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# The Efficiency of the Irrigation Systems Investment

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**The scope of the paper is to analyze the efficiency of investment in irrigation project. Specific themes analyzed are related to the study of irrigation investments and the efficiency of their settlement. Another nowadays problem is linked by major climate change that affect agriculture sector efficiency in general. Finally, the paper aims recommendation and solutions for financial and project management and for increase public administration efficiency facing worldwide major problems regarding scarcity and resources.**

**Keywords: Financial Management, Project Management, Efficiency, CPM Method, PERT Method, Climate Change, Irrigation.**

## I. INTRODUCTION

The management concept, as process, function and interest, is related to activities of leading, controlling, organizing, training, assessment, administration and foresight a business [3], like in Figure 1.

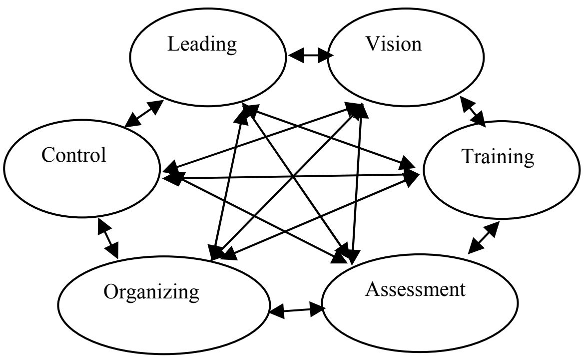


Fig. 1. Management concept
Source: by author using [3]

Project management activity concerns public or corporate finance management, as part of business management from public and corporate management (Figure 2), in order to increase competitive advantage in the market.
Corporate Finance Management is related to the decisions company takes in investing and financing operational activity both in public and private markets as Financial Management drives the activity of a private or public company to their financial and operational goals using accounting and financial data.
An investment is a financial and accounting process, through company follows to obtain probably profit (interest) or future cash-flow. In investment process three issues are considered:

1. The decision to invest,
2. Ąe selection of the investment projects,
3. The settlement of indebt firm policy and company productivity.

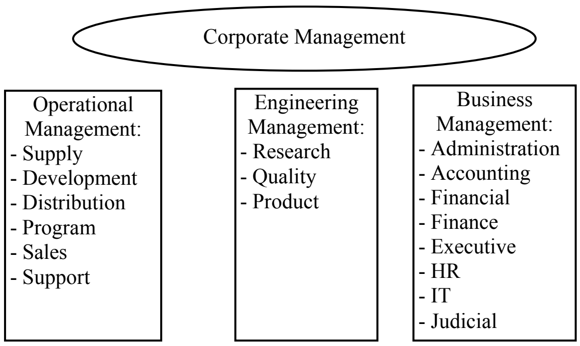


Fig. 2. Corporate Management System
Source: by author using [1]

The decision to invest is the most important financial decision a Chief Financial Officer (CFO) and manager must take, because of the amount of many implicated, the period and the high level of risk.
In the frame of environmental resources management, the water is considered not just a commercial product, but a heritage people must protect for the future of mankind.
The investment in water management system may be represented by [8]:
a) Equipment for water caption: plugs with pumping and/or gravitational, pipes, forage pits, aspiration and suppressing basins, defense and consolidation of (water) banks, works for conducting the water currents, with the assembly of the proper equipment;

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b) Equipment for water adduction and distribution: pipes, canals, hydrotechnical nods, dams, constructions of passage and under-passage, pumping stations, aspiration and suppressing basins, consolidations, stuffs, with the assembly of the proper installations;
c) Equipment for internal settlement: canals and underground pipes, which are feeding with water the irrigation installations and as it is the case, the assembly of the mobile pumping aggregates and of the proper installations, works of land levelling;
d) The assembly and fixing of the irrigation installations and of the pumping mobile aggregates;
e) Equipment for the water evacuation in case of damages: canals, pipes, evacuators, dams, with the proper installations;
f) Manufacture of irrigation equipment and installations.
The motivations of decision to invest in such irrigation equipment are related to the following reasons:

- For to rise and enhance the quality and quantity of the crop (agriculture production) according to present challenges (the overgrowing population and health risk and food security);
- For to grow up production capacity in order to satisfy the agriculture products and services demand;
- For to keep or develop the advantages comparing with the competitors;
- For to maintain or increase the market share of the company;
- For to explore and use the advantages of the new technologies;
- For to save the more and more scarce water resource;
- For to ameliorate the use of the land production factor;
- For to be prepared in case of emergency or natural disasters in the existing environment challenges (climate change, global warming, precipitation and temperature modification, water security alert and health risk, droughts conditions, environmental and soil degradation, wastage in using the clean water, increasing poor rainfall, depletion of ground water resources, greenhouse gas) and to reduce the loss.

The right decision supposes

1. To run certain steps of work (activity): to determine the cost of the investment, to find the financial sources, to foresee cash-flow, to determine the total cost of the investment, to compare the total cost with the estimated cash-flow;
2. To establish the methods used in project selection: with considering present value (net present worth method) or without considering present value (the time the investment is recovered). The method used take into consideration the liquidity, the time and the risk;
3. To evaluate the risk of the investment (Table 1) depending by the investment scope being well known that a high risk of a project supposes high level of the profit and reverse.

Table 1. Risk evaluation table

| Scope | Product/Market | Risk degree |
|---|---|---|
| Crop rising | Same/same | low |
| Distribution enlargement | Same/same | Low |
| Production diversification | New/same | low |
| Crop rising | New/same | Medium |
| Crop rising | New/new | medium |
| Production diversification | New/new | high |
| New technologies | New/new | high |

For a successful project, the project managers create a risk control list giving marks for every type of factors [6].

## II. METHODOLOGY

The methodology used in project management is from network analysis. The method in network analysis are focused on computing and optimizing the critical path between the activities [4]. The basic network analysis methods include Critical Path Method (CPM), Critical Chain Method (CCM), Program Evaluation and Review Technique (PERT), Graphical Evaluation and Review Technique (GERT), Metra Potential Method (MPM) [5]. CPM and PERT Methods will be aplied to solve the irrigation project management proposed in this paper.

## III. IRRIGATION PROJECT DESIGNING USING PERT AND CPM METHOD

The project represents a sequence of certain activities (that can be thousand as number), well determined on time, with the purpose to create a new product or technology. The difficulty of the project implementation depends also on the number of activities. The present paper is referring to a project of implementing a new irrigation equipment and technology.
The first step is to describe the project crystal clear for people implicated in the project: the list of all activities and time required, the sequences of the activities and the dependencies between them, the model of the network (the network between the activities.
If the project is at first time, it is recommended to use Program Evaluation and Review Technique Method (PERT Method), with periodically actualization of the project. In the case the time for the activities of the

project can be expressed more preciously it is recommended to use Critical Path Method (CPM).
In the frame of this paper we call "work" the process of implementation or manufacturing activities targeted towards execution and setting the irrigation investment. The work has more activities. An activity represents the sum of rather homogeneous operations, which participate to the achievement of a part of the work. The model is the network diagram formed by arches (represented by the activities) and nodes (represented by the start-end events).
The program represents the sequence of activities executions, so that the whole work finishes in planned terms, without surpassing the resources allocated. Every activity is formed by a set of events and the event means the stage an activity can be at a certain moment. Any activity is between two events: starting and ending ones [10]. If the investment's work (W) has n activities then (1):

$$A=(a_1, a_2, \ldots, a_i);\ i=1 \ldots n \qquad (1)$$

Where A is the set of activities,
$a_i$ - the activity number i
PERT Method supposes to create the draft of the network activity, to estimate (optimistic, realistic and pessimistic) the time of each activity, to compute time statistics (using beta distribution, equation 2), to determine the critical path, and to analyze the probabilities.

$$\bar{d}_n = \frac{a+4b+c}{6} \qquad (2)$$

Where $\bar{d}_n$ is the investment shared average period of time
a – optimistic time,
b – realistic time,
c - pessimistic time.
The main difference between CPM and PERT Methods consists in the evaluation of the duration for executing certain activity: In CPM the period of time is evaluated in a certain number of days, but in PERT Method the period of time is appreciated in three situations: optimistic (the shortest, "a"), pessimistic (the longest, "c") and probable ("b"). The average value is calculated with relation 2.
The dispersion is computed with equation 3 and the average squared deviation with equation 4 [2]:

$$\sqrt{\sigma^2} = \frac{c-a}{6} \qquad (3)$$

$$z = \frac{d_p - \bar{d}_n}{\sigma^2} \qquad (4)$$

Where $\sqrt{\sigma^2}$ represents Average Squared Deviation,
$\sigma^2$ - represents Dispersion,
z – represents probability factor,
$d_p$ – represents planned duration of investment.
Furthermore, it is necessary to introduce a succession relation between all activities.
In irrigation investment project, we suppose that there are identified 7 activities, from $a_1$ to $a_7$ (Table 2).

Table 2. Investment activities and execution time

| Activity symbol (a) | Start-end of a | Name of a | Time for a (in days) | Symbol of previous activity |
|---|---|---|---|---|
| $a_1$ | 1,2 | Project execution draft | 18 | - |
| $a_2$ | 2,3 | Work space organization | 3 | $a_1$ |
| $a_3$ | 3,5 | Equipment 1 acquisition | 36 | $a_2$ |
| $a_4$ | 2,4 | Equipment 2 acquisition | 3 | $a_1$ |
| $a_5$ | 4,5 | Equipment 3 acquisition | 30 | $a_4$ |
| $a_6$ | 5,7 | Equipment assembling | 6 | $a_3$ |
| $a_7$ | 2,6 | Prepare for manufacturing | 36 | $a_1$ |

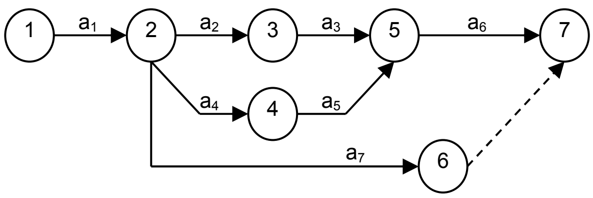

Fig. 3. Work graph for irrigation investment

The graph of investment activities and events (networks system of oriented arches, bordered by nodes) is illustrated in Figure 3.
Looking Figure 3, we can notice that there are more paths from event 1 to event 7: $P_{12357}$, $P_{12457}$ and $P_{1267}$ (so called full paths), the longest full path is called critic path:

$P_{12357}$=18+3+36+6=63 days (5)
$P_{12457}$=18+3+30+6=57 days (6)
$P_{1267}$=18+36+0=54 days (7)
$P_{cr}$ =max ($P_{12357}$, $P_{12457}$, $P_{1267}$)= $P_{12357}$=63 days (8)

The longest path is called critical. In our example, $P_{12357}$ is the critical path ($P_{cr}$) because it has the longest length (equations 5, 6, 7). Thus, the uncritical path has time reserves (represents the difference between maximum terms till activity execution is accepted and possible minimum terms). There are four moments: the earliest time to start the activity ($t_i$), the earliest time to finish the activity ($T_i$), the latest time to start the activity ($t_j$), and the latest time to finish the activity ($T_j$).
The minimum and maximum terms are established using optimality principle (relations 9 and 10).

$$t_i = maxP_{1i} \text{ and } t_j = maxP_{1j} \qquad (9)$$

$$T_i = P_{cr} - maxP_{in} \text{ and } T_j = P_{cr} - maxP_{jn} \qquad (10)$$

Where n represents the final event of the work

Using minimum and maximum term of the events we may calculate time reserve for each activity. Thus, we obtain:

$t_1 = 0;$

$t_2 = maxP_{12} = P_{12} = 18$ *days;*

$t_3 = maxP_{13} = P_{123} = 18+3 = 21$ *days;*

$t_4 = maxP_{14} = P_{124} = 18+3 = 21$ *days*

$t_5 = maxP_{15} = max(P_{1235}; P_{1245}) = max(18+3+36; 18+3+30) = max(57;51) = 57$ *days*

$t_6 = maxP_{16} = P_{126} = 18+36 = 54$ *days*

$t_7 = maxP_{17} = max(P_{12357}, P_{12457}, P_{1267}) = max(18+3+36+6, 18+3+30+6, 18+36) = max(63, 57, 54) = 63$ *days*

$T_7 = P_{cr}-0=63$ *days*

$T_6 = P_{cr}-P_{67} = 63-0 = 63$ *days*

$T_5 = P_{cr}-P_{57} = 63-6 = 57$ *days*

$T_4 = P_{cr}-P_{47} = T_5-P_{45} = 57-30 = 27$ *days*

$T_3 = P_{cr}-P_{37} = T_5-P_{35} = 57-36 = 21$ *days*

$T_2 = min(T_3-P_{23}; T_4-P_{24}; T_6-P_{26}) = min(31-3; 27-3; 63-36) = min(18; 24; 27) = 18$ *days*

$T_1 = T_2-P_{12} = 18-18 = 0$ *days*

If planned term of investment execution is 36 days, the probability factor is 0.127 (using relation 4).
Using Laplace function and interpolation methods it is obtained the probability of 54.09% that indicate a proper programming (under 25% it means very short term and above 60% indicates many time reserves, so it will be redacted), see Table 3.

Table 3. Average Squared Deviation and Dispersion

| $a_i$ | Activity duration | | | | $\sqrt{\sigma^2}$ | $\sigma^2$ |
|---|---|---|---|---|---|---|
| | a | b | c | $\bar{d}_n$ | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| $a_1$ | 16 | 17.5 | 22 | 18 | 1 | 1 |
| $a_2$ | 2 | 3 | 4 | 3 | 0.33 | 0.11 |
| $a_3$ | 30 | 36 | 42 | 36 | 2 | 4 |
| $a_4$ | 2 | 3 | 4 | 3 | 0.33 | 0.11 |
| $a_5$ | 25 | 29 | 39 | 30 | 2.33 | 5.43 |
| $a_6$ | 4 | 6 | 8 | 6 | 0.67 | 0.45 |
| $a_7$ | 30 | 36 | 42 | 36 | 2 | 4 |
| Total. | 52 | 62.5 | 76 | 63 | 4 | 16 |

After program is finished in its optimum variant, Gantt graph will be elaborated.
A very important facility of this method is that prolonging execution dates of some activities, in the framework of time reserves, it is possible to obtain cost reduction linked by the work deployment [1]. Therefore, this model is known in scientific literature as cost-time function optimization (Figure 4). In some condition, the investment execution period can be shorted, but this supposes cost increase (urgency cost). But also, an exaggerated prolonging can produce certainly cost increases.
After the convenient variant is chosen, and after all terms was established, we go to the investment launching process, re-drawing Gantt graphic depending by chosen variant, needed resources and mean for achieve any activity in established terms, passing, step by step Gantt graphic.
Any modification in the system leads to the program re-optimization.

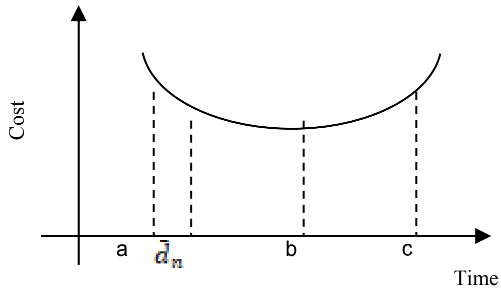


Fig. 4. Cost-time evolution

## IV. CONCLUSIONS

In planning and designing irrigation investment project in good conditions, we use Critical Path Methods. First, we ordered different sequential activities so that the results to correspond with the main target of the project, from terms and resources allocation points of view [10]. The designing process supplies data about economic and technical optimum and the planning process bunches economic and technical optimum with social optimum. In conclusion both methods of network analysis have been successfully applied in the paper. For a successful economy it must be created successful new projects or to develop the existent project properly.

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