

# Environmental Impact Assessment of Reservoir Dams (Case Study: The Syahoo Reservoir Dam and its Irrigation and Drainage Systems in Sarbishe County)

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## Abstract

**Background:** The aim of this paper is to assess the environmental impact of the Syahoo dam by analyzing the available environmental resources. **Methods:** The studies of the Syahoo reservoir dam project and its irrigation and drainage network systems were conducted in Sarbishe a County as one of the strategic areas in the east of Iran with the purpose of controlling and storing the seasonal floods of the Syahoo River. The environmental impacts of the plan were evaluate by gathering the data, information and available maps and field inspection of Syahoo river basin and Sarbishe county and using the modified leopold matrix method. **Results:** The results of the study show the predominance of the design implement option with positive score of +107 against the non-implement option with negative score of -1061 **Conclusion:** Thus that is accounted as a proper option in order to improve the quantity and quality index of environment of the area.

**Keywords:** Environmental Impact Assessment, Syahoo Dam

## 1. Introduction

Human has long sought to control natural phenomena to provide their needs .In this regard, the idea of dam construction was conceived in the human mind by looking for problems and consequences of drought and flood. Dams are important structures to adjust flow and sediment discharge of river, especially in periods of flood and to increase the possibility of its long-term usage. Besides the positive effects of dam construction, their negative impacts became obvious by creating fundamental changes in natural processes of hydraulic and hydrologic regime of the environment. By defining the concept of sustainable development, some studies were conducted in environmental impact assessment in order to predict the effects of activities and the functions of the plan on the environment, human health and social welfare. In other words systemic identification and assessment of the

consequences of the projects, programs and designs on the physicochemical, biological, cultural, economic and social environments were set on the agenda of the subsidiary institutions of the environment organization of Iran in every region.

Therefore, by conducting these studies, the implementation process of water resource developments projects was defined in line with sustainable development objectives. Finally the implementation led to optimal utilization of water resources of country with minimal environmental side effects in order to achieve the integrated management objectives of water resources<sup>1,2</sup>.

Javadi<sup>3</sup> conducted a study to evaluate the environmental impacts of Upper Gotvand dam on physical, biological, economic, social and cultural environment using the combination of two methods of Icold and Leopold matrix of environmental impact assessment. Some methods were presented to monitor and control the environmental adverse effects<sup>3</sup>.

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In<sup>4</sup> evaluated the environmental impacts of the Zayanderud dam using the Wooten and Rau matrix method. In this method, the activities of project were divided into two construction and operation phases and their effects were evaluated separately on the environmental parameters of the area. Total score of environmental impact assessment study of Zayanderud dam project after sum of positive and negative scores is (+52) and generally the effect of the Zayanderud dam construction on the environment was evaluated as positive.

In<sup>5</sup> evaluated the environmental impacts of the Sardasht dam in Khuzestan in the operation phase by investigation of the condition of the area and by usage of Checklists methods (sample-sensing). According to the result of this research, the environmental impacts were positive especially in operation phase and the number +508 was calculated as environmental effects index<sup>5</sup>.

The aim of this research is to investigate the environmental impacts of the Syahoo reservoir dam and its irrigation and drainage systems in Sarbishe city as one of the eastern strategic areas of Iran. This dam was constructed with the purpose of controlling and storing the seasonal floods and it will have diverse short-term and long-term effects on the environment of the area due to high operational amount of construction and high water storage. Practical management patterns can be presented for decreasing the adverse effects and consolidating the positive effects by their exact investigation and evaluation.

## 2. The Study of the Area of Plan

Using dams have gained significance in the present century due to the essential role of water in the formation of societies and their development planning, control and management of flood phenomenon and surface water control. Usage of dams is considered an important step in economic self-sufficiency and in development of the knowledge level and engineering grace of every society.

Nowadays, the water crisis and climate change regimes, much more than the past, have caused the societies to ponder about water saving and its optimal management. Dams possess the impacting potential on wide area of the environment around them. Thus in planning and implementation of sustainable development projects, the continuity of its positive effects and its negative effects control should be assured with strict prestige toward environmental effects of each project. Iran is

located in the dry and arid belt of the world and the South Khorasan province with average rainfall of less than 150 mm is considered a dry and arid area in country. Water shortage in the province and the presence of seasonal rivers with flood regime have led the water supply authorities to construct dams in order to store and manage the floods and use them in low rainfall seasons. In order to achieve the objectives mentioned before and to develop the agriculture in the Doreh plain and border areas, the studies of the construction project of the Syahoo dam and its irrigation and drainage systems were started in 2005 in Sarbishe county and it will be put into utilization in 2016 in case of required credits allocation.

Sarbishe county consists of three central, Mood and Doreh districts got independent from Birjand county (located in South Khorasan) in 2003 and is located in the east of Iran, the north-east margin of Loot plain and south-east of Birjand and in the Bijand-Zahedan international road with a population of four thousand (According to the 2011 census) and an area of 8251 square kilometers. This county is adjacent to Birjand County from north and west, to Nahbandan County from south and to Afghanistan from east.

**Table 1.** General specifications of the Syahoo dam

60 Degrees and 15 minutes east longitude and 32 Degrees and 18 minutes north latitude	Geographic position of the dam construction site
Soil dam with clay core	Dam Type
Syahoo	River's name
3028 Square Kilometers	Basin area
10.2 Million cubic meters	Annual gaining
4.6 Million cubic meters	Storage and Adjustment Volume
39 meters	Height from foundation
32 meters	Height from river bed
352 meters	Dam's crown length
9 meters	Dam's crown width
13.5 million cubic meters	Dam's reservoir volume

Sarbishe city as the center of the county is located in 66 km away from Birjand city, the center of the South Khorasan province and 533 km from Mashhad, the center of Razavi Khorasan provinces and 395 km from Zahedan, the center of the Sistan and Baluchestan province. Figure 1 shows the position of the Syahoo dam project and its irrigation and drainage systems.



Figure 1. Position of the Syahoo dam project and its irrigation and drainage systems.

General specifications of the Syahoo dam and its irrigation and drainage systems can be seen in Tables 1 and 2<sup>6</sup>:

### 3. Materials and Methods

#### 3.1 Environmental Impact Assessment Method of the Syahoo Dam in Sarbishe City and its Irrigation and Drainage Systems

Many different methods have been proposed to assess the environmental impacts of projects which in fact, they consist of five main groups of methods, special, checklists, matrixes, networks and overlapping. So the appropriate method to investigate projects will be selected according to the nature and characteristics of them such as the size, complexity, geographic location and environmental diversity<sup>7</sup>.

Table 2. General specifications of irrigation and drainage systems of the Syahoo dam

650 hectares	Net covered area
Agricultural development in Doreh plain in Sarbishe county	Implementation purpose
GRP 400-700	Material & Diameter of the primary-Irrigation system
5860 meters	Length of The primary-Irrigation system
PE 110-250	Diameter of the secondary Irrigation system
682 meters	Length of the secondary Irrigation system
Soil Drainage with trapezoid section	Drainage system

Modified Leopold matrix method was selected for the evaluation of the environmental impacts of the

Sياهو dam and its irrigation and drainage systems. This selection has been made based on studies and field observations in the studying region and determination of the characteristics and conditions of the project, existing facilities and the results of other researches. This matrix couldn't gain an appropriate opportunity for assessment of the development effects in our country due to the valuation of importance (greatness) on the range of -10 to +10 until the 1990s when Makhdom proposed a change in the valuation range from -5 to +5 which was welcomed by national researchers under the title of modified Leopard matrix (Iranian). Table 3 and 4 show classification of the domain and importance of project's effects in the modified Leopard matrix:

**Table 3.** Scores attributed to the effect domain in each of the three regions affected by the environmental impacts of the project

Score	Effect domain definition
1	The project's immediate area
2	The project's direct effects area
3	The project's indirect effects area

**Table 4.** The sorting method of effect importance according to its strength and weakness in the modified leopard matrix

No.	Expression	No.	Expression
+5	Very high positive effect	-5	Very high negative effect
+4	High positive effect	-4	High negative effect
+3	Average positive effect	-3	Average negative effect
+2	Low positive effect	-2	Low negative effect
+1	Slight positive effect	-1	Slight negative effect

In order to determine the effect of an activity on the environmental components, the numeric values of its domain and intensity are multiplied by each other. Finally a number will be acquired which will be a lead for selection of the appropriate option by addition of the indices for each environment (physical, biological, economic, social and cultural) in each construction and operation stage for different options<sup>8</sup>.

In this research, according to comprehensive studies conducted, 31 activities and 22 environmental factors were detected totally in physical, biological and economic, social and cultural environment of the region, in two construction and operation phases which will form a matrix in order to evaluate the environmental effects of the project<sup>9</sup>.

### 3.2 Studied Options in Evaluation of the Environmental Effects of the Project

In studies conducted for finding a proper option, finally one was selected as the prior option after investigation of several options in order to determine the position of Syahoo dam and the proposed structures in this project. Thus two options of the implementing and non-implementing of the Syahoo dam project in Sarbishe county and its irrigation and drainage systems were evaluated separately in two construction and operation phases.

The zero option or the non-implementation of the project means the abandoning of the area and not implement the project and usage of the natural resources according to the potentials of the region while the one option or the implementation in the current position includes the two construction (construction of the structure and its facilities) and operation phases of the project.

### 3.3 Determination of the Affected Regions by the Impacts of the Project

Generally according to the available instructions and with regard to important parameters like topography, ecological conditions and sensitivity, hydrological regime, cultural, social and economical structure of the region and also the aims and scopes of the project, three diverse areas were detected and evaluated for investigation of the environmental effects of the project and they are as follows:

- Immediate area: including the implementation area of the project, reservoir of the dam and the workshop.
- Direct effects area: including an area with radius of 7 kilometers from reservoir of the dam.
- Indirect effects area: including the whole area of Sarbishe county and Birjand county.

## 4. Discussion and Conclusion

### 4.1 Prediction and Evaluation of the Environmental Impacts of the Project on the Region

#### 4.1.1 The Zero or Non-Implementation Option

This item is the abandoning and non-implementation of the proportionate projects with existing natural potential at the region. Sarbishe county is located at a border region of Iran and it mutually borders with Afghanistan, a coun-

try involved in numerous controversies and the lack of appropriate leadership, adds to the strategic importance of the region. In general the most important consequences of non-implementation of the project at the region are as follows:

- Threatened agriculture at the region due to prolonged drought in recent two decades.
- Increased migration of people in the region due to the ongoing drought and population decline or evacuation of some of the villages in the border areas of the country.
- Increased tendency of the people to earn money through false jobs and in some cases, drug smuggling or contraband.
- Intensified and increased amount of dust and the penetration of adverse effects of 120-day winds of Sistan to the region due to ongoing droughts.
- Lack of proper flood control and the loss of this natural resource caused serious damage to the agriculture of the region.
- Construction of a dam leads to the consequent effects of water remnant and spreading of some water-transmittable diseases.
- Improper usage of the river water and consequent increasing of pumping from groundwater resources (For drinking and agricultural usage).

## 4.2 The One or Project Implementation Option

The project implementation item in two phases of construction and operation has positive and negative effects of short-term and long-term and they are as follows:

### 4.2.1 Prediction and Evaluation of the Environmental Impacts of the Project on the Physical Environment

- The loss of vegetation and surface soil erosion due to operations such as preparing the site location and construction of dams and its irrigation and drainage systems, excavation and embankment (embankment dam with clay core) and clean shaving of the plants of the reservoir.
- Dam construction spoils the sedimentation potential in downstream and causes the severe erosion of the bed of the river in this section.

- Muddy water generated during construction (construction phase) and after descaling operation (operation phase) contains large quantities of sediment that has descaling effects on downstream areas and the environment of the region.
- It is possible to collect and store much of the runoff from flooding and use it in droughts and dry seasons by construction of the dams.
- Storage of the flood water and creating proper conditions to implement the artificial recharge projects.
- In the construction phase, pollution caused by construction machinery, improper disposal of domestic sewage, oil and fuel of machineries and their movement in the direction of the river, cause pollution of groundwater and surface water.
- Creating the induced seismic proportional to factors such as reservoir condition, the process of water level raising, duration of dewatering etc.
- Creating thermal stratification in the reservoir of the dam and intensifying it with increase of water depth.
- Some landslides would happen as a result of the water fluctuations of the reservoir and increase of the moisture in the lands around the reservoir of the dam.
- Agricultural fertilizers should be used to compensate the effects caused by prevention of the dam from nutrient sediment transportation. Indiscriminate and unconscious usage of these fertilizers reduce the quality of river water and groundwater in the long term periods.

### 4.2.2 Prediction and Evaluation of the Environmental Impacts of the Project on the Biological Environment

- In the construction phase, the construction of dams and irrigation and drainage systems and clean shaving of the plants of the reservoir, construction of access roads and in the operation phase, dewatering of the dam has several side effects on aquatic and xerophyte habitats of the region.
- Exploitation of borrowed resources and the erosion caused by it increase the amount of sediment in rivers flow. All these activities increase the level of water, soil, air and sound pollution

thus creating an unsafe environment within the immediate region of the project and creating direct effects for aquatic and xerophyte habitats.

- Microclimate changes within the direct impacts of the project and consequent improvement of environmental conditions for animal habitation, native and expatriate animals.
- The development of agriculture with optimal usage of surface water resources and increase of irrigation efficiency in the region and improvement of downstream vegetation condition.

#### *4.2.3 Prediction and Evaluation of the Environmental Impacts of the Project on the Economic, Social and Cultural Environment*

- The return context of some of the immigrants and increase of the population of the region will be possible with time elapsing and employment improvement through the storage of seasonal floods, agriculture improvement, fish farming and increase of travel and tourism industry.
- Factors such as dust, wastewater and solid waste would endanger the health of the habitats of the region under study.
- The outbreak of a lot of tensions in construction phase due to ethnic textures and prejudices, the religious beliefs of native workers and the inhabitants of the villages in neighborhood of the dam.
- With construction of the Syahoo dam, the reservoir turns to a proper place to attract tourists and to boost the economics of the region and also to create relevant job opportunities.
- Due to the usage of the reservoir water of Syahoo in agriculture, its construction causes the development of the agriculture of the region within the direct effects of the project, development and creation of the relevant industries and job creation within the indirect effects of the project.
- Increasing of the area under cultivation and expansion of the suitable base for individuals in the field of agriculture and related industries, creates the favorable conditions for establishing various factories throughout the area and consequently increases the living standards of the people in the range of the indirect effect of the project.

- Creating appropriate background for economic prosperity and development of tourism industry

#### *4.2.4 Prediction and Evaluation of the Environmental Impacts Caused by the Pollutions of the Project*

- Air pollution and sonic level increasing in construction phase during activities such as excavation and embankment, construction of structure of the dam etc.
- Pollution intensification in the reservoir of the dam with increasing of vehicle traffics and visitors (experts, workers, tourists and local people) and consequently increased consumption of raw materials and production of various sewage and waste disposal (domestic, agricultural and industrial).
- In operation phase, the movement of vehicles on the road and establishment of office facilities increase the sonic level in the region.
- The reservoir of the dam could be a suitable environment for growing many infectious diseases such as malaria and hematological diseases.
- In case of drought and decrease of water level of the reservoir dam, aquatic plant growth causes damage to fishes.

In summary the results of analysis of the environmental impacts of the project with modified Leopold matrix method are shown in Table 5 by investigation and evaluation of the domain and importance of the consequences of the project:

According to Table 5, the total effects of the project on physical, biological, economic, social and cultural environments in construction phase and for the two options of the implementation and non-implementation of the project are -221 and -459.

The main activities of the project in construction phase with respect to its technical and operational characteristics in the immediate area of the project, direct and indirect effects area of the project is anticipated to be as follows:

- Clean shaving and bush removal of the construction site of the dam and its reservoir and the implementation of irrigation and drainage systems, excavation, embankment, land use change,

**Table 5.** The summary of environmental impact assessments of Syahoo dam and its drainage and irrigation systems in construction phase with modified Leopold matrix method for two implementation and non-implementation options

Non-implementation option of the project				Implementation option of the project				
Cultural Environment	Economic & Social Environment	Biological Environment	Physical Environment	Cultural Environment	Economic & Social Environment	Biological Environment	Physical Environment	
+9	+32	+19	+41	+4	+30	+6	+5	The total number of deterministic effects
-38	+161	-121	-182	-98	-228	-68	-20	The total value of deterministic effects
+7	+2	+4	+9	+3	+5	+3	+2	The total number of possible effects
+12	+17	-41	-29	-14	-17	-6	-8	The total value of possible effects
-26	+178	-162	-211	-112	-245	-74	-28	The total value of the deterministic and possible effects

**Table 6.** The summary of environmental impact assessments of Syahoo dam and its drainage and irrigation systems in operation phase with modified Leopold matrix method for two implementation and non-implementation options

Implementation option of the project				Non-implementation option of the project				
Cultural Environment	Economic & Social Environment	Biological Environment	Physical Environment	Cultural Environment	Economic & Social Environment	Biological Environment	Physical Environment	
+7	+22	+13	+15	+6	+8	+5	+12	The total number of deterministic effects
+19	+201	+33	+20	-28	-217	-18	-134	The total value of deterministic effects
+6	+4	+11	+8	+2	+3	+3	+7	The total number of possible effects
+8	+43	-9	+13	-13	-111	-22	-59	The total value of possible effects
+27	+224	+24	+33	-41	-328	-40	-193	The total value of the deterministic and possible effects

construction of technical and official buildings, major and minor access roads, waste and sewage production etc.

- The reason of lack of significant difference in total project score in the construction phase for the two options above is from relatively good state of current physical and biological environment of the region which is heavily influenced by pollutions generated from the activities of this phase. In other hand, creation of the related and unrelated jobs of the project has a great importance for local workers in the current economical conditions.
- In the construction phase period, due to the proximity of the project to rural and urban areas and prevailing traditional context, direct relation of the workers and the personnel would cause a relatively high level of social and cultural stress.

Summary results of the evaluation of the activities caused by project implementation on study area in operation phase with modified Leopold matrix method is presented in Table 6:

According to Table 6, the total effects of the project on physical, biological, economic, social and cultural environments in operation phase and for the two options of the implementation and non-implementation of the project are +328 and -602. The main activities of the project in this phase with respect to its technical and operational characteristics in the immediate area of the project and the direct and indirect effects area of the project is anticipated to be as follows:

- Modification of cultivation and irrigation patterns in the agricultural sector and its development in the long run, creation of jobs and industries related to agriculture by the private and public sectors, creation of a proper base for tourist arrivals and introduction of tourism attraction of the area and thus improving social and cultural indexes of indigenous peoples, Job creation associated with the tourism industry and tourism in the region, creation of artificial recharged plan to strengthen the quality and quantity of regional aquifers, enhancement of the climate conditions of the region and increasing the vegetation and animal species.

- In operation phase, the significant difference in total effects of the activities of the project indicates the importance of its construction in improvement of the environment conditions in long term period. The reason is that recent environmental studies show severe environmental degradation due to water shortage in the region over the past two decades.

This project is considered a useful step towards improving the environmental indexes of the region according to the comparison and integration of positive and negative effects and its beneficial and destructive aspects on the environment in construction and operation phase.

## 5. Conclusion

The purpose of the environmental impact assessment of every project is to systematically convert the qualitative and quantitative effects of its activities on the physical, biological, economic, social and cultural environments to scores which provide the basis for evaluation of positive and negative aspects of a project.

Based on the analysis of the environmental impacts of the project for two options of its implementation and non-implementation in both construction and operation phases, the following results were obtained:

- Total effects of the project on the environment in the construction phase and for two options of implementation and non-implementation of the project were -221 and -459 which is due to the lack of significant difference in total points caused by the relatively good state of the current physical and biological environment of the region which is under the impact of pollution generated from its activities. In the other hand, creation of the related and unrelated jobs of the project is of a great importance for local workers in the current economical conditions. In the period of the implementation of the project, direct relation of the workers and the personnel cause a relatively high level of social and cultural stress due to the proximity of the project to rural and urban areas and prevailing traditional context.
- The greatest negative effects are observed in the biological environment in the construction phase and then in the physical, economic, social and cultural environments which are highly controllable using existing solutions to reduce diverse

effects and to strengthen the positive effects of the project.

- The total activities' effects of the project in exploitation phase and for the two options of the implementation and non-implementation are +328 and -602. This significant difference indicates its construction importance in improving environmental conditions in the long term period.
- In the operation phase, the positive effects of the project can be observed in economic and social environment which its reason will be the undesirable living condition of the residents of the direct effect region and the consequences of its implementation on employment and agricultural boom of the area.

Thus the total point of the evaluation of the two options of implementation and non-implementation of the project in two construction and operation phases is +107 and -1061 respectively which indicates the positive effects of the implementation option compared to non-implementation option of the project. Therefore, with considering all of the consequences and long-term and short-term effects mentioned above, the construction project of Syahoo dam in Sarbishe County and its irrigation and drainage systems is considered an appropriate option for growth and development of an important part of South Khorasan province in order to achieve sustainable development objectives.

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