836-	19.94836-	P11	LL
					NONE	87719.15467	24.94280-	24.92280	P01	UL
95	P17	BS	.	.02000-	.	.	333.97225-	333.99225-	R25	UL
					NONE	1363.53376	734.08191-	734.06191	P04	LL
96	P18	BS	9999.99750	.02000-	.	.	213.90372-	213.92372-	P05	UL
					NONE	9999.99750	INFINITY-	INFINITY	NONE	
97	P19	BS	10999.98927	.02000-	.	5532.33986	968.05656-	968.07656-	P06	UL
					NONE	10999.98927	INFINITY-	INFINITY	NONE	
98	P20	BS	8737.47451	.02000-	.	.	62.44870-	62.46870-	P22	LL
					NONE	8737.47451	2304.20647-	2304.18647	R25	UL
99	P21	BS	1667.40888	.02000-	.	.	190.84308-	190.86308-	R73	UL
					NONE	13192.63822	185.59585-	185.57585	P05	UL
101	P23	BS	.	.02000-	.	.	INFINITY-	INFINITY-	NONE	
					NONE	2627.53822	857.16900-	857.14900	P36	LL
102	P24	BS	.	.02000-	.	.	868.38732-	868.40732-	R32	UL
					NONE	7274.07120	19.69634-	19.67634	P11	LL

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
103	P25	BS	10875.91667	.02000-	.	10237.71716	224.49486-	224.51486-	P11	LL
					NONE	12049.99215	271.03309-	271.01309	R73	UL
104	P26	BS	19999.99560	.02000-	.	.	30.30685-	30.32685-	P13	UL
					NONE	19999.99560	INFINITY-	INFINITY	NONE	
105	P27	BS	74999.98463	19.80000-	.	.	24.94281-	44.74281-	P01	UL
					NONE	74999.98463	INFINITY-	INFINITY	NONE	
106	P28	BS	.	22.00000-	.	.	219.86029-	241.86029-	R23	UL
					NONE	3081.15586	615.37447-	593.37447	P02	LL
107	P29	BS	12719.19417	19.80000-	.	5529.81644	19.92837-	39.72837-	P11	LL
					NONE	87719.11724	24.94281-	5.14281	P01	UL
108	P30	BS	.	50.40001-	.	.	333.97223-	384.37224-	R25	UL
					NONE	1368.53322	734.08188-	683.68187	P04	LL
109	P31	BS	9999.99866	40.30000-	.	.	213.90386-	254.20386-	P05	UL
					NONE	9999.99866	INFINITY-	INFINITY	NONE	
110	P32	BS	10999.99798	50.40001-	.	5532.34651	868.05627-	918.45628-	P06	UL
					NONE	10999.99798	INFINITY-	INFINITY	NONE	
111	P33	BS	8737.47533	40.30000-	.	.00887	62.44869-	102.74869-	P22	LL
					NONE	8737.47533	2304.20656-	2263.90656	R25	UL
112	P34	BS	1667.40816	30.20000-	.	.	190.84314-	221.04314-	R73	UL
					NONE	13192.64356	185.59588-	155.39588	P05	UL
113	P35	BS	.	40.30000-	.	.	1385.95625-	1426.25625-	R49	LL
					NONE	10429.89703	52.31532-	12.01532	P22	LL
115	P37	BS	.	19.80000-	.	.	868.38736-	888.18736-	R32	UL
					NONE	7274.06865	19.69635-	.10365-	P11	LL
116	P38	BS	10875.91737	30.20000-	.	10237.71753	224.49489-	254.69489-	P11	LL
					NONE	12049.99291	271.03308-	240.83308	R73	LL
117	P39	BS	19999.99609	19.80000-	.	.02115	30.30687-	50.10687-	P13	UL
					NONE	19999.99609	INFINITY-	INFINITY	NONE	
118	P40	BS	187499.97574	436.80005	.	.	9.97712-	426.82293	P01	UL
					NONE	187499.97574	INFINITY-	INFINITY	NONE	
119	P41	BS	.	110.24002	.	.	54.69162-	55.54840	R23	UL
					NONE	12386.24508	153.07825-	263.31826	P02	LL
120	P42	BS	24166.46736	571.20008	.	10506.63926	10.48861-	560.71147	P11	LL
					NONE	166666.35870	13.12779-	584.32787	P01	UL

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
121	P43	BS	.	403.20001	.	.	139.15509-	264.04492	R25	UL
					NONE	3284.49138	305.86745-	709.06746	P04	LL
122	P44	BS	299999.77595	67.20001	.	.	7.13013-	60.06989	P05	UL
					NONE	299999.77595	INFINITY-	INFINITY	NONE	
123	P45	BS	225499.80739	100.80004	.	113412.97442	42.34421-	58.45582	P06	UL
					NONE	225499.80739	INFINITY-	INFINITY	NONE	
124	P46	BS	183486.91205	84.00000	.	.	2.97375-	81.02625	P22	LL
					NONE	183486.91205	109.72409-	193.72409	R25	UL
125	P47	BS	17007.56118	168.00006	.	.	18.71011-	149.28995	R73	UL
					NONE	134584.87809	18.19567-	186.19573	P05	UL
126	P48	BS	.	168.80000	.	.	138.59563-	30.20437	R49	UL
					NONE	104298.94687	5.23153-	174.03153	P22	LL
127	P49	BS	.	117.60000	.	INFINITY-	117.60001-	.	R63	UL
					NONE	21545.81317	104.53280-	222.13280	P36	LL
128	P50	BS	.	180.00001	.	.	144.73121-	35.26880	R32	UL
					NONE	43644.41767	3.28273-	183.28273	P11	LL
129	P51	BS	100058.39459	168.00006	.	94186.96126	24.40163-	143.59843	P11	LL
					NONE	110859.88271	29.46013-	197.46018	R73	UL
130	P52	BS	119999.95221	180.00001	.	.	5.05114-	174.94886	P13	UL
					NONE	119999.95221	INFINITY-	INFINITY	NONE	
131	P53	BS	64667618.3944	.12000-	.	63190688.5726	.09701-	.21701-	P11	LL
					NONE	INFINITY	.12000-	.	R19	UL
133	P55	BS	125648363.745	.03000-	.	101616001.814	.02522-	.05522-	P13	UL
					NONE	134389025.259	.01639-	.01361-	P11	LL
134	P56	BS	169856290.541	.03000-	.	159397050.639	.01370-	.04370-	P11	LL
					NONE	198614244.922	.02108-	.00892-	P13	UL
135	P57	BS	194007826.610	.03000-	.	183247799.891	.01332-	.04332-	P11	LL
					NONE	223592415.200	.02049-	.00951-	P13	UL
136	P58	BS	34548248.3463	.03000-	.	29920702.6402	.06876-	.09876-	R73	UL
					NONE	299999792.181	.03000-	.	R16	UL
137	P59	BS	53072990.3375	.03000-	.	28853014.1382	.02502-	.05502-	P13	UL
					NONE	61881889.6701	.01626-	.01374-	P11	LL
138	P60	BS	123046262.704	.03000-	.	110698714.169	.04908-	.07908-	P13	LL
					NONE	299999813.823	.03000-	.	R18	UL

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..UPPER COST.. ..LOWER COST..	LIMITING PROCESS.	AT AT
140	P62	BS	25962678.7998	.08000-	.	25253133.7612	.85426-	.93426-	P13	UL
					NONE	INFINITY	.08000-	.	R12	UL
141	P63	BS	48651.20821	6.72000-	.	36344.94080	49.25430-	55.97429-	P13	UL
					NONE	59999.97939	6.72000-	.	R02	UL
142	P64	BS	10584.03555	8.40000-	.	9375.38960	501.50062-	509.90062-	P13	UL
					NONE	19999.99426	8.40000-	.	R03	UL
143	P65	BS	39999.96608	8.40000-	.	6112.77854	102.04759-	110.44759-	R70	UL
					NONE	39999.96608	INFINITY-	INFINITY	NONE	
144	P66	BS	119999.97007	8.40000-	.	79593.88580	62.26356-	70.66356-	R71	UL
					NONE	119999.97007	INFINITY-	INFINITY	NONE	
145	P67	BS	15680.75293	13.44000-	.	14454.45077	259.49014-	272.93014-	R73	UL
					NONE	24999.99478	13.44000-	.	R06	UL
146	P68	BS	149999.98652	13.44000-	.	139067.71090	29.10822-	42.54822-	R73	UL
					NONE	149999.98652	INFINITY-	INFINITY	NONE	
147	P69	BS	22143.99686	10.08000-	.	544.02557	28.06191-	38.14191-	P13	UL
					NONE	29999.99627	10.08000-	.	P08	UL
148	P70	BS	132582.34438	10.08000-	.	128867.57750	38.56838-	48.64838-	P11	LL
					NONE	169999.94253	10.08000-	.	R09	LL
150	P72	BS	77719.17418	13.40000-	.	76341.60903	396.09264-	409.49264-	P22	LL
					NONE	INFINITY	13.40000-	.	R20	UL
151	P73	BS	2719.13487	12.30000-	.	1341.62969	396.09261-	408.39261-	P22	LL
					NONE	INFINITY	12.30000-	.	R21	UL

Table C-7. Resources (rows) used in solution two

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	C1	BS	123847395.266	123847395.266-	NONE	NONE	1.00000
2	C2	BS	77349477.3441	77349477.3441-	NONE	NONE	.
3	R01	UL	120000.00000	.	NONE	120000.00000	739.87096-
4	R02	UL	19374.00000	.	NONE	19874.00000	6.72000-
5	R03	UL	10647.00000	.	NONE	10647.00000	8.40000-
6	R04	UL	11356.00000	.	NONE	11356.00000	104.11932-
7	R05	UL	21293.00000	.	NONE	21293.00000	64.69207-
8	R06	UL	21293.00000	.	NONE	21293.00000	13.44000-
9	R07	UL	65300.00000	.	NONE	65300.00000	40.30422-
10	R08	UL	44006.00000	.	NONE	44006.00000	10.08000-
11	R09	UL	21293.00000	.	NONE	21293.00000	10.08000-
12	R10	BS	12207.79785	9795.20215	NONE	22003.00000	.
13	R11	BS	.	1000.00000	NONE	1000.00000	.
14	R12	UL	25500000.0000	.	NONE	25500000.0000	.08000-
15	R13	UL	.	.	NONE	.	.03000-
16	R14	UL	.	.	NONE	.	.03000-
17	R15	UL	.	.	NONE	.	.03000-
18	R16	UL	.	.	NONE	.	.03000-
19	R17	UL	.	.	NONE	.	.03000-
20	R18	UL	.	.	NONE	.	.03000-
21	R19	UL	.	.	NONE	.	.12000-
22	R20	UL	50000.00000	.	NONE	50000.00000	13.40000-
23	R21	BS	75077.97851	39922.02149	NONE	115000.00000	.
24	R22	UL	.	.	NONE	.	845.67296-
25	R23	UL	.	.	NONE	.	872.47240-
26	R24	UL	.	.	NONE	.	838.95296-
27	R25	UL	.	.	NONE	.	354.49881-
28	R26	UL	.	.	NONE	.	1431.43944-
29	R27	UL	.	.	NONE	.	1802.12800-
30	R28	UL	.	.	NONE	.	1275.42598-
31	R29	UL	.	.	NONE	.	1183.31006-
32	R30	UL	.	.	NONE	.	1141.15609-
33	R31	UL	.	.	NONE	.	949.12599-
34	R32	UL	.	.	NONE	.	912.59275-
35	R33	UL	.	.	NONE	.	927.06952-
36	R34	UL	.	.	NONE	.	868.38480-
37	R35	BS	99455348.8682	200544651.131	NONE	299999999.999	.
38	R36	BS	128330348.109	171669651.891	NONE	299999999.999	.
39	R37	BS	147885375.684	152114624.315	NONE	299999999.999	.
40	R38	BS	43587397.3342	256412602.665	NONE	299999999.999	.
41	R39	BS	53073000.0000	246926999.999	NONE	299999999.999	.
42	R40	BS	93669180.6592	206330819.340	NONE	299999999.999	.
43	R41	UL	.	.	NONE	.	1025.67391-
44	R42	UL	.	.	NONE	.	387.05422-
45	R43	UL	.	.	NONE	.	1013.95391-
46	R44	UL	.	.	NONE	.	587.32301-
47	R45	UL	.	.	NONE	.	1686.98163-
48	R46	UL	.	.	NONE	.	1938.05120-
49	R47	UL	.	.	NONE	.	1454.93214-

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	R48	UL	.	.	NONE	.	1435.92826-
51	R49	UL	.	.	NONE	.	1399.42026-
52	R50	UL	.	.	NONE	.	1664.97294-
53	R51	UL	.	.	NONE	.	1039.86960-
54	R52	UL	.	.	NONE	.	1121.60116-
55	R53	UL	.	.	NONE	.	1039.86720-
56	R54	UL	.	.	NONE	.	436.80000-
57	R55	UL	.	.	NONE	.	110.24000-
58	R56	UL	.	.	NONE	.	571.20000-
59	R57	UL	.	.	NONE	.	403.20000-
60	R58	UL	.	.	NONE	.	67.20000-
61	R59	UL	.	.	NONE	.	100.80000-
62	R60	UL	.	.	NONE	.	84.00000-
63	R61	UL	.	.	NONE	.	165.00000-
64	R62	UL	.	.	NONE	.	168.80000-
65	R63	UL	.	.	NONE	.	224.21982-
66	R64	UL	.	.	NONE	.	180.00000-
67	R65	UL	.	.	NONE	.	168.00000-
68	R66	UL	.	.	NONE	.	180.00000-
69	R67	BS	.	.	NONE	.	.
70	R68	BS	40414.00521	19585.99479	NONE	60000.00000	.
71	R69	BS	7014.38154	2985.61846	NONE	10000.00000	.
72	R70	UL	40000.00000	.	NONE	40000.00000	95.71932-
73	R71	UL	120000.00000	.	NONE	120000.00000	56.29207-
74	R72	BS	12065.52405	12934.47595	NONE	25000.00000	.
75	R73	UL	150000.00000	.	NONE	150000.00000	26.86422-
76	R74	BS	22144.00000	7856.00000	NONE	30000.00000	.
77	R75	BS	106469.38281	63530.61719	NONE	170000.00000	.
78	R76	BS	.	1000.00000	NONE	1000.00000	.

Table C-8. Activities (columns) used in solution two

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
79	P01	BS	55077.97651	41.43000-	.	75000.00000	.
80	P02	BS	.	34.62000-	.	NONE	.
81	P03	LL	.	58.30000-	.	NONE	24.94280-
82	P04	LL	.	148.30000-	.	NONE	742.13390-
83	P05	UL	10000.00000	137.00000-	.	10000.00000	216.14778
84	P06	UL	11000.00000	126.40000-	.	11000.00000	827.53464
85	P07	BS	9777.11239	95.40000-	.	NONE	.
86	P08	BS	4650.40706	107.50000-	.	NONE	.
87	P09	LL	.	90.80000-	.	NONE	57.23430-
88	P10	BS	.	108.35000-	.	NONE	.
89	P11	BS	.	73.80000-	.	NONE	.
90	P12	BS	9494.50204	72.90000-	.	NONE	.
91	P13	UL	20000.00000	27.50000-	.	20000.00000	5.79765
92	P14	BS	55077.97851	.02000-	.	NONE	.
93	P15	LL	.	.02000-	.	NONE	643.24238-
94	P16	BS	.	.02000-	.	NONE	.
95	P17	BS	.	.02000-	.	NONE	.
96	P18	BS	10000.00000	.02000-	.	NONE	.
97	P19	BS	11000.00000	.02000-	.	NONE	.
98	P20	BS	9777.11239	.02000-	.	NONE	.
99	P21	BS	4650.40706	.02000-	.	NONE	.
100	P22	BS	.	.02000-	.	NONE	.
101	P23	BS	.	.02000-	.	NONE	.
102	P24	LL	.	.02000-	.	NONE	44.20555-
103	P25	BS	9494.50204	.02000-	.	NONE	.
104	P26	BS	20000.00000	.02000-	.	NONE	.
105	P27	BS	55077.97851	19.80000-	.	NONE	.
106	P28	BS	.	22.00000-	.	NONE	.
107	P29	BS	.	19.80000-	.	NONE	.
108	P30	BS	.	50.40000-	.	NONE	.
109	P31	BS	10000.00000	40.30000-	.	NONE	.
110	P32	BS	11000.00000	50.40000-	.	NONE	.
111	P33	BS	9777.11239	40.30000-	.	NONE	.
112	P34	BS	4650.40706	30.20000-	.	NONE	.
113	P35	BS	.	40.30000-	.	NONE	.
114	P36	BS	.	60.50000-	.	NONE	.
115	P37	BS	.	19.80000-	.	NONE	.
116	P38	BS	9494.50204	30.20000-	.	NONE	.
117	P39	BS	20000.00000	19.80000-	.	NONE	.
118	P40	BS	137694.94628	436.80000	.	NONE	.
119	P41	BS	.	110.24000	.	NONE	.
120	P42	BS	.	571.20000	.	NONE	.
121	P43	BS	.	403.20000	.	NONE	.
122	P44	BS	300000.00000	67.20000	.	NONE	.
123	P45	BS	225500.00000	100.80000	.	NONE	.
124	P46	BS	205319.36015	84.00000	.	NONE	.
125	P47	BS	47434.15199	168.00000	.	NONE	.
126	P48	BS	.	168.80000	.	NONE	.
127	P49	LL	.	117.60000	.	NONE	106.61982-

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
128	P50	BS	.	180.00000	.	NONE	.
129	P51	BS	87349.41879	168.00000	.	NONE	.
130	P52	BS	120000.00000	180.00000	.	NONE	.
131	P53	BS	50976481.0176	.12000-	.	NONE	.
132	P54	LL	.	358.40000-	.	NONE	358.40000-
133	P55	BS	95455348.8683	.03000-	.	NONE	.
134	P56	BS	128330348.109	.03000-	.	NONE	.
135	P57	BS	147885375.684	.03000-	.	NONE	.
136	P58	BS	43587397.3342	.03000-	.	NONE	.
137	P59	BS	53073000.0000	.03000-	.	NONE	.
138	P60	BS	93669180.6592	.03000-	.	NONE	.
139	P61	LL	.	630.20000	.	NONE	3686.85665-
140	P62	BS	13895897.6223	.08000-	.	NONE	.
141	P63	BS	40414.00521	6.72000-	.	NONE	.
142	P64	BS	7014.38154	8.40000-	.	NONE	.
143	P65	BS	40000.00000	8.40000-	.	NONE	.
144	P66	BS	120000.00000	8.40000-	.	NONE	.
145	P67	BS	12065.52405	13.44000-	.	NONE	.
146	P68	BS	150000.00000	13.44000-	.	NONE	.
147	P69	BS	22144.00000	10.08000-	.	NONE	.
148	P70	BS	106469.38281	10.08000-	.	NONE	.
149	P71	LL	.	6.72000-	.	NONE	6.72000-
150	P72	BS	25077.97851	13.40000-	.	NONE	.
151	P73	LL	.	12.30000-	.	NONE	12.30000-

Table C-9. Resources (rows) used in solution three

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	C1	BS	164175053.834	164175053.834-	NONE	NONE	1.00000
2	C2	BS	116331228.592	116331228.592-	NONE	NONE	.
3	R01	UL	180000.00000	.	NONE	180000.00000	509.76937-
4	R02	UL	19874.00000	.	NONE	19874.00000	6.72000-
5	R03	UL	10647.00000	.	NONE	10647.00000	1160.63532-
6	R04	UL	11356.00000	.	NONE	11356.00000	8.40000-
7	R05	UL	21293.00000	.	NONE	21293.00000	5.40000-
8	R06	UL	21293.00000	.	NONE	21293.00000	13.44000-
9	R07	UL	65300.00000	.	NONE	65300.00000	104.35775-
10	R08	UL	44006.00000	.	NONE	44006.00000	10.08000-
11	R09	UL	21293.00000	.	NONE	21293.00000	82.56656-
12	R10	BS	18028.56638	3974.43362	NONE	22003.00000	.
13	R11	BS	.	1000.00000	NONE	1000.00000	.
14	R12	UL	30500000.0000	.	NONE	30500000.0000	.08000-
15	R13	UL	.	.	NONE	.	.03000-
16	R14	UL	.	.	NONE	.	.03000-
17	R15	UL	.	.	NONE	.	.03000-
18	R16	UL	.	.	NONE	.	.03000-
19	R17	UL	.	.	NONE	.	.03000-
20	R18	UL	.	.	NONE	.	.03000-
21	R19	UL	.	.	NONE	.	.12000-
22	R20	UL	100000.00000	.	NONE	100000.00000	13.40000-
23	R21	BS	148865.27816	1134.72184	NONE	150000.00000	.
24	R22	UL	.	.	NONE	.	680.38178-
25	R23	UL	.	.	NONE	.	68.59792-
26	R24	UL	.	.	NONE	.	673.66178-
27	R25	BS	.	.	NONE	.	.
28	R26	UL	.	.	NONE	.	878.67546-
29	R27	UL	.	.	NONE	.	1287.47341-
30	R28	UL	.	.	NONE	.	701.86297-
31	R29	UL	.	.	NONE	.	722.41097-
32	R30	UL	.	.	NONE	.	682.25897-
33	R31	UL	.	.	NONE	.	871.16870-
34	R32	UL	.	.	NONE	.	843.09096-
35	R33	UL	.	.	NONE	.	1066.74854-
36	R34	UL	.	.	NONE	.	846.08856-
37	R35	BS	132917271.844	167082728.156	NONE	299999999.999	.
38	R36	BS	212392287.899	87607712.1006	NONE	299999999.999	.
39	R37	BS	268018438.785	31981561.2139	NONE	299999999.999	.
40	R38	BS	26137371.7371	273862628.262	NONE	299999999.999	.
41	R39	BS	42591381.6939	257408618.305	NONE	299999999.999	.
42	R40	BS	154823958.176	145176041.823	NONE	299999999.999	.
43	R41	UL	.	.	NONE	.	975.71215-
44	R42	UL	.	.	NONE	.	335.81140-
45	R43	UL	.	.	NONE	.	968.99215-
46	R44	UL	.	.	NONE	.	74.89480-
47	R45	UL	.	.	NONE	.	1238.60695-
48	R46	UL	.	.	NONE	.	1430.64527-
49	R47	UL	.	.	NONE	.	1038.58422-

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	R48	UL	.	.	NONE	.	1079.41846-
51	R49	UL	.	.	NONE	.	1097.73822-
52	R50	UL	.	.	NONE	.	420.60199-
53	R51	UL	.	.	NONE	.	1039.86960-
54	R52	UL	.	.	NONE	.	1459.35360-
55	R53	UL	.	.	NONE	.	1039.86720-
56	R54	UL	.	.	NONE	.	436.80000-
57	R55	UL	.	.	NONE	.	110.24000-
58	R56	UL	.	.	NONE	.	571.20000-
59	R57	UL	.	.	NONE	.	403.20000-
60	R58	UL	.	.	NONE	.	67.20000-
61	R59	UL	.	.	NONE	.	100.80000-
62	R60	UL	.	.	NONE	.	84.00000-
63	R61	UL	.	.	NONE	.	168.00000-
64	R62	UL	.	.	NONE	.	177.06391-
65	R63	UL	.	.	NONE	.	117.60000-
66	R64	UL	.	.	NONE	.	180.00000-
67	R65	UL	.	.	NONE	.	168.00000-
68	R66	UL	.	.	NONE	.	180.00000-
69	R67	BS	.	.	NONE	.	.
70	R68	BS	24515.24275	35484.75725	NONE	60000.00000	.
71	R69	UL	10000.00000	.	NONE	10000.00000	1152.23532-
72	R70	BS	26032.78544	13967.21456	NONE	40000.00000	.
73	R71	BS	81130.45899	38869.54101	NONE	120000.00000	.
74	R72	BS	19712.93595	5287.06405	NONE	25000.00000	.
75	R73	UL	150000.00000	.	NONE	150000.00000	90.91775-
76	R74	BS	12796.23140	17203.76860	NONE	30000.00000	.
77	R75	UL	170000.00000	.	NONE	170000.00000	72.48656-
78	R76	BS	.	1000.00000	NONE	1000.00000	.

Table C-10. Activities (columns) used in solution three

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
79	P01	UL	75000.00000	41.43000-	.	75000.00000	24.94280
80	P02	LL	.	34.62000-	.	NONE	542.81226-
81	P03	BS	62520.61945	58.30000-	.	NONE	.
82	P04	LL	.	148.30000-	.	NONE	753.94697-
83	P05	UL	10000.00000	137.00000-	.	10000.00000	124.26289
84	P06	UL	11000.00000	126.40000-	.	11000.00000	542.98164
85	P07	BS	4870.22675	95.40000-	.	NONE	.
86	P08	BS	.	107.50000-	.	NONE	.
87	P09	BS	.	90.80000-	.	NONE	.
88	P10	BS	.	108.35000-	.	NONE	.
89	P11	LL	.	73.80000-	.	NONE	50.00320-
90	P12	BS	5264.49509	72.90000-	.	NONE	.
91	P13	BS	11344.65871	27.50000-	.	20000.00000	.
92	P14	BS	75000.00000	.02000-	.	NONE	.
93	P15	BS	.	.02000-	.	NONE	.
94	P16	BS	62520.61945	.02000-	.	NONE	.
95	P17	LL	.	.02000-	.	NONE	262.31869-
96	P18	BS	10000.00000	.02000-	.	NONE	.
97	P19	BS	11000.00000	.02000-	.	NONE	.
98	P20	BS	4870.22675	.02000-	.	NONE	.
99	P21	BS	.	.02000-	.	NONE	.
100	P22	BS	.	.02000-	.	NONE	.
101	P23	LL	.	.02000-	.	NONE	1787.68077-
102	P24	BS	.	.02000-	.	NONE	.
103	P25	BS	5264.49509	.02000-	.	NONE	.
104	P26	BS	11344.65871	.02000-	.	NONE	.
105	P27	BS	75000.00000	19.80000-	.	NONE	.
106	P28	BS	.	22.00000-	.	NONE	.
107	P29	BS	62520.61945	19.80000-	.	NONE	.
108	P30	BS	.	50.40000-	.	NONE	.
109	P31	BS	10000.00000	40.30000-	.	NONE	.
110	P32	BS	11000.00000	50.40000-	.	NONE	.
111	P33	BS	4870.22675	40.30000-	.	NONE	.
112	P34	LL	.	30.20000-	.	NONE	27.81136-
113	P35	BS	.	40.30000-	.	NONE	.
114	P36	BS	.	60.50000-	.	NONE	.
115	P37	BS	.	19.80000-	.	NONE	.
116	P38	BS	5264.49509	30.20000-	.	NONE	.
117	P39	BS	11344.65871	19.80000-	.	NONE	.
118	P40	BS	187500.00000	436.80000	.	NONE	.
119	P41	BS	.	110.24000	.	NONE	.
120	P42	BS	118789.17696	571.20000	.	NONE	.
121	P43	BS	.	403.20000	.	NONE	.
122	P44	BS	300000.00000	67.20000	.	NONE	.
123	P45	BS	225500.00000	100.80000	.	NONE	.
124	P46	BS	102274.76172	84.00000	.	NONE	.
125	P47	BS	.	168.00000	.	NONE	.
126	P48	LL	.	168.80000	.	NONE	8.26391-
127	P49	BS	.	117.60000	.	NONE	.

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
128	P50	BS	.	180.00000	.	NONE	.
129	P51	BS	45433.35486	168.00000	.	NONE	.
130	P52	BS	68067.95224	180.00000	.	NONE	.
131	P53	BS	90830150.8276	.12000-	.	NONE	.
132	P54	LL	.	358.40000-	.	NONE	358.40000-
133	P55	BS	122917271.844	.03000-	.	NONE	.
134	P56	BS	212392287.899	.03000-	.	NONE	.
135	P57	BS	268018438.786	.03000-	.	NONE	.
136	P58	BS	26137371.7371	.03000-	.	NONE	.
137	P59	BS	42591381.6940	.03000-	.	NONE	.
138	P60	BS	154823958.176	.03000-	.	NONE	.
139	P61	LL	.	630.20000	.	NONE	10717.04606-
140	P62	BS	22222347.6478	.08000-	.	NONE	.
141	P63	BS	24515.24275	6.72000-	.	NONE	.
142	P64	BS	10000.00000	8.40000-	.	NONE	.
143	P65	BS	26032.78544	8.40000-	.	NONE	.
144	P66	BS	81130.45899	8.40000-	.	NONE	.
145	P67	BS	19712.93595	13.44000-	.	NONE	.
146	P68	BS	150000.00000	13.44000-	.	NONE	.
147	P69	BS	12796.23140	10.08000-	.	NONE	.
148	P70	BS	170000.00000	10.08000-	.	NONE	.
149	P71	LL	.	6.72000-	.	NONE	6.72000-
150	P72	BS	48365.27816	13.40000-	.	NONE	.
151	P73	LL	.	12.30000-	.	NONE	12.30000-

Table C-11. Resources (rows) used in solution four

NUMBER	...ROW...	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	C1	BS	142276450.849	142276450.849-	NONE	NONE	.
2	C2	BS	105585805.704	105585805.704-	NONE	NONE	1.00000
3	R01	UL	150000.00000	.	NONE	150000.00000	597.44853-
4	R02	UL	19874.00000	.	NONE	19874.00000	8.40000-
5	R03	UL	10647.00000	.	NONE	10647.00000	10.08000-
6	R04	UL	11356.00000	.	NONE	11356.00000	72.07109-
7	R05	UL	21293.00000	.	NONE	21293.00000	30.95330-
8	R06	UL	21293.00000	.	NONE	21293.00000	13.44000-
9	R07	UL	65300.00000	.	NONE	65300.00000	21.23637-
10	R08	UL	44006.00000	.	NONE	44006.00000	11.76000-
11	R09	UL	21293.00000	.	NONE	21293.00000	11.76000-
12	R10	BS	11788.38163	10214.61837	NONE	22003.00000	.
13	R11	BS	.	1000.00000	NONE	1000.00000	.
14	R12	UL	20460000.0000	.	NONE	20460000.0000	.05000-
15	R13	UL	.	.	NONE	.	.04000-
16	R14	UL	.	.	NONE	.	.04000-
17	R15	UL	.	.	NONE	.	.04000-
18	R16	UL	.	.	NONE	.	.04000-
19	R17	UL	.	.	NONE	.	.04000-
20	R18	UL	.	.	NONE	.	.04000-
21	R19	UL	.	.	NONE	.	.14000-
22	R20	UL	30000.00000	.	NONE	30000.00000	16.80000-
23	R21	UL	105000.00000	.	NONE	105000.00000	13.40000-
24	R22	UL	.	.	NONE	.	739.81953-
25	R23	UL	.	.	NONE	.	118.72620-
26	R24	UL	.	.	NONE	.	753.25953-
27	R25	UL	.	.	NONE	.	315.04183-
28	R26	UL	.	.	NONE	.	520.23220-
29	R27	UL	.	.	NONE	.	1069.68650-
30	R28	UL	.	.	NONE	.	1031.91933-
31	R29	UL	.	.	NONE	.	918.69257-
32	R30	UL	.	.	NONE	.	972.57618-
33	R31	UL	.	.	NONE	.	807.00032-
34	R32	UL	.	.	NONE	.	775.48206-
35	R33	UL	.	.	NONE	.	794.99941-
36	R34	UL	.	.	NONE	.	726.86606-
37	R35	BS	99139346.4500	200860653.549	NONE	299999999.999	.
38	R36	BS	193432949.792	106567050.207	NONE	299999999.999	.
39	R37	BS	223456794.718	76543205.2811	NONE	299999999.999	.
40	R38	BS	40234869.5141	259765130.485	NONE	299999999.999	.
41	R39	BS	28852999.9999	271146999.999	NONE	299999999.999	.
42	R40	BS	110154434.656	189845565.343	NONE	299999999.999	.
43	R41	UL	.	.	NONE	.	952.78013-
44	R42	UL	.	.	NONE	.	296.52390-
45	R43	UL	.	.	NONE	.	966.22013-
46	R44	UL	.	.	NONE	.	580.40704-
47	R45	UL	.	.	NONE	.	813.92741-
48	R46	UL	.	.	NONE	.	1239.26200-
49	R47	UL	.	.	NONE	.	1227.61960-

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	R48	UL	.	.	NONE	.	1208.73278-
51	R49	UL	.	.	NONE	.	1266.73644-
52	R50	UL	.	.	NONE	.	1518.70996-
53	R51	UL	.	.	NONE	.	989.15586-
54	R52	UL	.	.	NONE	.	1016.03119-
55	R53	UL	.	.	NONE	.	940.53986-
56	R54	UL	.	.	NONE	.	403.20000-
57	R55	UL	.	.	NONE	.	84.00000-
58	R56	UL	.	.	NONE	.	537.60000-
59	R57	UL	.	.	NONE	.	336.00000-
60	R58	UL	.	.	NONE	.	33.60000-
61	R59	UL	.	.	NONE	.	67.20000-
62	R60	UL	.	.	NONE	.	67.20000-
63	R61	UL	.	.	NONE	.	134.40000-
64	R62	UL	.	.	NONE	.	143.94887-
65	R63	UL	.	.	NONE	.	201.81033-
66	R64	UL	.	.	NONE	.	172.39389-
67	R65	UL	.	.	NONE	.	134.40000-
68	R66	UL	.	.	NONE	.	113.30000-
69	R67	UL	.	.	NONE	.	336.00000-
70	R68	BS	32418.39632	27581.60368	NONE	60000.00000	.
71	R69	BS	8899.66613	11100.33387	NONE	20000.00000	.
72	R70	UL	40000.00000	.	NONE	40000.00000	61.99109-
73	R71	UL	120000.00000	.	NONE	120000.00000	20.87330-
74	R72	BS	14611.06940	10388.93060	NONE	25000.00000	.
75	R73	UL	150000.00000	.	NONE	150000.00000	7.79637-
76	R74	BS	544.00000	29456.00000	NONE	30000.00000	.
77	R75	BS	142314.05303	27685.94697	NONE	170000.00000	.
78	R76	BS	.	1000.00000	NONE	1000.00000	.

Table C-12. Activities (columns) used in solution four

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
79	P01	UL	75000.00000	51.43000-	.	75000.00000	4.27550
80	P02	LL	.	44.62000-	.	NONE	611.39615-
81	P03	BS	31883.81629	68.30000-	.	NONE	.
82	P04	LL	.	158.30000-	.	NONE	586.91080-
83	P05	LL	.	147.00000-	.	10000.00000	429.57637-
84	P06	UL	11000.00000	136.40000-	.	11000.00000	215.21347
85	P07	BS	8923.28581	105.40000-	.	NONE	.
86	P08	BS	11636.22716	117.50000-	.	NONE	.
87	P09	BS	.	100.80000-	.	NONE	.
88	P10	BS	.	118.35000-	.	NONE	.
89	P11	BS	.	83.80000-	.	NONE	.
90	P12	BS	11556.67075	82.90000-	.	NONE	.
91	P13	BS	.	37.50000-	.	20000.00000	.
92	P14	BS	75000.00000	.02000-	.	NONE	.
93	P15	BS	.	.02000-	.	NONE	.
94	P16	BS	31883.81629	.02000-	.	NONE	.
95	P17	BS	.	.02000-	.	NONE	.
96	P18	BS	.	.02000-	.	NONE	.
97	P19	BS	11000.00000	.02000-	.	NONE	.
98	P20	BS	8923.28581	.02000-	.	NONE	.
99	P21	BS	11636.22716	.02000-	.	NONE	.
100	P22	BS	.	.02000-	.	NONE	.
101	P23	BS	.	.02000-	.	NONE	.
102	P24	BS	.	.02000-	.	NONE	.
103	P25	BS	11556.67075	.02000-	.	NONE	.
104	P26	BS	.	.02000-	.	NONE	.
105	P27	BS	75000.00000	20.80000-	.	NONE	.
106	P28	BS	.	23.00000-	.	NONE	.
107	P29	BS	31883.81629	20.80000-	.	NONE	.
108	P30	BS	.	51.40000-	.	NONE	.
109	P31	BS	.	41.30000-	.	NONE	.
110	P32	BS	11000.00000	51.40000-	.	NONE	.
111	P33	BS	8923.28581	41.30000-	.	NONE	.
112	P34	BS	11636.22716	31.20000-	.	NONE	.
113	P35	BS	.	41.30000-	.	NONE	.
114	P36	BS	.	61.50000-	.	NONE	.
115	P37	BS	.	20.80000-	.	NONE	.
116	P38	BS	11556.67075	31.20000-	.	NONE	.
117	P39	LL	.	20.80000-	.	NONE	305.94886-
118	P40	BS	187500.00000	403.20000	.	NONE	.
119	P41	BS	.	84.00000	.	NONE	.
120	P42	BS	60579.25094	537.60000	.	NONE	.
121	P43	BS	.	336.00000	.	NONE	.
122	P44	BS	.	33.60000	.	NONE	.
123	P45	BS	225500.00000	67.20000	.	NONE	.
124	P46	BS	187389.00201	67.20000	.	NONE	.
125	P47	BS	118689.51700	134.40000	.	NONE	.
126	P48	LL	.	100.80000	.	NONE	43.14687-
127	P49	LL	.	67.20000	.	NONE	134.61023-

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
128	P50	LL	.	113.30000	.	NONE	59.09389-
129	P51	BS	106321.37089	134.40000	.	NONE	.
130	P52	BS	.	113.30000	.	NONE	.
131	P53	BS	68837538.9350	.14000-	.	NONE	.
132	P54	BS	.	336.00000-	.	NONE	.
133	P55	BS	99139346.4500	.04000-	.	NONE	.
134	P56	BS	193432949.792	.04000-	.	NONE	.
135	P57	BS	223456794.718	.04000-	.	NONE	.
136	P58	BS	40234869.5142	.04000-	.	NONE	.
137	P59	BS	28852999.9999	.04000-	.	NONE	.
138	P60	BS	110134434.656	.04000-	.	NONE	.
139	P61	LL	.	570.20000	.	NONE	3090.14508-
140	P62	BS	25042551.0252	.05000-	.	NONE	.
141	P63	BS	32418.39632	8.40000-	.	NONE	.
142	P64	BS	8899.66613	10.08000-	.	NONE	.
143	P65	BS	40000.00000	10.08000-	.	NONE	.
144	P66	BS	120000.00000	10.08000-	.	NONE	.
145	P67	BS	14611.06940	13.44000-	.	NONE	.
146	P68	BS	150000.00000	13.44000-	.	NONE	.
147	P69	BS	544.00000	11.76000-	.	NONE	.
148	P70	BS	142314.05303	11.76000-	.	NONE	.
149	P71	LL	.	8.40000-	.	NONE	8.40000-
150	P72	BS	76883.81629	16.80000-	.	NONE	.
151	P73	BS	1883.81629	13.40000-	.	NONE	.

Table C-13. Resources (rows) used in solution five

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	C1	BS	121569964.563	121569964.563-	NONE	NONE	.
2	C2	BS	87834962.4450	87834962.4450-	NONE	NONE	1.00000
3	R01	UL	120000.00000	.	NONE	120000.00000	616.68019-
4	R02	UL	19374.00000	.	NONE	19874.00000	8.40000-
5	R03	UL	10647.00000	.	NONE	10647.00000	10.08000-
6	R04	UL	11356.00000	.	NONE	11356.00000	69.06767-
7	R05	UL	21293.00000	.	NONE	21293.00000	28.11922-
8	R06	UL	21293.00000	.	NONE	21293.00000	13.44000-
9	R07	UL	65300.00000	.	NONE	65300.00000	20.17136-
10	R08	UL	44006.00000	.	NONE	44006.00000	11.76000-
11	R09	UL	21293.00000	.	NONE	21293.00000	11.76000-
12	R10	BS	8524.25989	13478.74011	NONE	22003.00000	.
13	R11	BS	.	1000.00000	NONE	1000.00000	.
14	R12	UL	25500000.0000	.	NONE	25500000.0000	.05000-
15	R13	UL	.	.	NONE	.	.04000-
16	R14	UL	.	.	NONE	.	.04000-
17	R15	UL	.	.	NONE	.	.04000-
18	R16	UL	.	.	NONE	.	.04000-
19	R17	UL	.	.	NONE	.	.04000-
20	R18	UL	.	.	NONE	.	.04000-
21	R19	UL	.	.	NONE	.	.14000-
22	R20	UL	50000.00000	.	NONE	50000.00000	16.80000-
23	R21	BS	74242.59891	40757.40109	NONE	115000.00000	.
24	R22	UL	.	.	NONE	.	741.37569-
25	R23	UL	.	.	NONE	.	120.80007-
26	R24	UL	.	.	NONE	.	759.09119-
27	R25	UL	.	.	NONE	.	915.51613-
28	R26	UL	.	.	NONE	.	957.42049-
29	R27	UL	.	.	NONE	.	1069.68650-
30	R28	UL	.	.	NONE	.	1040.21393-
31	R29	UL	.	.	NONE	.	926.30449-
32	R30	UL	.	.	NONE	.	548.84961-
33	R31	UL	.	.	NONE	.	824.94105-
34	R32	UL	.	.	NONE	.	779.55177-
35	R33	UL	.	.	NONE	.	813.17987-
36	R34	UL	.	.	NONE	.	730.93577-
37	R35	BS	72946314.2913	227053685.708	NONE	299999999.999	.
38	R36	BS	151906893.718	148093106.281	NONE	299999999.999	.
39	R37	BS	177334317.572	122665682.427	NONE	299999999.999	.
40	R38	BS	49273914.1823	250726085.817	NONE	299999999.999	.
41	R39	BS	28852999.9999	271146999.999	NONE	299999999.999	.
42	R40	BS	30777339.0223	219222660.977	NONE	299999999.999	.
43	R41	UL	.	.	NONE	.	953.61084-
44	R42	UL	.	.	NONE	.	297.37591-
45	R43	UL	.	.	NONE	.	971.32634-
46	R44	UL	.	.	NONE	.	558.92712-
47	R45	UL	.	.	NONE	.	821.38248-
48	R46	UL	.	.	NONE	.	1239.26200-
49	R47	UL	.	.	NONE	.	1234.54216-

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	R48	UL	.	.	NONE	.	1215.12284-
51	R49	UL	.	.	NONE	.	841.63784-
52	R50	UL	.	.	NONE	.	1529.68049-
53	R51	UL	.	.	NONE	.	993.22557-
54	R52	UL	.	.	NONE	.	1033.03568-
55	R53	UL	.	.	NONE	.	634.59100-
56	R54	UL	.	.	NONE	.	403.20000-
57	R55	UL	.	.	NONE	.	84.00000-
58	R56	UL	.	.	NONE	.	539.85026-
59	R57	UL	.	.	NONE	.	336.00000-
60	R58	UL	.	.	NONE	.	33.60000-
61	R59	UL	.	.	NONE	.	67.20000-
62	R60	UL	.	.	NONE	.	67.20000-
63	R61	UL	.	.	NONE	.	134.40000-
64	R62	UL	.	.	NONE	.	100.80000-
65	R63	UL	.	.	NONE	.	202.80083-
66	R64	UL	.	.	NONE	.	173.07218-
67	R65	UL	.	.	NONE	.	134.40000-
68	R66	UL	.	.	NONE	.	113.30000-
69	R67	UL	.	.	NONE	.	336.00000-
70	R68	BS	24181.17433	35818.82567	NONE	60000.00000	.
71	R69	BS	5330.01040	4669.98960	NONE	10000.00000	.
72	R70	UL	40000.00000	.	NONE	40000.00000	58.98767-
73	R71	UL	120000.00000	.	NONE	120000.00000	18.03922-
74	R72	BS	10995.83789	14004.16211	NONE	25000.00000	.
75	R73	UL	150000.00000	.	NONE	150000.00000	6.73136-
76	R74	BS	544.00000	29456.00000	NONE	30000.00000	.
77	R75	BS	116201.07913	53798.92087	NONE	170000.00000	.
78	R76	BS	.	1000.00000	NONE	1000.00000	.

Table C-14. Activities (columns) used in solution five

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
79	P01	BS	74242.59891	51.43000-	.	75000.00000	.
80	P02	LL	.	44.62000-	.	NONE	626.99519-
81	P03	BS	.	68.30000-	.	NONE	.
82	P04	BS	.	158.30000-	.	NONE	.
83	P05	BS	.	147.00000-	.	10000.00000	.
84	P06	UL	11000.00000	136.40000-	.	11000.00000	195.98181
85	P07	BS	9962.92197	105.40000-	.	NONE	.
86	P08	BS	14619.22510	117.50000-	.	NONE	.
87	P09	LL	.	100.20000-	.	NONE	433.82322-
88	P10	BS	.	118.35000-	.	NONE	.
89	P11	BS	.	83.80000-	.	NONE	.
90	P12	BS	10175.25401	82.90000-	.	NONE	.
91	P13	BS	.	37.50000-	.	20000.00000	.
92	P14	BS	74242.59891	.02000-	.	NONE	.
93	P15	BS	.	.02000-	.	NONE	.
94	P16	BS	.	.02000-	.	NONE	.
95	P17	LL	.	.02000-	.	NONE	590.73236-
96	P18	LL	.	.02000-	.	NONE	428.51136-
97	P19	BS	11000.00000	.02000-	.	NONE	.
98	P20	BS	9962.92197	.02000-	.	NONE	.
99	P21	BS	14619.22510	.02000-	.	NONE	.
100	P22	BS	.	.02000-	.	NONE	.
101	P23	BS	.	.02000-	.	NONE	.
102	P24	BS	.	.02000-	.	NONE	.
103	P25	BS	10175.25401	.02000-	.	NONE	.
104	P26	LL	.	.02000-	.	NONE	310.01857-
105	P27	BS	74242.59891	20.80000-	.	NONE	.
106	P28	BS	.	23.00000-	.	NONE	.
107	P29	BS	.	20.80000-	.	NONE	.
108	P30	BS	.	51.40000-	.	NONE	.
109	P31	BS	.	41.30000-	.	NONE	.
110	P32	BS	11000.00000	51.40000-	.	NONE	.
111	P33	BS	9962.92197	41.30000-	.	NONE	.
112	P34	BS	14619.22510	31.20000-	.	NONE	.
113	P35	BS	.	41.30000-	.	NONE	.
114	P36	BS	.	61.50000-	.	NONE	.
115	P37	BS	.	20.80000-	.	NONE	.
116	P38	BS	10175.25401	31.20000-	.	NONE	.
117	P39	BS	.	20.80000-	.	NONE	.
118	P40	BS	185606.49729	403.20000	.	NONE	.
119	P41	BS	.	84.00000	.	NONE	.
120	P42	LL	.	537.60000	.	NONE	2.25026-
121	P43	BS	.	336.00000	.	NONE	.
122	P44	BS	.	33.60000	.	NONE	.
123	P45	BS	225500.00000	67.20000	.	NONE	.
124	P46	BS	209221.36137	67.20000	.	NONE	.
125	P47	BS	149116.09607	134.40000	.	NONE	.
126	P48	BS	.	100.80000	.	NONE	.
127	P49	LL	.	67.20000	.	NONE	135.60083-

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
128	P50	LL	.	113.30000	.	NONE	59.77218-
129	P51	BS	93612.33690	134.40000	.	NONE	.
130	P52	BS	.	113.30000	.	NONE	.
131	P53	BS	55146353.8839	.14000-	.	NONE	.
132	P54	BS	.	336.00000-	.	NONE	.
133	P55	BS	72946314.2914	.04000-	.	NONE	.
134	P56	BS	151906893.719	.04000-	.	NONE	.
135	P57	BS	177334317.572	.04000-	.	NONE	.
136	P58	BS	45273914.1823	.04000-	.	NONE	.
137	P59	BS	28352999.9999	.04000-	.	NONE	.
138	P60	BS	80777339.0223	.04000-	.	NONE	.
139	P61	LL	.	570.20000	.	NONE	3038.87619-
140	P62	BS	12651687.7992	.05000-	.	NONE	.
141	P63	BS	24181.17433	8.40000-	.	NONE	.
142	P64	BS	5330.01040	10.08000-	.	NONE	.
143	P65	BS	40000.00000	10.08000-	.	NONE	.
144	P66	BS	120000.00000	10.08000-	.	NONE	.
145	P67	BS	10995.83789	13.44000-	.	NONE	.
146	P68	BS	150000.00000	13.44000-	.	NONE	.
147	P69	BS	544.00000	11.76000-	.	NONE	.
148	P70	BS	116201.07913	11.76000-	.	NONE	.
149	P71	LL	.	8.40000-	.	NONE	8.40000-
150	P72	BS	24242.59891	16.80000-	.	NONE	.
151	P73	LL	.	13.40000-	.	NONE	13.40000-

Table C-15. Resources (rows) used in solution six

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	C1	BS	162396126.505	162396126.505-	NONE	NONE	.
2	C2	BS	124732500.329	124732500.329-	NONE	NONE	1.00000
3	R01	UL	180000.00000	.	NONE	180000.00000	522.49518-
4	R02	UL	19874.00000	.	NONE	19874.00000	8.40000-
5	R03	UL	10647.00000	.	NONE	10647.00000	414.49508-
6	R04	UL	11356.00000	.	NONE	11356.00000	40.23087-
7	R05	UL	21293.00000	.	NONE	21293.00000	10.08000-
8	R06	UL	21293.00000	.	NONE	21293.00000	13.44000-
9	R07	UL	65300.00000	.	NONE	65300.00000	41.96133-
10	R08	BS	42121.42171	1884.57829	NONE	44006.00000	.
11	R09	UL	21293.00000	.	NONE	21293.00000	59.33673-
12	R10	BS	15721.34856	6281.65144	NONE	22003.00000	.
13	R11	BS	.	1000.00000	NONE	1000.00000	.
14	R12	UL	30500000.0000	.	NONE	30500000.0000	.05000-
15	R13	UL	.	.	NONE	.	.04000-
16	R14	UL	.	.	NONE	.	.04000-
17	R15	UL	.	.	NONE	.	.04000-
18	R16	UL	.	.	NONE	.	.04000-
19	R17	UL	.	.	NONE	.	.04000-
20	R18	UL	.	.	NONE	.	.04000-
21	R19	UL	.	.	NONE	.	.14000-
22	R20	UL	100000.00000	.	NONE	100000.00000	16.80000-
23	R21	BS	146813.13453	3186.86547	NONE	150000.00000	.
24	R22	UL	.	.	NONE	.	677.63339-
25	R23	UL	.	.	NONE	.	65.96208-
26	R24	UL	.	.	NONE	.	691.07339-
27	R25	UL	.	.	NONE	.	785.25268-
28	R26	UL	.	.	NONE	.	789.27468-
29	R27	UL	.	.	NONE	.	734.83168-
30	R28	UL	.	.	NONE	.	842.39422-
31	R29	UL	.	.	NONE	.	759.15868-
32	R30	UL	.	.	NONE	.	902.15520-
33	R31	UL	.	.	NONE	.	786.72401-
34	R32	UL	.	.	NONE	.	753.56273-
35	R33	UL	.	.	NONE	.	950.44727-
36	R34	UL	.	.	NONE	.	704.94673-
37	R35	BS	119743310.546	180256689.454	NONE	299999999.999	.
38	R36	BS	228190983.492	71809016.5070	NONE	299999999.999	.
39	R37	BS	278716791.654	21283208.3449	NONE	299999999.999	.
40	R38	BS	27274103.1989	272725896.800	NONE	299999999.999	.
41	R39	BS	27280120.7757	272719879.224	NONE	299999999.999	.
42	R40	BS	145329866.541	154670133.458	NONE	299999999.999	.
43	R41	UL	.	.	NONE	.	936.61467-
44	R42	UL	.	.	NONE	.	279.94394-
45	R43	UL	.	.	NONE	.	950.05467-
46	R44	UL	.	.	NONE	.	414.60739-
47	R45	UL	.	.	NONE	.	668.85272-
48	R46	UL	.	.	NONE	.	906.22486-
49	R47	UL	.	.	NONE	.	1092.90738-

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
50	R48	UL	.	.	NONE	.	1084.38304-
51	R49	UL	.	.	NONE	.	710.89804-
52	R50	UL	.	.	NONE	.	1711.12361-
53	R51	UL	.	.	NONE	.	634.59250-
54	R52	UL	.	.	NONE	.	1141.27100-
55	R53	UL	.	.	NONE	.	634.59100-
56	R54	UL	.	.	NONE	.	403.20000-
57	R55	UL	.	.	NONE	.	84.00000-
58	R56	UL	.	.	NONE	.	537.60000-
59	R57	UL	.	.	NONE	.	336.00000-
60	R58	UL	.	.	NONE	.	33.60000-
61	R59	UL	.	.	NONE	.	67.20000-
62	R60	UL	.	.	NONE	.	67.20000-
63	R61	UL	.	.	NONE	.	134.40000-
64	R62	UL	.	.	NONE	.	100.80000-
65	R63	UL	.	.	NONE	.	241.16008-
66	R64	UL	.	.	NONE	.	113.30000-
67	R65	UL	.	.	NONE	.	134.40000-
68	R66	UL	.	.	NONE	.	113.30000-
69	R67	UL	.	.	NONE	.	336.00000-
70	R68	BS	20835.30856	39164.69144	NONE	60000.00000	.
71	R69	UL	10000.00000	.	NONE	10000.00000	404.41508-
72	R70	UL	40000.00000	.	NONE	40000.00000	30.15087-
73	R71	BS	78614.98402	41385.01598	NONE	120000.00000	.
74	R72	BS	18869.94232	6130.05768	NONE	25000.00000	.
75	R73	UL	150000.00000	.	NONE	150000.00000	28.52133-
76	R74	BS	.	30000.00000	NONE	30000.00000	.
77	R75	UL	170000.00000	.	NONE	170000.00000	47.57673-
78	R76	BS	.	1000.00000	NONE	1000.00000	.

Table C-16. Activities (columns) used in solution six

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
79	P01	UL	75000.00000	51.43000-	.	75000.00000	4.27550
80	P02	LL	.	44.62000-	.	NONE	577.72660-
81	P03	BS	71813.13453	68.30000-	.	NONE	.
82	P04	BS	.	158.30000-	.	NONE	.
83	P05	BS	.	147.00000-	.	10000.00000	.
84	P06	BS	10400.35104	136.40000-	.	11000.00000	.
85	P07	BS	8670.71431	105.40000-	.	NONE	.
86	P08	BS	6885.80149	117.50000-	.	NONE	.
87	P09	BS	.	100.80000-	.	NONE	.
88	P10	BS	.	116.35000-	.	NONE	.
89	P11	BS	.	83.80000-	.	NONE	.
90	P12	BS	7229.99864	82.90000-	.	NONE	.
91	P13	BS	.	37.50000-	.	20000.00000	.
92	P14	BS	75000.00000	.02000-	.	NONE	.
93	P15	BS	.	.02000-	.	NONE	.
94	P16	BS	71813.13453	.02000-	.	NONE	.
95	P17	LL	.	.02000-	.	NONE	672.19465-
96	P18	LL	.	.02000-	.	NONE	450.30133-
97	P19	BS	10400.35104	.02000-	.	NONE	.
98	P20	BS	8670.71431	.02000-	.	NONE	.
99	P21	BS	6885.80149	.02000-	.	NONE	.
100	P22	LL	.	.02000-	.	NONE	440.23032-
101	P23	BS	.	.02000-	.	NONE	.
102	P24	LL	.	.02000-	.	NONE	341.84951-
103	P25	BS	7229.99864	.02000-	.	NONE	.
104	P26	LL	.	.02000-	.	NONE	293.23501-
105	P27	BS	75000.00000	20.80000-	.	NONE	.
106	P28	BS	.	23.00000-	.	NONE	.
107	P29	BS	71813.13453	20.80000-	.	NONE	.
108	P30	BS	.	51.40000-	.	NONE	.
109	P31	BS	.	41.30000-	.	NONE	.
110	P32	BS	10400.35104	51.40000-	.	NONE	.
111	P33	BS	8670.71431	41.30000-	.	NONE	.
112	P34	BS	6885.80149	31.20000-	.	NONE	.
113	P35	BS	.	41.30000-	.	NONE	.
114	P36	BS	.	61.50000-	.	NONE	.
115	P37	BS	.	20.80000-	.	NONE	.
116	P38	BS	7229.99864	31.20000-	.	NONE	.
117	P39	BS	.	20.80000-	.	NONE	.
118	P40	BS	187500.00000	403.20000	.	NONE	.
119	P41	BS	.	84.00000	.	NONE	.
120	P42	BS	136444.95560	537.60000	.	NONE	.
121	P43	BS	.	336.00000	.	NONE	.
122	P44	BS	.	33.60000	.	NONE	.
123	P45	BS	213207.19631	67.20000	.	NONE	.
124	P46	BS	182085.00041	67.20000	.	NONE	.
125	P47	BS	70235.17518	134.40000	.	NONE	.
126	P48	BS	.	100.80000	.	NONE	.
127	P49	LL	.	67.20000	.	NONE	173.96008-

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
128	P50	BS	.	113.30000	.	NONE	.
129	P51	BS	66515.98750	134.40000	.	NONE	.
130	P52	BS	.	113.30000	.	NONE	.
131	P53	BS	82973918.8992	.14000-	.	NONE	.
132	P54	BS	.	336.00000-	.	NONE	.
133	P55	BS	119743310.546	.04000-	.	NONE	.
134	P56	BS	228190983.492	.04000-	.	NONE	.
135	P57	BS	278716791.655	.04000-	.	NONE	.
136	P58	BS	27274103.1989	.04000-	.	NONE	.
137	P59	BS	27280120.7757	.04000-	.	NONE	.
138	P60	BS	145329866.541	.04000-	.	NONE	.
139	P61	LL	.	570.20000	.	NONE	5771.90969-
140	P62	BS	21307482.9865	.05000-	.	NONE	.
141	P63	BS	20835.30856	8.40000-	.	NONE	.
142	P64	BS	10000.00000	10.08000-	.	NONE	.
143	P65	BS	40000.00000	10.08000-	.	NONE	.
144	P66	BS	78614.98402	10.08000-	.	NONE	.
145	P67	BS	19369.94232	13.44000-	.	NONE	.
146	P68	BS	150000.00000	13.44000-	.	NONE	.
147	P69	LL	.	11.76000-	.	NONE	11.76000-
148	P70	BS	170000.00000	11.76000-	.	NONE	.
149	P71	LL	.	8.40000-	.	NONE	8.40000-
150	P72	BS	46813.13453	16.80000-	.	NONE	.
151	P73	LL	.	13.40000-	.	NONE	13.40000-

Table C-17. Ranges of major resources at limit level

Resource	Solution Two				
	Supply	Level	MVP $	Range of MVP	
				Lower Activity	Upper Activity
Land (R01)	120,000 ha	120,000 ha	739.87	96,951 ha	138,310 ha
Labor Jan. 1-Feb. 28 (R02)	19,874 hr	19,874 hr	6.72	288 hr	66,288 hr
Labor Mar. 7-Mar. 15 (R03)	10,647 hr	10,647 hr	8.40	7,661 hr	17,661 hr
Labor Mar. 16-Mar. 31 (R04)	11,356 hr	11,356 hr	104.12	0.0 hr	29,433 hr
Labor Ap. 1-Ap. 30 (R05)	21,293 hr	21,293 hr	64.69	0.0 hr	61,852 hr
Labor May 1-May 30 (R06)	21,293 hr	21,293 hr	13.44	8,358 hr	33,358 hr
Labor May 31-Aug. 30 (R07)	65,300 hr	65,300 hr	40.30	34,810 hr	153,705 hr
Labor Sept. 1-Oct. 31 (R08)	44,006 hr	44,006 hr	10.08	36,150 hr	66,150 hr
Labor Nov. 1-Nov. 30 (R09)	21,293 hr	21,293 hr	10.08	0.0 hr	127,762 hr
Operating Capital (R12)	$25,450,000	$25,450,000	.08	0.0	39,400,000
Hiring Labor Mar. 1-Mar. 15 (R69)	-	-	-	-	-
Hiring Labor Mar. 16-Mar. 31 (R70)	40,000 hr	40,000 hr	95.70	2,081 hr	58,077 hr
Hiring Labor Ap. 1-Ap. 30 (R71)	120,000 hr	120,000 hr	56.30	51,494 hr	160,559 hr
Hiring Labor May 31-Aug. 30 (R73)	150,000 hr	150,000 hr	26.86	119,510 hr	238,405 hr
Hiring Labor Nov. 1-Nov. 30 (R75)	-	-	-	-	-

Table C-17. (continued)

Resource	Solution Three				
	Supply	Level	MVP $	Range of MVP	
				Lower Activity	Upper Activity
Land (R01)	180,000 ha	180,000 ha	509.77	176,062 hr	180,606 ha
Labor Jan. 1-Feb. 28 (R02)	19,874 hr	19,874 hr	6.72	0.0 hr	44,389 hr
Labor Mar. 7-Mar. 15 (R03)	10,647 hr	10,647 hr	1,160.64	10,314 hr	12,665 hr
Labor Mar. 16-Mar. 31 (R04)	11,356 hr	11,356 hr	8.4	0.0 hr	37,389 hr
Labor Ap. 1-Ap. 30 (R05)	21,293 hr	21,293 hr	8.4	0.0 hr	102,423 hr
Labor May 1-May 30 (R06)	21,293 hr	21,293 hr	13.4	16,006 hr	41,006 hr
Labor May 31-Aug. 30 (R07)	65,300 hr	65,300 hr	104.36	59,718 hr	90,924 hr
Labor Sept. 1-Oct. 31 (R08)	44,006 hr	44,006 hr	10.08	26,802 hr	56,802 hr
Labor Nov. 1-Nov. 30 (R09)	21,293 hr	21,293 hr	82.57	18,864 hr	25,587 hr
Operating Capital (R12)	$30,500,000	$30,500,000	0.08	0.0	$52,700,000
Hiring Labor Mar. 1-Mar. 15 (R69)	1,000 hr	1,000 hr	1,152.2	9,667 hr	12,018 hr
Hiring Labor Mar. 16-Mar. 31 (R70)	-	-	-	-	-
Hiring Labor Ap. 1-Ap. 30 (R71)	-	-	-	-	-
Hiring Labor May 31-Aug. 30 (R73)	150,000 hr	150,000 hr	90.92	144,418 hr	175,624 hr
Hiring Labor Nov. 1-Nov. 30 (R75)	170,000 hr	170,000 hr	72.48	167,571 hr	174,294 hr

Table C-17. (continued)

Resource	Solution Four				
	Supply	Level	MVP $	Range of MVP	
				Lower Activity	Upper Activity
Land (R01)	150,000 ha	150,000 ha	597.45	148,268 ha	181,807 ha
Labor Jan. 1-Feb. 28 (R02)	19,874 hr	19,874 hr	8.40	0.0 hr	52,292 hr
Labor Mar. 7-Mar. 15 (R03)	10,647 hr	10,647 hr	10.08	453 hr	19,547 hr
Labor Mar. 16-Mar. 31 (R04)	11,356 hr	11,356 hr	72.07	0.0 hr	22,442 hr
Labor Ap. 1-Ap. 30 (R05)	21,293 hr	21,293 hr	30.95	0.0 hr	33,042 hr
Labor May 1-May 30 (R06)	21,293 hr	21,293 hr	13.44	10,904 hr	35,904 hr
Labor May 31-Aug. 30 (R07)	65,300 hr	65,300 hr	21.23	0.0 hr	96,565 hr
Labor Sept. 1-Oct. 31 (R08)	44,006 hr	44,006 hr	11.76	14,550 hr	44,550 hr
Labor Nov. 1-Nov. 30 (R09)	21,293 hr	21,293 hr	11.76	0.0 hr	163,607 hr
Operating Capital (R12)	$20,460,000	$20,460,000	0.05	0.0	$45,500,000
Hiring Labor Mar. 1-Mar. 15 (R69)	-	-	-	-	-
Hiring Labor Mar. 16-Mar. 31 (R70)	40,000 hr	40,000 hr	61.99	5,392 hr	51,086 hr
Hiring Labor Ap. 1-Ap. 30 (R71)	120,000 hr	120,000 hr	20.87	52,868 hr	131,749 hr
Hiring Labor May 31-Aug. 30 (R73)	150,000 hr	150,000 hr	7.80	79,756 hr	181,265 hr
Hiring Labor Nov. 1-Nov. 30 (R75)	-	-	-	-	-

Table C-17. (continued)

Resource	Solution Five				
	Supply	Level	MVP $	Range of MVP: Lower Activity	Range of MVP: Upper Activity
Labor (R01)	120,000 ha	120,000 ha	616.68	97,719 ha	120,696 ha
Labor Jan. 1-Feb. 28 (R02)	19,874 hr	19,874 hr	8.40	0.0 hr	44,055 hr
Labor Mar. 7-Mar. 15 (R03)	10,647 hr	10,647 hr	10.80	5,977 hr	15,977 hr
Labor Mar. 16-Mar.31 (R04)	11,356 hr	11,356 hr	69.07	6,898 hr	63,773 hr
Labor Ap. 1-Ap. 30 (R05)	21,293 hr	21,293 hr	28.12	16,569 hr	95,467 hr
Labor May 1-May 30 (R06)	21,293 hr	21,293 hr	13.44	7,289 hr	32,289 hr
Labor May 31-Aug. 30 (R07)	65,300 hr	65,300 hr	20.17	52,729 hr	126,883 hr
Labor Sept. 1-Oct. 31 (R08)	44,006 hr	44,006 hr	11.76	14,550 hr	44,550 hr
Labor Nov. 1-Nov. 30 (R09)	21,293 hr	21,293 hr	11.76	0.0 hr	137,494 hr
Operating Capital (R12)	$25,500,000	$25,500,000	0.05	0.0 hr	$38,150,000
Hiring Labor Mar. 1-Mar. 15 (R69)	-	-	-	-	-
Hiring Labor Mar. 16-Mar. 31 (R70)	40,000 hr	40,000 hr	58.99	35,542 hr	92,417 hr
Hiring Labor Ap. 1-Ap. 30 (R71)	120,000 hr	120,000 hr	18.04	115,276 hr	194,174 hr
Hiring Labor May 31-Aug. 30 (R73)	150,000 hr	150,000 hr	6.73	137,429 hr	211,583 hr
Hiring Labor Nov. 1-Nov. 30 (R75)	-	-	-	-	-

Table C-17. (continued)

Resource	Solution Six				
	Supply	Level	MVP $	Range of MVP	
				Lower Activity	Upper Activity
Land (R01)	180,000 ha	180,000 ha	522.50	177,513 ha	181,919 ha
Labor Jan. 1-Feb. 28 (R02)	19,874 hr	19,874 hr	8.40	0.0 hr	40,709 hr
Labor Mar. 7-Mar. 15 (R03)	10,647 hr	10,647 hr	414.50	9,619 hr	11,979 hr
Labor Mar. 16-Mar. 31 (R04)	11,356 hr	11,356 hr	40.23	0.0 hr	32,965 hr
Labor Ap. 1-Ap. 30 (R05)	21,293 hr	21,293 hr	10.08	0.0 hr	99,908 hr
Labor May 1-May 30 (R06)	21,293 hr	21,293 hr	13.44	15,163 hr	40,163 hr
Labor May 31-Aug. 30 (R07)	65,300 hr	65,300 hr	41.96	50,749 hr	84,155 hr
Labor Sept. 1-Oct. 31 (R08)	-	-	-	-	-
Labor Nov. 1-Nov. 30 (R09)	21,293 hr	21,293 hr	59.34	7,667 hr	24,076 hr
Operating Capital (R12)	$30,500,000	$30,500,000	0.05	0.0	$51,800,000
Hiring Labor Mar. 1-Mar. 15 (R69)	10,000 hr	10,000 hr	404.41	8,972 hr	11,332 hr
Hiring Labor Mar. 16-Mar. 31 (R70)	40,000 hr	40,000 hr	30.15	11,799 hr	61,609 hr
Hiring Labor Ap. 1-Ap. 30 (R71)	-	-	-	-	-
Hiring Labor May 31-Aug. 30 (R73)	150,000 hr	150,000 hr	28.52	135,450 hr	168,855 hr
Hiring Labor Nov. 1-Nov. 30 (R75)	170,000 hr	170,000 hr	47.58	156,374 hr	172,783 hr

Table C-18. Ranges of major activities at limit level[a] (solutions 2-6)

Activity	Solution Two				Solution Three			
	Level	Penalty Cost $	Range of penalty cost		Level	Penalty Cost $	Range of penalty cost	
			Lower Activity	Upper Activity			Lower Activity	Upper Activity
Growing barley (P01)	-	-	-	-	-	-	-	-
Growing tomato (P05)	10,000 ha	216.15	0.0 ha	14,035 ha	10,000 ha	124.28	6,273 ha	14,534 ha
Growing potato (P06)	10,000 "	827.53	5532 "	12,940 "	11,000 "	542.98	10,396 "	11,545 "
Growing oats (P13)	20,000 "	5.80	0.0 "	27,274 "	-	-	-	-

[a]The above activities are at limit level because they are upper bounded.

Table C-18. (continued)

Activity	Solution Four				Solution Five			
	Level	Penalty Cost $	Range of Penalty cost		Level	Penalty Cost $	Range of Penalty cost	
			Lower Activity	Upper Activity			Lower Activity	Upper Activity
Growing barley (P01)	75,000 ha	4.27	0.0 ha	106,884 ha	-	-	-	-
Growing tomato (P05)	-	-	-	-	-	-	-	-
Growing potato (P06)	11,000 "	215.21	10,566 "	12,731 "	11,000 ha	195.98	10,866 ha	18,273 ha
Growing oats (P13)	-	-	-	-	-	-	-	-

Table C-18. (continued)

Activity	Solution Six			
	Level	Penalty Cost $	Range of Penalty cost	
			Lower Activity	Upper Activity
Growing barley (P01)	75,000 ha	4.27	0.0 ha	146,813 ha
Growing tomato (P05)	-	-	-	-
Growing potato (P06)	-	-	-	-
Growing oats (P13)	-	-	-	-

Table C-19. Ranges of major resources at intermediate level (solutions 2-6)

Resource	Solution Two					
	Supply	Level	MVP at the lower activity $	MVP at the upper activity $	Range of MVP lower activity	Range of MVP upper activity
R08	-	-	-	-	-	-
R10	22,003 hr	12,208 hr	6.72	244.01	11,208 hr	13,526hr
R21	115,000 "	75,078 "	12.30	351.08	0.0 "	86,062
R35	300,000,000 "	99,400,000 "	0.01	0.03	75,400,000 "	-
R36	300,000,000 "	128,300,000 "	0.03	0.01	117,870,000 "	157,000,000 "
R37	300,000,000 "	147,800,000 "	0.03	0.01	137,000,000 "	177,000,000 "
R38	300,000,000 "	43,600,000 "	0.03	0.03	39,000,000 "	-
R39	300,000,000 "	53,000,000 "	0.01	0.03	29,000,000 "	-
R40	300,000,000 "	93,700,000 "	0.01	0.03	81,000,000 "	-
R68	60,000 "	40,414 "	9.40	6.72	28,108 "	-
R69	10,000 "	7,014 "	95.94	8.40	5,806 "	-
R70						
R71						
R72	25,000 "	12,065 "	52.91	13.44	8,974 "	-
R74	30,000 "	22,144 "	5.37	10.08	544 "	-
R75	170,000 "	106,469 "	86.56	10.08	102,754 "	-
R76						

Table C-19. (continued)

Resource	Solution Three					
	Supply	Level	MVP at the lower activity $	MVP at the upper activity $	Range of MVP	
					lower activity	upper activity
R08						
R10	22,003 hr	18,028 hr	6.72	138.80	17,028 hr	19,297hr
R21	150,000 "	148,865 "	12.30	130.67	0.0 "	148,865 "
R35	300,000,000 "	133,000,000 "	0.02	0.03	132,900,000 "	139,700,000 "
R36	300,000,000 "	212,000,000 "	0.02	0.02	202,000,000 "	212,000,000 "
R37	300,000,000 "	268,000,000 "	0.02	0.02	260,000,000 "	275,000,000 "
R38	300,000,000 "	26,000,000 "	0.09	0.02	26,000,000 "	35,000,000 "
R39	300,000,000 "	43,000,000 "	0.02	0.02	42,000,000 "	50,000,000 "
R40	300,000,000 "	146,000,000 "	0.03	0.03	146,000,000 "	-
R68	60,000 "	24,515 "	77.25	6.72	24,515 "	-
R69						
R70	40,000 "	26,033 "	8.69	8.40	9,149 "	-
R71	120,000 "	81,130 "	32.76	5.50	73,722 "	-
R72	25,000 "	19,713 "	136.82	13.44	19,712 "	-
R74	30,000 "	19,796 "	25.62	10.08	0.0 "	-
R75						
R76						

Table C-19. (continued)

Resource	Solution Four					
	Supply	Level	MVP at the lower activity $	MVP at the upper activity $	Range of MVP	
					Lower activity	Upper activity
R08						
R10	22.003 hr	11,788 hr	8.4	595.28	10,788 hr	11,788 hr
R21						
R35	300,000,000 "	99,000,000 "	0.14	0.03	89,000,000 "	116,000,000 "
R36	300,000,000 "	193,000,000 "	0.11	0.04	181,000,000 "	-
R37	300,000,000 "	223,000,000 "	0.03	0.04	202,000,000 "	-
R38	300,000,000 "	40,000,000 "	0.02	0.04	10,000,000 "	-
R39	300,000,000 "	29,000,000 "	0.08	0.04	28,000,000 "	-
R40	300,000,000 "	110,000,000 "	0.61	0.04	108,000,000 "	-
R68	30,000 "	32,418 "	43.23	8.40	0.0 "	-
R69	20,000 "	8,900 "	340.01	10.08	4,778 "	-
R70						
R71						
R72	25,000 "	14,611 "	96.50	13.44	6,731 "	-
R74	30,000 "	544 "	53.14	11.76	0.0 "	-
R75	170,000 "	142,314 "	34.54	11.76	141,477 "	-
R76	1,000 "	-	0.0	8.40	0.0 "	-

Table C-19. (continued)

Resource	Solution Five					
	Supply	Level	MVP at the lower activity $	MVP at the upper activity $	Range of MVP	
					Lower activity	Upper activity
R08						
R10	22,003 hr	8,524 hr	8.40	585.40	7,524 hr	8,524 hr
R21	115,000 "	74,243 "	13.40	111.72	0.0 "	75,000 "
R35	300,000,000 "	73,000,000 "	0.12	0.02	72,000,000 "	76,000,000 "
R36	300,000,000 "	152,000,000 "	0.10	0.04	151,000,000 "	154,000,000 "
R37	300,000,000 "	177,000,000 "	0.02	0.04	173,000,000 "	-
R38	300,000,000 "	49,000,000 "	0.01	0.04	44,000,000 "	-
R39	300,000,000 "	29,000,000 "	0.07	0.04	28,000,000 "	-
R40	300,000,000 "	81,000,000 "	0.63	0.04	59,000,000 "	-
R68	60,000 "	24,181 "	37.36	8.40	21,900 "	-
R69	10,000 "	5,330 "	293.84	10.08	5,040 "	-
R70						
R71						
R72	25,000 "	10,996 "	60.01	13.44	9,586 "	-
R74	30,000 "	544 "	48.39	11.76	0.0 "	-
R75	170,000 "	116,202 "	31.46	11.76	115,364 "	-
R76	1,000 "	-	0.0	8.40	0.0 "	-

Table C-19. (continued)

Resource	Solution Six					
	Supply	Level	MVP at the lower activity $	MVP at the upper activity $	Range of MVP	
					lower activity	upper activity
R08	44,006 hr	42,121 hr	11.76	161.23	12,121 hr	44,424 hr
R10	22,003 "	15,721 "	8.40	831.57	14,721 "	15,721 "
R21	150,000 "	146,813 "	13.40	130.22	0.0 "	154,796 "
R35	300,000,000 "	120,000,000 "	0.18	0.04	117,000,000 "	-
R36	300,000,000 "	228,000,000 "	0.10	0.04	228,000,000 "	-
R37	300,000,000 "	279,000,000 "	0.03	0.04	279,000,000 "	-
R38	300,000,000 "	27,000,000 "	0.06	0.04	20,000,000 "	-
R39	300,000,000 "	27,000,000 "	0.12	0.04	21,000,000 "	-
R40	300,000,000 "	145,000,000 "	0.17	0.04	145,000,000 "	-
R68	60,000 "	20,835 "	49.95	8.40	12,512 "	-
R69						
R70						
R71						
R72	120,000 "	78,615 "	23.84	10.08	61,176 "	-
R74	25,000 "	18,870 "	171.96	13.44	18,870 "	-
R75	30,000 "	-	0.0	11.76	0.0 "	-
R76	1,000 "	-	0.0	8.4	0.0	8.4 "