STUDIA UBB NEGOTIA, LVIII, 4, 2013, pp. 91 - 107
(RECOMMENDED CITATION)

USING MATHEMATICAL MODELS OF DYNAMIC PROGRAMMING FOR ENVIRONMENTAL INVESTMENT PROJECTS

DORU IOAN ARDELEAN[1], TANIA ANGELICA LAZAR[2]

ABSTRACT. This paper aim is to approach the problem of optimizing the functions with restrictions, applying specific methods, algorithms and software to optimize the financial investments for the ecological rehabilitation. The final aim is the improvement of the economic and technological management, therefore increasing the efficiency of implementation.

Key words: *environmental projects, financing, dynamic programming.*

JEL classification: Q56, C53, C61

1. Introduction

The investment decisions of government agencies or private companies are circumscribed by budgets whose magnitudes are largely beyond their control.

Using mathematical programming tools to explore the choice of optimal investment project combinations is not a new concern of researchers and practitioners. For example, Baumol and Quandt (1965) were interested in the issue of capital rationing in investment projects as limiting case of diverging of borrowing and lending-rate problems and used mathematical programming for optimal decision. Cord (1964) developed a

[1] Lecturer dr., Faculty of Economics Sciences, Vasile Goldis Western University of Arad, dard2706@yahoo.com

[2] Teaching Assistant dr., Faculty of Automation and Computer Science, Technical University of Cluj-Napoca, tanialazar@mail.utcluj.ro

model for optimally selecting capital investments with uncertain returns, under conditions of limited funds using dynamic programming is used to compute solutions. Other authors embraced and developed the idea of optimization of funds allocation in investment projects (Krolak, 1970; Shechter and Hammer, 1970; Harvey &Cabot, 1974; Heidenberger, 1996)

The problem of funds allocation in investment projects was formulate in several studies in a stochastic linear programming framework, highlighting that the borrowing rate is an important factor in determining the optimal solution (Kira et al, 2000).

Regarding the problem of funding sources allocation in investment projects, Vasilescu et al. (2000) and Cistelecan (2002) pointed out that in the investment projects, the methods of dynamic programming are appropriate and tools for investment optimizations can be developed.

As regards to the environmental investments project, the range of sources for funding them in Romania comprises the following possibilities (Vacarel et al., 1999; Platon, 1997, 2004): economic agents funds; budgetary funds - the national budget assigns sources for: investments in environment protection, fiscal advantages, subsidizing bank interests, funding of research and development activities; special funds dedicated to some major actions for environment protection; loans granted by World Bank and United Nation Development Program for environment protection; guaranties - collection systems for waste to recycle them; issue of negotiable permits; mandatory insurances against pollution risks; conversion of external debt of some developing countries in funds for environment protection and restoration; Structural Funds of the European Union.

As a difference from developed countries where are used specific and differentiated funds for environmental project, specific for Romania, as the other developing countries, is that the funds are *polyvalent*, funding of ecological restoration for several domains being possible. Because of the scarcity of traditional budgetary funds, the funding of environment projects is based on extra-budgetary mechanisms (Stanciu, 2004). But in a healthy economy, the financing of the environment protection costs has to be provide from private sources, according to the principle ”the polluter pays”. This means that the polluter has to cover the costs of pollution prevention and control. This principle is not applicable in Romania, where it is misunderstood, as a coercive instrument applied to those who violate the allowed pollution norms.

In line with the above considerations, any allocation strategy of environmental projects funding has to take into consideration the whole range of available sources. This situation generates the need to optimize the allocation of financial sources in order to support the decision making for environmental investment projects.

The present paper is unique in its purpose, by offering a decisional model based on mathematical programming, useful for private and public entities from Romania for their funding strategies of environmental projects. In the paper it is described a set of financing alternatives, based on optimization procedures of the funding sources allocation.

We consider the topic of this paper quite useful today due to the fact that from the European Union there are available funds of billions of Euros for environmental projects but the Romanian public and private actors are not able to attract them. Thus, we consider relevant to analyse the reasons leading to such situation and to identify the solutions to overcome this shortfall. One of the main reasons of the very low level of environment funds accessing is the fact that the beneficiaries of such funds are local administrative authorities which fail to adapt their own resources to the funding process of investments carried out during several years. This fact leads to the stoppage of such investments. As a solution for this phenomenon, we consider useful to use mathematical models in environmental investment projects in order to optimize the distribution in time and space of the available sources, which allows the amendment of the annual funding sources structure, based on a model of optimization.

Our paper represents a part of the first study dedicated to ecological restoration of rivers courses from the North-Western region of Romania (Ierului, Turului and Barcaului Valley) having as objective to establish an optimal set of required works for the ecological rehabilitation of these valleys. The approach comprises ecological as well as financial implications for the public and private actors involved in such investments.

Generally, the structure of funding an environmental investment project includes: own funds or initial sources, amortization and external sources (grants or bank loans).

Currently, the problem of funding sources allocation in investment projects can be solved through linear programming, but in the case of investment for ecological restoration, the dynamic programming is more appropriate, due to the different sequences carried out during several years.

The mathematical models of dynamic programming investment consists of a system of recurrence relations and an objective function (Vasilescu et al., 2000), for example referring to maximize profit of the beneficiary obtained during the execution of the investment objective of its output on production capacities put into operation during this period.

The paper "Mathematical Programming using MS Excel Solver, Management Scientist, Matlab" (Cocan and Vasilescu, 1999) is addressed to specialists in various fields, generally managers and all those who want to improve the efficiency of their performance, by taking scientifically based effective decisions. The MS Excel Solver allows calculating solutions for the what-if type scenarios constructed by cells with variable values and cells with restrictions. The Solver module is launched from the Tools menu of the application running MS-Excel, by Solver command.

Further, we illustrate the dynamic programming models using an ecological rehabilitation project for the Ierului Valley.

2. Mathematical models of dynamic programming

Let M a subset of Euclidean space R^n, specified as a set of limitations on the possibilities (equalities or inequalities), called restriction and/or system of recurrence relations which members of M must satisfy. Elements of M are called *admissible solutions*. Les also f be a function defined on M to set R called the *objective function.* An admissible solution that minimizes (or maximizes, if that is the purpose) the objective function is called an *optimal solution.*

The function f has a *local minimum point* x^* if there exists some $\delta > 0$ such that $f(x^*) \leq f(x)$, for all x in M, with $\| x - x^* \| \leq \delta$. Similarly, the function f has a *local maximum point* x^* if there exists some $\delta > 0$ such that $f(x^*) \geq f(x)$, for all x in M, with $\| x - x^* \| \leq \delta$ (Lazar et al., 2009). A global optimum is a point from M which provides the lowest value for all x in M (global minimum) or the highest value (global maximum) for all x in M. Additional conditions about the function f (e.g. the function is convex) are necessary to ensure that the local optimum is also global optimum.

Based on description of the function f and of the subset M, we can classify the problem as linear, non-linear, quadratic, multiple-objective, discrete optimization problem and so on.

Dynamic programming models are carried out in different stages and the results to be obtained in the following periods depend on the decisions that were taken in previous moments (Vasilescu et al., 2000).

Model number 1 - mathematical model of dynamic programming of the proposed investments for the ecological rehabilitation of Ierului Valley.

In order to develop the first mathematical model of dynamic programming we use the symbols:

x - the investment values of ecological rehabilitation, (all the used indicators are expressed in thousands);

i - the year for which the calculation is made;

x_i - the investment values of ecological rehabilitation in years 2010+i-1 (where i = 1,...,10);

$$\sum_{i=1}^{10} x_i = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10};$$

Model number 2 - mathematical model of dynamic programming of the proposed investments for the ecological rehabilitation of Ierului Valley based on costs.

In order to develop the second mathematical model of dynamic programming we use the symbols:

x - the investment values of ecological rehabilitation, (all the used indicators are expressed in thousands);

c – constants related to values of investment ***x***;

i – index of value of the investment x_i where i = 1,...,40;

x_i– the value i for the investment of ecological rehabilitation where i = 1,...,40;

c_i – the constant ***i*** (rate) on the principal amount x_i where i = 11,...,40;

$x_i * c_i$ – costs related to the amount x_i for the ecological rehabilitation investment where i = 11,...,40.

Regarding this, we must do the following considerations:

- x_i – the total investment value for the ecological rehabilitation in 2010+i-1, where i = 1,...,10;
- if i = 11,...,40; j=mod(i-10,3); k=round((i-9)/3); for:
  - j = 0, x_i are the values of total own resources (self-financing) for ecological rehabilitation and $x_i * c_i$ are the investment costs in 2010+k-1 (where i = 11,...,40) ;
  - j = 2, x_i are the values of total attracted sources for investments in ecological rehabilitation and $x_i * c_i$ are the investment costs in 2010+k-1 (where i = 11,...,40);

- j = 1, x_i are the values of total bank loans for investment of ecological rehabilitation and $x_i * c_i$ are the investment costs in 2010+k-1 (where i = 11,…,40).

For i = 1,…,10; j = 10+(i-1)*3, we have:

$$x_i = x_{j+1} + x_{j+2} + x_{j+3}.$$

The total investments value for ecological rehabilitation in 2010 + i-1 are equal to the total own resources (self-financing) for ecological rehabilitation investments in 2010 + i-1, plus total investment attracted sources for ecological rehabilitation in 2010 + i -1 and plus the whole amount of bank loans for ecological rehabilitation investments in 2010 + i-1 (where i = 1, ..., 10).

For i = 11 …,40: $\sum_{i=11}^{40} x_i * c_i = x_{11}*c_{11} + x_{12}*c_{12} + x_{13}*c_{13} + x_{14}*c_{14} + x_{15}*c_{15} + x_{16}*c_{16} + x_{17}*c_{17} + x_{18}*c_{18} + x_{19}*c_{19} + x_{20}*c_{20} + x_{21}*c_{21} + x_{22}*c_{22} + x_{23}*c_{23} + x_{24}*c_{24} + x_{25}*c_{25} + x_{26}*c_{26} + x_{27}*c_{27} + x_{28}*c_{28} + x_{29}*c_{29} + x_{30}*c_{30} + x_{31}*c_{31} + x_{32}*c_{32} + x_{33}*c_{33} + x_{34}*c_{34} + x_{35}*c_{35} + x_{36}*c_{36} + x_{37}*c_{37} + x_{38}*c_{38} + x_{39}*c_{39} + x_{40}*c_{40}$;

3. Optimal model of distributing resources in space and time (material, human and financial) available for an ecological rehabilitation project

Dynamic programming models of investments in ecological rehabilitation are based on the knowledge of Ierului Valley investments funds.

It follows to establish the ecological and economic production capacity to be built in each year of implementation, the quantities of materials required for their operation and their recovery, so that the profit obtained during the execution of the ecological and economic objective, would be maxim.

An example of structure of the sources of financing for ecological rehabilitation projects is:

Financing sources for ecological rehabilitation projects initiated between 2010 - 2014 in Appendix 1, together with data obtained by dynamic programming ecological rehabilitation project financing during 2010-2019 in Appendix 2, allow us to build the table below, which contains the sources of financing for ecological rehabilitation projects during 2010-2019.

Table 1.

Structure of financing sources for ecological rehabilitation projects of Ierului Valley for the period 2010-2019

- thou RON -

Financing sources	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total	Weight (%)
1. Own resources (self-financing)												
Criş Waters Directorate Oradea	0	0	0	0	0	0	0	0	0	0	0	
- Someş-Crişuri Branch ANIF Oradea	0	0	800	800	800	800	800	800	800	800	6400	50,778756
Forestry Departments Bihor and Satu Mare	200,2	200,2	200,2	200,2	200,2	200,2	200,2	200,2	200,2	200,2	2002	
- County Councils Bihor and Satu Mare	31,28	31,28	31,28	31,28	31,28	31,28	31,28	31,28	31,28	31,28	312,8	
- Local Councils	57,76	57,76	57,76	57,76	57,76	57,76	57,76	57,76	57,76	57,76	577,6	
- money	25,76	25,76	25,76	25,76	25,76	25,76	25,76	25,76	25,76	25,76	257,6	
- land	0	0	1600	1600	1600	0	0	0	0	0	4800	
- deposits interests	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	2,6	
- local parishes (land)	0	400	400	400	0	0	0	0	0	0	1200	
- local population	528,56	528,56	528,56	528,56	528,56	528,56	528,56	528,56	528,56	528,56	5285,6	
TOTAL 1 OWN RESOURCES (SELF-FINANCING)	***843,82***	***1243,82***	***3643,82***	***3643,82***	***3243,82***	***1643,82***	***1643,82***	***1643,82***	***1643,82***	***1643,82***	***20838,2***	
2. Attracted sources												
Criş Waters Directorate Oradea	0	0	160	160	160	160	160	160	160	160	1280	42,593118
- Someş-Crişuri Branch ANIF Oradea	16	16	16	16	16	16	16	16	16	16	160	
Forestry Departments Bihor and Satu Mare	160	0	160	0	160	0	0	0	0	0	480	

Financing sources	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total	Weight (%)
- Governmental funds	928	928	928	928	928	928	928	928	928	928	9280	
-Governmental credits	0	0	0	1040	0	0	0	0	0	0	1040	
-Environment Agency Fund	0	0	800	800	800	0	0	0	0	0	2400	
- EU structural funds	0	0	1879,04	0	0	0	0	0	0	0	1879,04	
- LIFE Programme + (Environment agency Bihor and Satu Mare)	0	0	160	0	0	0	0	0	0	0	160	
-Cofinances (various)	0	0	680	0	0	0	0	0	0	0	680	
- Bonds (agricultural companies)	0	0	0	120	0	0	0	0	0	0	120	
TOTAL 2 Attracted Sources	***1104***	***944***	***4783,04***	***3064***	***2064***	***1104***	***1104***	***1104***	***1104***	***1104***	***17479,04***	
3. Bank loans												
-Commercial Banks Romania	0	800	800	800	0	0	0	0	0	0	2400	6,6281261
- European or international banks (repayable funds)	0	0	0	320	0	0	0	0	0	0	320	
TOTAL 3 Bank loans	***0***	***800***	***800***	***1120***	***0***	***0***	***0***	***0***	***0***	***0***	***2720***	
TOTAL 1-3	***1947,82***	***2987,82***	***9226,86***	***7827,82***	***5307,82***	***2747,82***	***2747,82***	***2747,82***	***2747,82***	***2747,82***	***41037,24***	**100**

Data analysis resulting from the calculation of the optimal model of distribution in space and time of hypothetical resources (material, human and financial) available to finance environmental investments of Ierului Valley leads to the following conclusion: the weight of investment projects to finance environmental investments of Ierului Valley represents only about 8% of the hypothetical financial funds held by the actors in the area, to be allocated in an optimistic scenario for the rehabilitation

of Ierului Valley and about 11% of the hypothetical expected value to be allocated in the pessimistic variant of the ecological rehabilitation. This leads to the conclusion that **there are real conditions for ensuring the material, human and financial resources** to its portfolio of investment projects on the rehabilitation of Ierului Valley.

In what follows, we are going to proceed by implementing *the model 2 - the mathematical model of dynamic programming sources available to finance projects on the rehabilitation of Ierului Valley depending on costs.*

Based on the data obtained from the table no. 1, we consider:

- the total annual values obtained by Model no. 1 as fixed and achievable;
- the financing basic structure remains the same, but we change the value of the three components of the process of financing: own resources (self-financing), attracted sources and the bank loans, to achieve - given the actual conditions of the crisis – the optimal alternative, in terms of costs and real economic opportunities of project stakeholders.

We will study 6 alternatives:

1. The reduction of credits at 0.
2. Reduction of own income to 50%: at Someş-Criş Branch of ANIF Oradea, Bihor and Satu Mare Forestry Department; to 0 for: Bihor and Satu Mare county councils, local councils in the area and businesses in the agriculture of the area.
3. Reduction of own incomes to 25% on: Someş-Criş Branch of ANIF Oradea, Bihor and Satu Mare Forestry Department; to 0 for: Bihor and Satu Mare county councils, local councils in the area and businesses in the agriculture of the area.
4. Reduction of attracted funds to 50% on: Someş-Criş Branch of ANIF Oradea, Bihor and Satu Mare Forestry Department; to 0 for: Bihor and Satu Mare county councils, local councils in the area, businesses in the agriculture of the area, the population in the area.
5. Reduction of attracted funds to 25% on: Someş-Criş Branch of ANIF Oradea, Bihor and Satu Mare Forestry Department; to 0 for: Bihor and Satu Mare county councils, local councils in the area, businesses in the agriculture of the area, the population in the area.
6. Standard version with own resources, normal attracted sources (100%) and reduced bank loans, as resulting from the display environmental financed projects *Ierului Valley*.

In this model, for the above six alternatives we have the following common restrictions:

- $\boldsymbol{x_i}$ (where i=1, ..., 10) are the investment values of the financing sources of initial investments of ecological rehabilitation for *Ierului Valley* during 2010, ..., 2019.

The recurrence relations for $\boldsymbol{x_i}$ (where i=1,...,5) will be constructed from the values given in Appendix 1. These relationships are:

- total financing sources in 2010, in amount of 1947.816 thousand RON

$$x_1 \geq 1.947{,}816$$

- total additional financing sources in 2011 than in 2010, in amount of 1,040 thousand RON

$$x_2 - x_1 \geq 1.040$$

- total additional financing source in 2012 than in 2010, in amount of 7279.04 thousand RON

$$x_3 - x_1 \geq 7.279{,}04$$

- total additional financing source in 2013 than in 2010, in amount of 5,880 thousand RON

$$x_4 - x_1 \geq 5.880$$

- total additional financing source in 2014 than in 2010, in amount of 3,360 thousand RON

$$x_5 - x_1 \geq 3.360$$

- the difference in total financing source in 2015 to 2014 is 1,600 thousand related to own resources (self-financing) - land value in the agriculture businesses in the area, 800 thousand RON attracted sources from the Agency Fund for the Environment, 160 thousand RON attracted sources from the Directorate Criş Waters Oradea

$$x_5 - x_6 \geq 2.560$$

- $x_i \geq 0$, i = 1,...,5;
- $x_i = x_{i+1}$ i = 6,...,9;
- *the objective function* is $\boldsymbol{\min\left(\sum_{i=11}^{40} x_i^* \, c_i\right)}$, and represents the total investment costs for financing ecological rehabilitation projects of Ierului Valley during 2010-2019, where:

- for i = 11,...,40; j=mod(i-10,3); k=round((i-9)/3):
- j = 0, x_i are the values of total own resources (self-financing) for

ecological rehabilitation investments and xi*c_i , the related costs to 2010 + k-1 (where i = 11, ..., 40) $c_i = 0$;

- j = 2, x_i are the values of total attracted sources for ecological rehabilitation investments and $x_i * c_i$ the related costs to 2010+k-1 (where i = 11,…,40) $c_i = 0$;
- j = 1, x_i are the values of total bank loans for ecological rehabilitation investment and $x_i * c_i$ the related costs to 2010+k-1 (where i = 11,…,40) $c_i = 15/100$;

- for i = 1…,10, j = 10+(i-1)*3, we have by default the following restrictions:

$$x_i = x_{j+1} + x_{j+2} + x_{j+3},$$

common to the 6 alternatives (the total investment value for ecological rehabilitation in 2010 + i-1 are equal to the total own resources) ecological rehabilitation investment in 2010 + i-1, plus the total attracted sources for investments in ecological rehabilitation 2010 + i-1 and the whole amount of bank loans for ecological rehabilitation investments in 2010 + i-1.

4. Choosing the optimal alternative for financing ecological rehabilitation projects of Ierului Valley

Analyzing the optimization procedures on the allocation of financial resources based on appropriate software, we reach some results that lead to optimal decisions.

Choosing the optimal financing, it can either be done for each project, either considering the amount value of all ecological rehabilitation projects for Ierului Valley, as we are going to do.

We consider that the amount of financing for all ecological rehabilitation projects for Ierului Valley is 41,037,260 RON, for any optimization alternative. We note that the value used to finance those projects may change, for example by increasing the relative cost taking into consideration the cost for obtaining borrowed sources **(**interest, commission, unfavorable exchange rate differences, etc.).

In table no. 2 there are synthesis results on the *structure of financing and the cost of obtaining financing on the all 6 alternatives of optimization.*

For the purpose of this paper, the funding sources of environmental investment projects can be divided in three categories: *own, attracted* and *borrowed* (bank loans) (see Cistelecan M.L., 2002). We consider as

own sources the budgetary funds foreseen in the annual budgetary plan of public administrative entities or private entities (investments' beneficiaries) and available for co-funding the environmental investments, we refer to *attracted sources* as funds acquired from various donors or financers, through their financing programmes (i.e. European Union, Romanian Government Agencies) and by *borrowed sources* we mean contracted funds through bank loans.

Table 2.

Financing sources for ecological rehabilitation projects of Ierului Valley and financing costs suitable to optimization scenarios

Alternatives	Own sources		Attracted sources		Borrowed sources		Total financing sources		Purchase cost financing sources (RON)
	value (RON)	weight of the total (%)	value (RON)	weight of the total (%)	value (RON)	weight of the total (%)	value (RON)	weight of the total (%)	
1.	23.558.220	57,41	17.479.040	42,59	-	-	41.037.260	100	-
2.	10.201.000	24,86	17.479.040	42,59	13.357.180	32,55	41.037.260	100	2.003.580
3.	8.100.500	19,74	17.479.040	42,59	15.457.680	37,67	41.037.260	100	2.318.650
4.	20.838.200	50,78	16.399.040	39,96	3.799.980	9,26	41.037.260	100	570.000
5.	20.838.200	50,78	14.599.040	35,58	5.5.99.980	13,65	41.037.260	100	840.000
6.	20.838.200	50,78	17.479.040	42,59	2.720.000	6,63	41.037.260	100	408.000

It should be noted from the very beginning that the projects financing cost is directly proportional with the weight of the interest bearing borrowed sources in the total financing sources.

-***Version 1***-The financial costs are 0.00 RON, because financing is based on a maximum level of own sources (57.41%) and of attracted sources (42.59%).Therefore, loans are not needed (0.00%). However, *this alternative is not applicable to current conditions* because generally, the public actors interested in projects financing do *not have sufficient own sources* and also they are not willing to fully exhaust them on financing only environmental investment projects. On the other hand, getting funds for environment projects is marked by uncertainty due to the increasing national and international competition for Community Funds. Therefore, *version 1 is not used in any real situation*.

- ***Version 2*** *h*as a *large financing cost* of 2.003.580 RON, plus the value of the initial financing, resulting in a total financing of ecological rehabilitation projects of Ierului Valley of 43,040,840 RON (financing increase with 4.88%). There are used a *few own sources* (24.86%) – that are much reduced during the crisis - and *the highest level of attracted*

sources (42.59%), desirable situation for players with weak economic and financial power, especially in crisis conditions. Appealing to more borrowed sources (32.57%), increases the cost of financing. Therefore, *loans purchased are acquired over a longer period of time* (at least in the medium term), that is after the financial crisis. But this version is marked by uncertainty, especially in terms of attracted funds.

-Version 2 has a *higher financing cost* of 2.003.580 RON, to which is added the value of initial financing, resulting a total amount for ecological rehabilitation projects for the Ierului Valley of 43,040,840 RON (a financing increase of 4.88%). The level of own sources is low (24.86%) - the decrease is due to the economic crisis- and that of attracted sources is the highest (42.59%). It is a desirable situation for economically and financially weak players, especially during the economic crisis. By using more borrowed sources (32.57%) the financing cost is increasing. As a result, the *purchased loans* are acquired for a longer period of time (at least on the medium term). However, this version is marked by uncertainty, especially in terms of attracted funds.

- ***Version 3***. It uses the *lowest weight of own sources* (19.74%) and the *maximum weight of attracted sources (*42.59%) and also of the *borrowed sources* (37.67%), which will lead to higher final costs (2.318.650 RON) and the project financing cost will increase to 41.037.260 + 2.318.650 = 43.355.910 RON, meaning a increase of 5.65%. This version has several drawbacks, such as: high financing cost (5.65%) and the uncertainty to provide a high level of attracted sources (42.59%). *Therefore, this version is not preferred under normal conditions.*

- ***Version 4*** has the following financing structure: *a high weight of own sources* (50.78%), *a modest weight of attracted funds* (39.96%) and *the lowest weight of loan sources* (9.26%). It is a version with a lower financing cost of only 570.000 RON. It would be a plausible option if public actors could provide their own financial resources.

- ***Version 5*** consists of : a *high weight of own sources* (50.78%), a *lower weight of attracted funds* (35.58%) and *reasonable borrowed sources* (13.65%), resulting a reasonable cost of buying sources, of 840.000 RON. In this case, the project depends on the high level of own sources.

- ***Version 6*** is considered a normal one. The financing sources comprise: a *high weight of own funds* (50.78%) and *attracted funds* (42.59%) and *low weight of loans* (6.63%). The *financing cost is reduced* to the level of 408.000 RON. This is *the best option for projects financing*

under a normal financial statement, but not recommended due to the high level of own resources very difficult to be provided in times of crisis.

5. Conclusions

The project of ecological restoration of Ierului Valley had as a main aim to conserve and protect wet areas containing reminiscences of ancient primary and secondary vegetation and flora existing in this location. It is expected at the end of restoration project of the Ierului Valley to regain its former look, disappeared as a result of sewerages and inning, and to offer to the local population the needed natural resources from rehabilitated ecosystems

The economic crisis of 2008-2012 had a direct impact on the amount of financial resources available at the level of administrative entities involved in the project, called 'own resources'.

Due to this situation, the best financing alternative for the project under scrutiny is that using a lower level of 'own sources' category.

As such the second and third versions (alternatives) proposed above are suitable. Thus, the second version might be better since it has the lowest final cost (24.86 % own funds + 42,59% attracted sources + 32,55 % borrowed sources at a cost of 2.003.580 RON).

This means that there is an alternative to contract a bank loan of 13.357.100 RON, but due to bank interests and fees, it can be refunded in a medium term of 5-10 years, when the crisis will be past.

Therefore, given the current conditions, the established goals cannot be achieved with a minimum level of costs and a maximum level of effects.

Certainly, if the general financial situation will improve and the actors interested in environment projects will possess an enhanced ability to attract community resources and higher budgetary funds, the optimization program proposed in our paper allows to pass to another financing version, for example to alternative 4, 5 or 6, with lower financing costs between 408.000 – 840.000 RON.

The paper highlights various alternatives useful for administrative entities in their decision taking process on financing environment projects. They can choose the appropriate alternative taking into consideration the availability of budgetary funds dedicated to 'own resources' in financing environment projects.

REFERENCES

Baumol, W.J and Quandt, R.E (1965), *Investment and discount rates under capital rationing-a programming approach*, The Economic Journal, Vol. 75, 298, pp.317-329

Cistelecan M.L. (2002), *Economia, eficienta si finantarea investitiilor*, Ed. Economica, Bucuresti;

Cocan M., Vasilescu A. (2000), *Programarea matematică folosind MS Excel Solver, Management Scientist, Mathlab,* 2nd edition, Ed. Albastra, Cluj-Napoca;

Cord, J. (1964), *A method for allocation funds to investments projects when returns are subject to uncertainty*, Management science, vol.10, issue 2,pp.

Heidenberger, K. (1996), *Dynamic project selection and funding under risk: A decision tree based MILP approach*, European Journal of Operational Research, 95(2), pp.284-298

Herbei M., Mazuru L., Foroglu I. (2006), *Gestiune financiară*, Ed. Mirton, Timisoara;

Kira, D.,Kusy, M., Rakita, I. (2000), *The effect of project risk on capital rationing under uncertainty*, The Engineering Economist, 45 (1), pp.37-55

Krolak,P.D. (1971), *Portofolio evaluation & re-evaluation: an experiment in subjective probability, man-machine learning and decision making*, Decision science 2(2), pp:225-238

Lazar V., Lazar T., Petrusel G. (2009), *Matematici aplicate in economie*, Ed. Casa Cartii de Stiintă, Cluj-Napoca;

Platon, V. (1997), *Protecția mediuluis si dezvoltarea economica. Institutii si mecanisme in perioada de tranzitie*, Editura Didactica si Pedagogica, Bucuresti;

Platon, V. (2004), *Finantarea activitatilor de protectie a mediului. Intre teorie si practica*, Editura Economica, Bucuresti;

Shechter,M. and Hammer, P.L. (1970), *A note on the dynamic planning of investment projects*, European Economic Review 2(1), pp.111-121

Stanciu, V., Bran, A.G., Bran, Fl. (2004), *Politici financiare de protectia mediului*. In Volumul Sesiunii de Comunicari Stiintifice "Lumea financiara-prezent si perspective" Cluj Napoca, 12-13.12.2004, p.700-704;

Vasilescu I., Romanu I., Cicea Cl. (2000), *Investitii*, Ed. Economica, Bucuresti;

Vacarel, I., Angelache, G., Bercea, F., Bistriceanu, Gh.D., Bodnar, M., Mosteanu, T., Georgescu, Fl. (2000), *Finante publice*, Editia a II-a, Editura Didactica si Pedagogica;

Vivien F.D. (1994), *Economie et écology*, Ed. La Décuverte, Paris.

Appendix 1

Structure of financing sources for ecological rehabilitation projects of Ierului Valley for the period 2010-2014

Financing sources	2010	2011	2012	2013	2014	Total
1. Own resources (self-financing)						
Cris Waters Directorate Oradea	0	0	0	0	0	0
- Somes-Crisuri Branch ANIF Oradea	0	0	800	800	800	2400
Forestry Departments Bihor and Satu Mare	200,2	200,2	200,2	200,2	200,2	1001
- County Councils Bihor and Satu Mare	31,28	31,28	31,28	31,28	31,28	156,4
- Local Councils	57,76	57,76	57,76	57,76	57,76	288,8
- money	25,76	25,76	25,76	25,76	25,76	128,8
- land	0	0	1600	1600	1600	4800
- deposits interests	0,26	0,26	0,26	0,26	0,26	1,30
- local parishes (land)	0	400	400	400	0	1200
- local population	528,56	528,56	528,56	528,56	528,56	2642,8
TOTAL Own resources (self-financing)	***843,82***	***1243,82***	***3643,82***	***3643,82***	***3243,82***	***12619,10***
2. Attracted sources						
Cris Waters Directorate Oradea	0	0	160	160	160	480
- Somes-Crisuri Branch ANIF Oradea	16	16	16	16	16	80
Forestry Departments Bihor and Satu Mare	160	0	160	0	160	480
- Governmental funds	928	928	928	928	928	4640
- Governmental credits	0	0	0	1040	0	1040
- Environment Agency Fund	0	0	800	800	800	2400
- EU structural funds	0	0	1879,04	0	0	1879,04
- LIFE Programme + (Environment agency Bihor and Satu Mare)	0	0	160	0	0	160
- Cofinances (various)	0	0	680	0	0	680
- Bonds (agricultural companies)	0	0	0	120	0	120
TOTAL 2 Attracted sources	***1104***	***944***	***4783,04***	***3064***	***2064***	***11959,04***
3. Bank loans						
- Commercial Banks from Romania	0	800	800	800	0	2400
- European or international banks (repayable funds)	0	0	0	320	0	320
TOTAL 3 Bank loans	***0***	***800***	***800***	***1120***	***0***	***2720***
TOTAL 1-3	**1947,82**	**2987,82**	**9226,86**	**7827,82**	**5307,82**	**27298,14**

Appendix 2

Dynamic programming sources of financing environmental rehabilitation projects of Ierului Valley during 2010-2019

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	
-1	1	0	0	0	0	0	0	0	0	1.040,00
-1	0	1	0	0	0	0	0	0	0	7.279,04
-1	0	0	1	0	0	0	0	0	0	5.880,00
-1	0	0	0	1	0	0	0	0	0	3.360,00
0	0	0	0	1	-1	0	0	0	0	2560
1	0	0	0	0	0	0	0	0	0	1.948
0	1	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	-1	1	0	0	0	0
0	0	0	0	0	-1	0	1	0	0	0
0	0	0	0	0	-1	0	0	1	0	0
0	0	0	0	0	-1	0	0	0	1	0
1	1	1	1	1	1	1	1	1	1	
1.947,82	2.987,82	9.226,86	7.827,82	5.307,82	2.747,82	2.747,82	2.747,82	2.747,82	2.747,82	41.037,2