Ministry of Education of the Republic of Moldova

Technical University of Moldova
Faculty “Computers, Informatics and Microelectronics”

Report

Laboratory Work No.2
Operational Research

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Problem 1

You suddenly hear the awesome news that your grand-grand-uncle's cousin, that left to Nigeria a long time ago, has left you with quite a piece of land in the wonderful Telenești area near Budăi (total area is about 1,2 sq. km). You, a huge fan of linear programming, have built this map in order to see things more clearly.

At some point you have decided to grow some crops on this field. Upon consulting the specialists, you arrive to the following options:

- Each 0.1 sq. km of land (not forest) needs 200 lei/month to be taken care of
- Each 0.1 sq. km of the forest costs 100 lei/month for its care
- Keep in mind that you have limited territory for forests! Measure it! Note: Consider that you pay these two at the end of the year out of the profits.
- At least 0.5 sq km of the forest needs to be kept
- You can invite hunters into the forest. The estimated profit there is around 20K lei/sq.km/year
- The potato seeds cost you 100 lei/sq. km
- From each 0.1 sq km of the field you can collect 1 ton of potatoes
- Potatoes can be farmed twice a year.
- A potato tractor costs 500lei/sq. km (It collects your potatoes)
- A ton of potatoes can be sold on the market with 2K lei
- You can also make wine (of course!). Grape seeds cost you 800 lei/sq. km. For simplicity, let's consider that it's a yearly investment. (You kill all the grape plants each year)
- Each 0.1 sq. km of land can give you 2 tons of grapes / year
- The people that collect the grapes need to be paid (there's no wine yet). They ask for 5000lei/sq. km
- You can make 400 litres of wine with 1 ton of grapes
- The wine is sold at 6 lei/litre

Unfortunately, although your kind uncle gave you the land, he didn't give you the money, so you put together three months worth of student's scholarships (a total of 1500 lei) and set out to create the greatest farming empire Budăi has ever seen.
Considering that you're a fan of linear programming, how do you go about organizing this area? What will you farm and how much of the area will you farm?
Using your result, develop a simulation that will show your income over time. Use per-year estimations to develop your method. How will this method change if you consider that you won't have to put the grapes in again each year? How will this change considering that you will pay the grape collectors 2 times less, but give them 100 liters of wine instead?

Solution:

(The basic method we will use is simplex method.)
I used an already implemented class Simplex.
It uses two phase method where in first phase the simplex method is applied to a specially constructed auxiliary linear programming problem leading to a final simplex table containing a basic feasible solution to the original problem.
It assigns a cost of -1 to each artificial variable and a cost of 0 to all other variables in the objective function. Objective function is minimized, and after that runs the simplex iterations.
In the second phase it assign the actual cost to the variables in the func. and a zero to every artificial variable that appears in the basis at the zero level. After that this new objective func. is maximized by simplex meth. to the given constraints.

Income maximization equation:

First that we need to do is to maximize the function in which our variables will represent square kilometers of the land. The function itself will represent the profit of the business, so without the expenses of keeping care of the land.

- x1 will be the forest area, x2 will be the potato area and x3 the grapes area.

z = (20k (lei/sq.km/year) – (10*100(lei per 0.1km)*12(months))) * x1 + (40k(20tons of potatoes, cause farmed twice a year) – (10*200*12) * x2 + (48k (8000litres per year) – (10*200*12)) *x3 = 8000*x1 + 16000*x2 + 24000*x3

The constants beside the variables being calculated for 1 sq. km for the care per month of the area.

Outcome:

- The constraints are formed by the additional expenses and restrictions for the specific area.

(1000+200)x2 + (5000+800)x3 <= 1500
x1 >= 0.5
x1 + x2 + x3 <= 1.2

Where 1500 is the initial investment, and 1.2 the maximum size of the land.

Adds:

By calculating the maximum profit of the next years we change the investment from ”1500” to the maximum profit gained in previous year. By this we will see how the solution will change, gaining better profit cause of less restrictions in procuring supplies.

If we consider that we won't have to put the grapes in again we just don't mention the seeds cost. So it obtains:
1200*x2 + 5000*x3 <=1500

Considering that we will pay the grape collectors 2 times less, but give them 100 liters of wine instead we obtain this constraint and equation for profit:

z = 8000x1 + 16000x2 + 24000x3 – 600
1200*x2 + 3300*x3 <=1500

Results:

Forest area: 0.5
Potatoes area: 0.5565217
Grapes area: 0.14347
Profit: 16347.826

After reinvestment:

Forest area: 0.5
Potatoes area: 0
Grapes area: 0.7
Profit: 20800

No new grape seeds:

Forest area: 0.5
Potatoes area: 0.526315
Grapes area: 0.173684
Profit: 16589.47

Less paid collectors, bonus 100 liters to them:

Forest area: 0.5
Potatoes area: 0.38571
Grapes area: 0.31428
Profit: 17714.28