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The Economic Development of Dam Construction Projects by Applying A Critical Chain Project Management

By Mohammad Javad Khosravi
Islamic Azad University

Abstract- The dam construction industry in Iran has always been considered as one of the country's most important industries due to the lack of rainfall. To accomplish this, we need to properly manage the dam construction process. Traditional algorithms, such as the Critical Paths Methods (CPM) and Program Evaluation and Review Technique (PERT) have been used since ancient times to plan and control most of the projects, including dam construction projects. With traditional methods of project management, a large percentage of time and resources are often lost due to reasons such as the lack of prioritization, student syndrome, and bad multi-tasking. The Critical Chain Project Management (CCPM) is a method for project planning, with emphasis on the resources needed to carry out the project. In this research, which was done on the Kahir reservoir, the CPM method was first used and then analyzed by CCPM method. Using resource dependency, identifying and embedding project buffers and leveling resources in this study reduced the implementation time of the project for 27 days

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I. INTRODUCTION

Increasing the population of cities and the people's desire to live in urban areas, reduce rainfall and imbalance in rainfall, has led the country's managers to increasingly control surface water management. There fore, managers considered building the dam as a strategic factor to deal with these problems. In fact, most developed countries consider the construction and implementation of numerous water resource development projects to accelerate the development of economic and social development. Dams are one of the most important development infrastructures with an emphasis on drinking water supply and increasing economic growth through irrigation of agricultural products, increased subsurface production and power generation, and flood control. Recognizing and evaluating these impacts in the process of sustainable rural development in relation to the situation of villages can be very useful and in order to exploit the capabilities created as a result of the construction of the dam.

Author : Ph.D Student of Urban Development, Islamic Azad University, Tehran North Branch. e-mail: Khosravicbr@gmail.com

In addition to the positive effects of these structures, we often see their negative impacts in various social, economic and environmental dimensions. Population displacement, migration, change in the type of economic activity, the spread of diseases and the disappearance of plant and animal species are among the negative effects of these structures. In recent years, extensive research has been carried out on the dam construction industry. Of the most important branches in the dam construction are flood control[1-4], water supply[5, 6], hydroelectric power generation[7], irrigation [8], reservoir operation [9-17], environmental and so on[18-24].

II. RESEARCH METHODOLOGY

a) Kahir Reservoir Dam

Kahir dam is a Roller-Compacted Concrete (RCC) type with a capacity of 314 million cubic meters (MCM)with the aim of irrigation and water supply since its launch in 2011.The lake has a length of 21 km, an overflow capacity of 8560 m^3/sec, a reservoir area of 23 km^2, and an overflow type is Ogee spillway without a valve. The length of the crest of the dam is 382.5 m, the width of the crown is 5 meters, the height is 54.5 meters and the volume of the reservoir is 314 million cubic meters in normal size.

Annual water supply of 20 MCM is carried out irrigation under pressure method, Chabahar and Konarak industries amount to 13 MCM, supply of drinking water from Chabahar and Konarak to 15 MCM, Rural water supply to 1400000 m3, and Artificial feeding on the bottom of the Kahir Dam is about 5 MCM of the general purpose of making the Kahir Reservoir. After using this dam, 2,450 hectares of downstream agricultural land will be used for irrigated irrigation systems. Other information is given below.

Location: Sistan and Baluchestan province
City: Chabahar
Dam site: 5 km north of the Kahir village
Purpose: Providing agricultural and drinking water
Adjustable water Annual: 55 MCM
Basin: Persian Gulf and Oman Sea
Sub-basin: Baluchestan rivers
River name: Kahir
Reservoir storage in normal: 314 MCM
Executive: Sistan and Balouchestan Ministry of Water

Figure 1: location of dam site

III. Methodology

Floatation and leveling of resources in the project:

The following table is part of the Work-Breakdown Structure (WBS) of the Kahir dam construction project (dam body), which is used by the CPM method to control the project.

Table 1: Work-Breakdown Structure (WBS) of construction of the body of the Kahir dam using CPM method

Activity	Duration of activity (day)	Start (day)
Excavation of the body of dam	25	7
Guide wall reinforcement	68	16
Guide wall formatting execution	69	22
Guide wall concrete construction	67	25
Excavation of dam Cut off Wall	8	30
Drilling	515	32
Regularization and profiling of substrate for shell execution	12	35
Execution of plastic concrete in sealing wall	523	39
Filtration and horizontal drain	423	44
Implementation of RIP Rap	501	44
Preparation and execution of the shell of the first part	419	45
Execution of clay layers	412	45
Execution of filter and straight drainage	349	45
Execution of sealing wall	531	274

The following chart also shows the Gantt Chart of the CPM method of activity related to the dam body. The total of these activities is 799 days. The red color indicates the criticality of the activities. The resource chart used with the CPM method for the dam body section is given below. It is clear that this chart is before the leveling of resources.

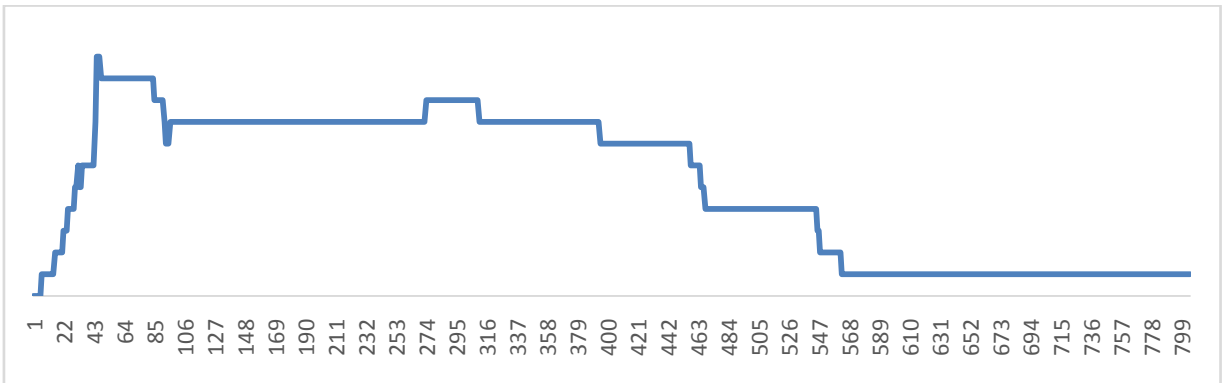

Figure 2: Resources used in the dam body through the CPM method before resources leveling

After applying the changes to the floats, we get the following results. (The origin of the starting day is shown in the table below as of August 22, 2012)

Table 2: Work-Breakdown Structure (WBS) of the construction of body in Kahir dam using CCPM method

Activity	Duration of activity (day)	Start (day)
Excavation of the body of dam	25	0
Guide wall reinforcement	68	15
Guide wall formatting execution	69	83
Guide wall concrete construction	67	152
Excavation of dam Cut off Wall	8	23
Drilling	515	25
Regularization and profiling of substrate for shell execution	12	28
Execution of plastic concrete in sealing wall	523	232
Filtration and horizontal drain	423	137
Implementation of RIP Rap	501	193
Preparation and execution of the shell of the first part	419	38
Execution of clay layers	412	38
Execution of filter and straight drainage	349	93
Execution of sealing wall	531	265

A comparison chart of the CPM and CCPM method is presented in the following figure. As can be seen clearly, the CCPM method does not exceed the maximum amount of resources.

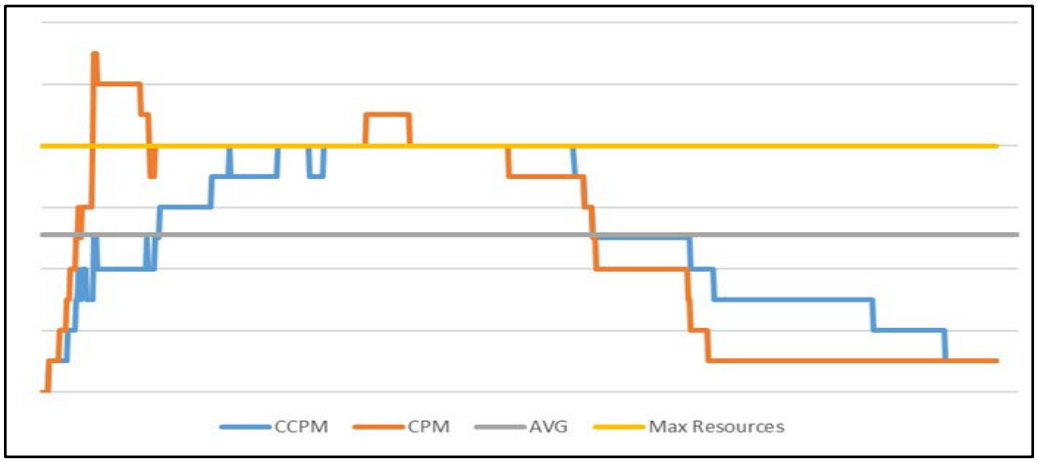

Figure 3: Resource chart used in the dam body using CCPM method after resource leveling

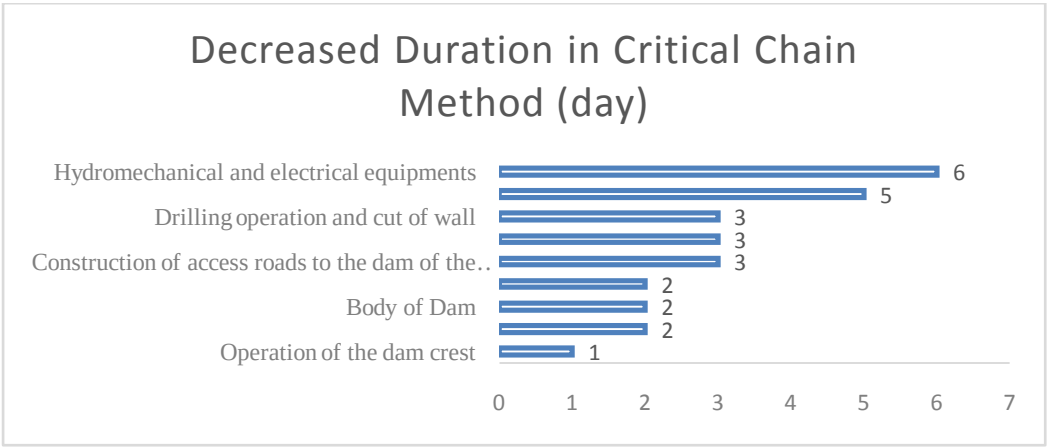

Figure 4: The decreased duration of activities in the CCPM method

The total duration of the project is 1348 days based on the CCPM method. This amount reduced the completion time of the project by 27 days to the planned CPM duration.

IV. Results and Discussion

As shown in the figures below, taking into account the floats and slack in the activities, the activities move as far as possible to the extent that they allow the leveling of the maximum resources to be appropriate. These changes are available to reduce resources to reach available resources. The result of the time of these changes was to shift the time of some activities to the Finish to Start type. Most of the changes in the current example are from day 394 to day 452 and from day 497 to day 764.We are seeing a decrease in resources in the 15th to 202th and 226th to 230th and 273th to 312th days of the project in order to flatten the resources. Most of the changes mentioned above are due to the shifting of the reinforcing operations, the formatting and execution of the guide wall, Execution of plastic concrete in cut off wall and the implementation of the horizontal drain filter. Due to the lack of flotation in the excavation of the body of the dam, the excavation of the dam's cut off wall and profiling of the substrate for the shell execution, as well as the preparation and implementation of the shell (in the first part) and the implementation of clay layers (Due to being in critical activities), there was no shifting in these cases.

Allocation of resources in CPM and CCPM Procedures

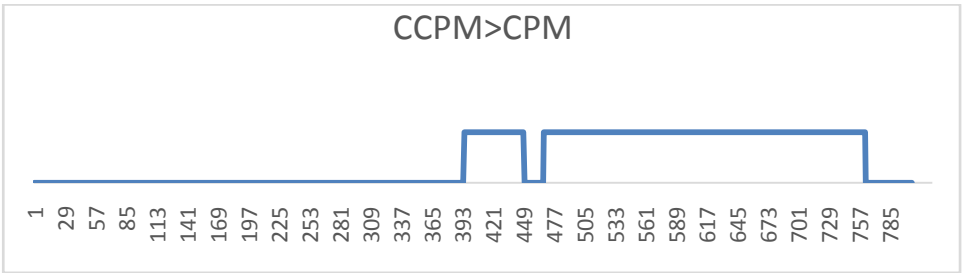

Figure 5: Comparison of the days when the sources of the CCPM method are higher than the CPM method

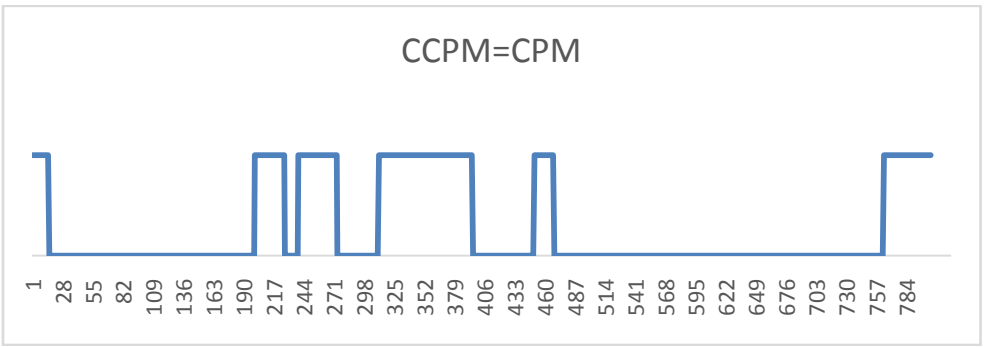

Figure 6: Comparison of the days when the sources of the CCPM method are equal to the CPM method

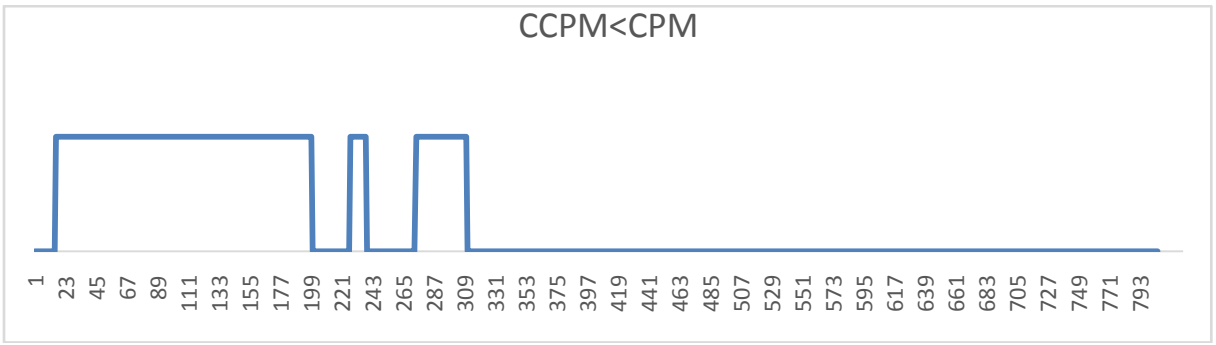

Figure 7: Comparison of days when resources of the CCPM method are less than CPM

V. Allocation of Resources and cpm Method

As indicated in the figures below, the amount of resources available in the CPM method at some time intervals from the project is greater than the maximum amount of allocated resources. The resource constraints lead to the use of critical chain management method (CCPM) in project control. Therefore, in order to solve

this problem, the difference in resources needed for project management and control with the CPM method should be reduced to the maximum amount of available resources to zero.

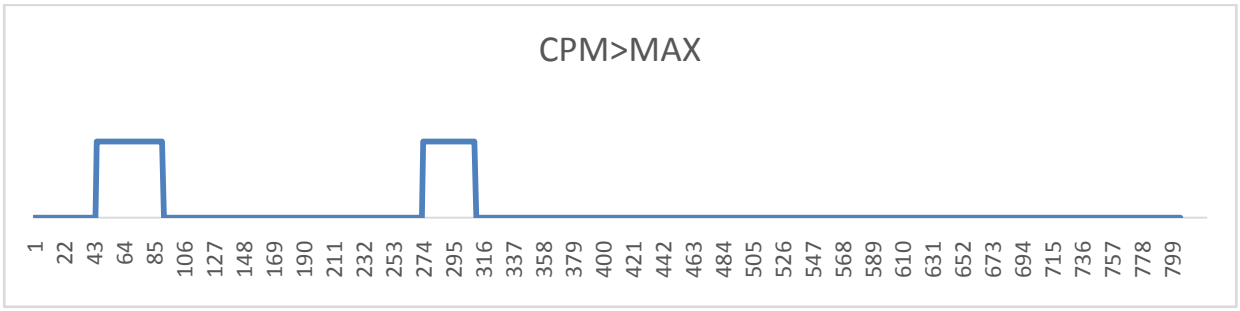

Figure 8: Comparison of days of the project where the resources of the CPM method are greater than the maximum amount of resources.

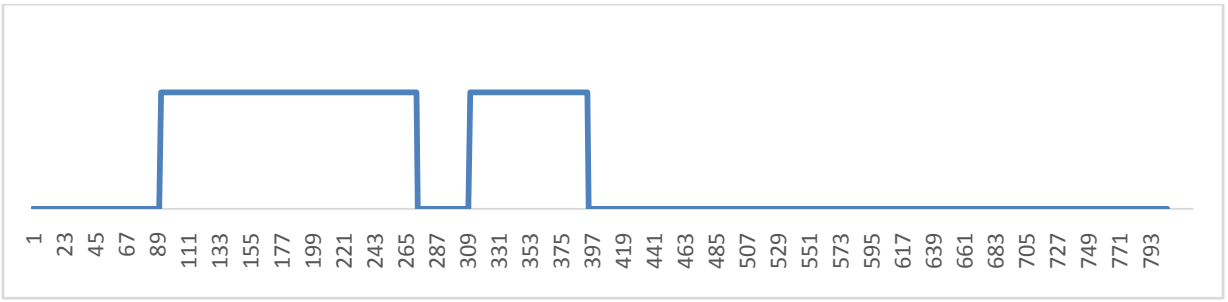

Figure 9: Comparison of days of the project, where resources of the CPM method are equal to the maximum amount of resources.

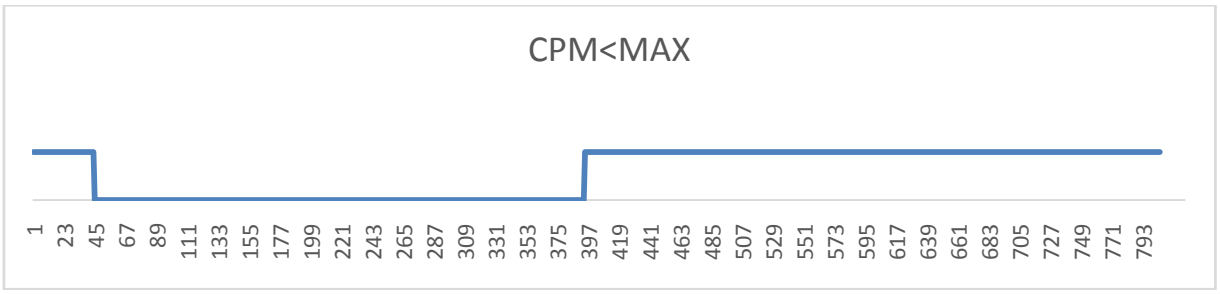

Figure 10: Comparison of days of the project where the resources of the CPM method are less than the maximum amount of resources.

VI. Allocation of Resources and CPM Meth

The efficiency of the CCPM method is clearly demonstrated due to the non-violation of maximum resources.

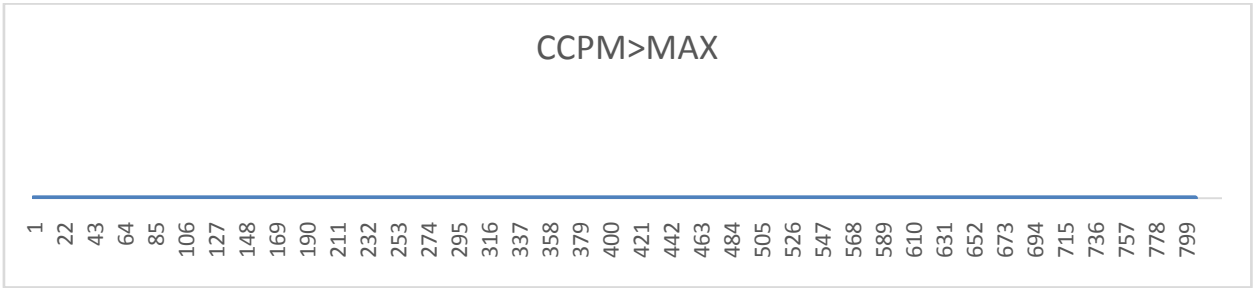

Figure 11: Comparison of days of the project where the resources of the CCPM method are greater than the maximum amount of resources.

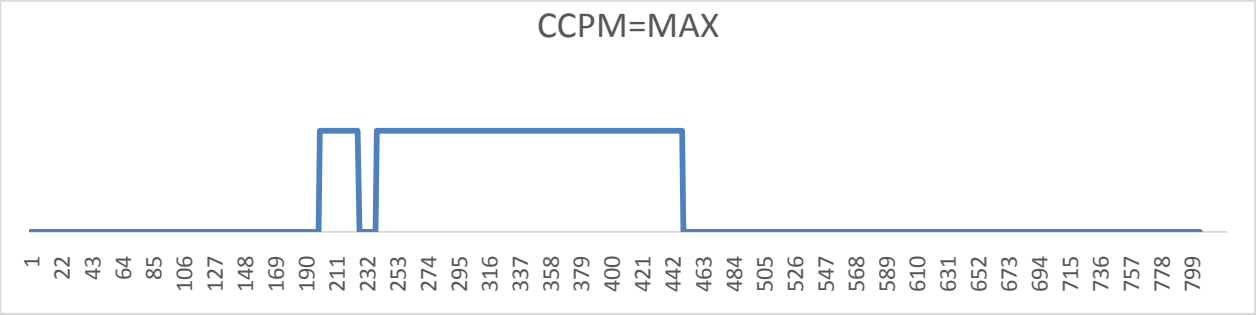

Figure 12: Comparison of days of the project where the sources of the CCPM method are equal to the maximum amount of resources.

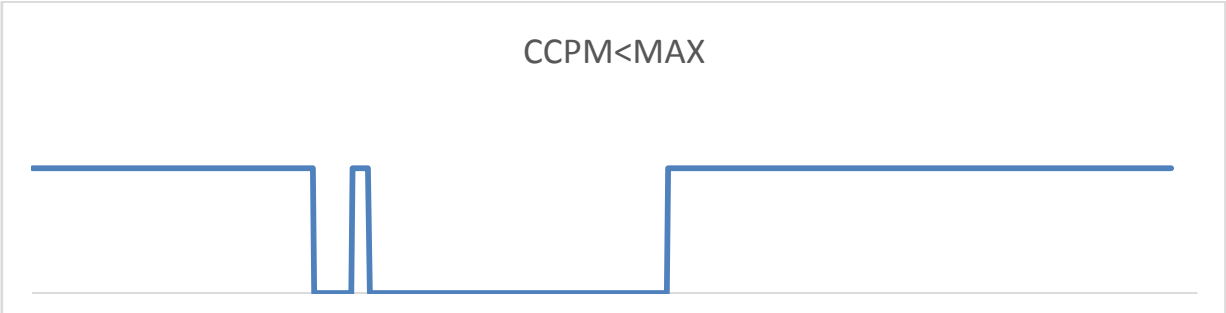

Figure 13: Comparison of days of the project where the resources of the CCPM method are less than the maximum amount of resources.

VII. Economic Analysis

In order to carry out the economic analysis (due to the reduction of 27 days of the project time) in the present project (using the critical chain method for the project of construction of the Kahir dam) the sum of the resulting benefits including employment income and income from operation were used. The direct benefits of this project were the value of agricultural income in the region, fish farming and hydropower production, and non-direct benefits included employment during the construction phase and operating period. Data used in the calculation and analysis below have been received from Sistan-Balouchestan Regional Water Organization and reliable sources.

Part I: Calculation of the amount of proceeds from early utilization (27 days)

Amount of proceeds from exploitation: 209880000000 Rials

Early operation ratio:7.397% = 27/365

As a result, the product of this percentage is equal to the amount of income equivalent to:15525369863 Rials.

Part II: Calculation of the amount of employment income

The ratio of 7.397% is sufficient to multiply one year's income from work of 110 million Rials. Therefore, the amount of 8136987 Rials is also considered as 27-day earnings. The sum of the figures obtained is 15533506849 Rials, which is the total sum of the revenues.

VIII. Conclusion

Construction of dam like other civil engineering activities will have positive and negative effects, especially in the long run. Of the most important positive effects of dam building on the region are the following: Increase in rural development, Increase in the value of arable land, Increased revenues through jobs (agricultural and non-agricultural), Increased employment. Also, with the construction of the dam, we see an increase in employment (falling unemployment) in the region. According to inflation and unemployment in the Philips theory, inflation in the region is also decreasing with increasing employment. As a result, we will see income growth, well-being, health and education in the region.

However, damage to ancient monuments (if any), damage to facilities within the study area (such as school, roads, water, electricity, and telecommunications), environmental impacts, high cost of resettlement are among the negative economic consequences of dam construction projects. It is important to consider the social issues and the sustainable development of the project and increase the amount of profit for the project.

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