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ENVIRONMENTAL IMPACT ASSESSMENT OF NEW ASSIUT BARRAGE USING QUANTITATIVE MATRICES METHOD

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ABSTRACT

Environmental Impact Assessment (EIA) is a procedure for assessing the environmental implication of a decision to implement policies and plans for the new development projects. The new Assiut Barrage and its hydropower station will enhance irrigation system, provide the community with the clean electricity, and improve locality traffic paths. Whoever the construction stage may affect the ambient environment with different factors. EIA using quantitative matrices was applied in this study to assess the effects of construction works and operating stage on the local environment. Quantitative Matrix is a two-dimensional table that defines the impacts arising from the interaction between project activities and environmental components. The investigated environmental factors are surface water, soil erosion, groundwater, ambient air quality, fauna, flora, and traffic volume. A comparison between using Quantitative and Weighted Matrices is applied and discussed in this study. The results showed that Quantitative Matrix has more detail related to environmental components than weighted matrix, while Weighted Matrix is useful in the alternative sites selection of the developed projects according to environmental issues. The result of this study is used to audit and improve environmental policies and planes during both of construction and operating stage of the Assiut new Barrage. Also, the study can be applied on any similar future riverine construction works.

Keywords: *Construction Projects, Environmental Impacts, Air Quality, Assiut new Barrage, Ambient Environment, Quantitative Matrix*

INTRODUCTION

Human activities, in particular large-scale industrial, energy, construction, water resources, or agricultural projects, considerably affect the natural environment. Environmental Impact Assessment (EIA) is a decision tool employed to identify and evaluate the probable environmental consequences of certain proposed development actions. Environmental Impact Assessment (EIA) requires the qualitative and quantitative prediction, assessment and evaluation of the impacts of human activities on the environment in terms of appropriate indicators (Cashmore, 2004; Jay *et al*., 2007). EIA first came about as the result of the National Environmental Policy Act, passed in 1969 by the United States government (Leopold, 1971, Sánchez-Triana & Ortolano, 2001, Ogola, 2007). It can be used to identify the type, magnitude

and potential changes in the environment as a result of an activity or policy. Several studies lists a number of areas that need to be covered such as population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archeological heritage, landscape, and the inter-relationship between these factors. Different methods and techniques were used for EIA such as the Loran methodology, Leopold Matrix, Check List, Simple Check List, and stepped matrices among others (Lee, 1983,Thompson, 1990, Momtaz, 2002, Duinker & Greig, 2007).

Lattemann and Höpner, 2008 studied the EIA of the desalination of seawater projects around the world. They discussed the issues of the concentration and chemical discharges to the marine environment, the emissions of air pollutants and the energy demand of the processes. Li *et al.* (1999) used GIS based map overlay method to develop a comprehensively environmental vulnerability around road and its impact on the environment. Pastakia and Jensen, 1998 used the Rapid Impact Assessment Matrix (RIAM) as a tool to organize, analyze and present the results of a complete environmental impact assessment. They applied the method on the study of EIA of fly ash deposition into a landfill. Josimovic *et al.* (20140 used the Leopold matrix in carrying out EIA for a wind farm in Serbia (case study). The obtained EIA results have enabled the precise identification of possible environmental impacts of the wind farm project, as well as removal of dilemmas and problems related to the public resistance to the realization of the project through a transparent relationship with stakeholders. Fedra (1990) discussed the methods and procedures of EIA, the relationship between indicators, standards, and in particular the use of computer-based tools, models and expert systems that combine traditional modelling approaches which new techniques of artificial intelligence and dynamic computer graphics. Several studies used the spatial techniques to address the EIA such GIS and remote sensing (João & Fonseca, 1996, Warner & Diab, 2002, Abbas & Ukoje, 2009).

Marttunen and Hämäläinen (1999) presented the decision analysis interview-method to assessment the environmental impacts of two water development projects. They concluded that decision analysis interviews can well be used in assessing the importance of environment impacts. Liu & Lai (2009) and Peche & Rodríguez (2009) proposed an integrated decision-support framework that employs fuzzy logic to manipulate the subjectivity of EIA. The proposed approach was applied to the EIAs of construction projects, exemplified in a case study of the Taiwan High-Speed Rail project. Toro *et al*., 2010 evaluated EIA systems in Colombia, using the model and the control mechanisms proposed and applied in other countries. The results found that EIA regulations in Colombia were ineffective because of limited scope, inadequate administrative support and the inexistence of effective control mechanisms and public participation.

Environmental impact assessment of the Aswan High Dam; Egypt and its hydropower plant was carried out by (Rashad & Ismail, 2000). They considered several environmental factors such physical effects, social impacts, coastal erosion, groundwater regime, evaporation from the reservoir, river water levels Hydropower and greenhouse gases emissions, and biological effects.

The study indicated that the High Dam has overall positive environmental factors even though it has contributed to some environmental problems.

This study is aiming to investigate EIA for the New Assiut Barrage. The objectives were the assessment of various environmental aspects and their impacts on the local or/and global environment. The study evaluated the environmental impacts of the project on water, soil, fauna, flora, traffic, navigation, and irrigation system. Also, any negative action should be considered to be mitigated by the authority.

MATERIALS AND METHODS

Study Area

The Old Assiut Barrage was constructed between 1892 and 1902 to sustain a water level difference of about 4 m in order to feed the Ibrahimia Canal. The New Assiut Barrage and its Hydropower Plant were initiated in May 2012 to replace the old one and it is suggested to be finished in March 2018. The project is considered as one of the most important environmental projects that established to enhance water control and development in Egypt in coming years. The new Barrage is constructed 350 m downstream of the old barrage as illustrated in figure (1) with power generating capabilities of total capacity 32 MW. Assiut governorate is stretching for about 120 km along the banks of the river Nile Such location is 365 kilometers south of the capital Cairo.

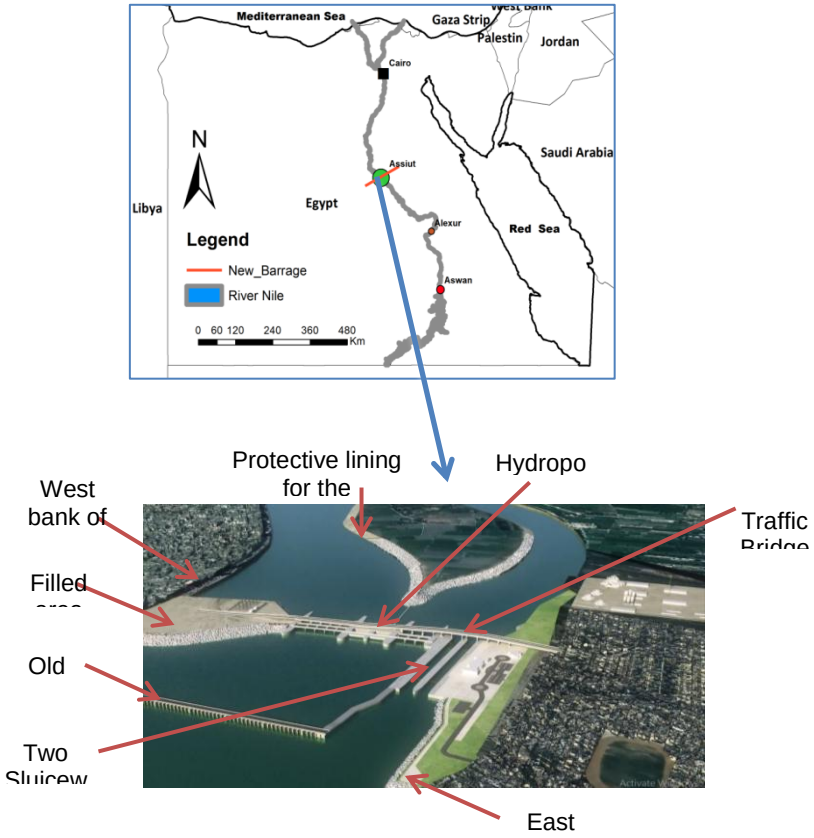

Fig. 1: Location and main elements of the New Assiut Barrage project

Methodology

Application of this study was carried out on the new Assiut Barrage. The data is collected during the construction stages of the project such as continues measurement of noise, total suspended particulates, water quality, and groundwater level. The details of the new Barrage elements and its location was draw using AutoCAD and the designed maps were created using ArcMap-GIS software. Figures and tables were produced using Microsoft Office. Arrangement and analysis of the data were carried out along with the main conclusion of the study.

Results and Discussion

Environmental Impact Assessment of Assiut new barrage is carried out in this study for the construction stage and the operation process. Although the construction stage is almost finished, the study focuses on review the environmental effects to be used for similar construction works. The construction stages included several work activities such as excavation, soil removed and reservation, island cutting, installed construction bit, foundations, civil construction, mechanical and electrical construction among others. The scope of environmental impacts during construction stages are soil, farms, fisheries, traffic, noise, dust and surface water of the river Nile.

Check List Method

A checklist of some variables is used to illustrate the effects of the construction stage related to environmental issues as presented in Table (1). The variables are classified into three main groups; effects on farm and soil, surface and groundwater, and air quality. The effects of the work activities are simply classified into three levels; they are YES, MY BE, and NO as given in Table (1).

Table (1): Check List evaluation of EIA during construction stage of NAB

Environmental Factor	YES	MAY BE	NO	Comments
Land Form				**The top soil around the project is temporary removed during the construction stage. The top soil will be returned again to its original location after the construction stage.**
• Extensive disruption to or displacement of the soil?	√			
• Impact to land classified as prime of unique farmland?			√	
• Changes in ground contours, shorelines, stream channels, or river banks?	√			
• Increased wind or water erosion of soils?				
• Effects of silt trapping behind the new barrage	√			
• Effects of the cultivated areas at the banks	√	√		
Air/Climatology				**The most negative effects of work activities on the air quality were inside the project border.**
• All pollutant emissions	√			
• Noise	√			
• TSP	√			
• Deterioration of ambient air quality?		√		
• Air movement, humidity or temperature?			√	
• Emissions of hazardous air pollutants	√			
Surface and Groundwater				
• Irrigation systems			√	
• Rise water level upstream the Barrage	√			
• Rise water level downstream			√	
• Groundwater level increases in the upstream side		√		
• Drop of water level in downstream of the dam			√	
• Surface Water quality of the river Nile	√			
• Surface water seepage from adjacent lands toward the river		√		

For the soil, the impacts of the construction stage are evidence according to Table (1). A cut of 1.25 m of the topsoil from the banks and the island is removed and stored in a secure area. Also, surface water of the river Nile is affected due to the huge activity in the river stream especially on the first stages of the project. For air quality, the Total Suspended Particles (TSP) are measuring daily during the construction stages of new Assiut Barrage at a distance 60 m north the project to investigate the project impacts on the environment as presented in Figure (2). As illustrated in the figure, most the measured values are increased than the permissible limit (230 µg/m^3) assigned by the Environmental Egyptian Law No 4/1994 (EEL4/94). The causes of this high level are not the project activities. The substantial causes are the traffic and the roads around the project are not sprayed by water even it is not good asphalted. The same result can be noticed for the measured noise levels which presented in Figure (3). The measured noise before November 2015 was less than the permissible levels assigned by EEL4/94 (65 dBA). The ambient noise level increased after this date due to the increase in public traffic. Although the excavation and dumping stages were from 2012 to 2015, the noise level in this period was accepted according to EEL 4/94. The noise levels and TSP were studied inside the NAB project by the authors in the previous publication (Rabeiy, 2017).

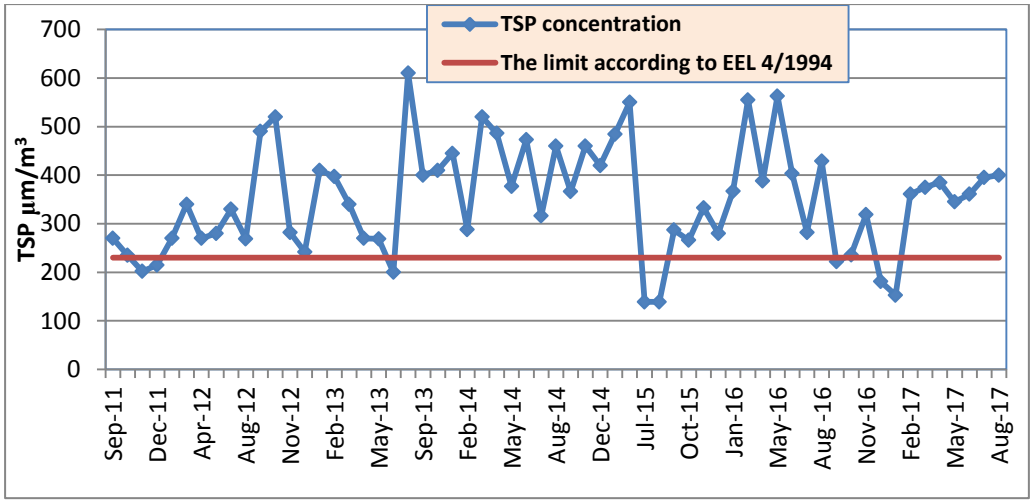

Figure (2): Measured noise level outside the project

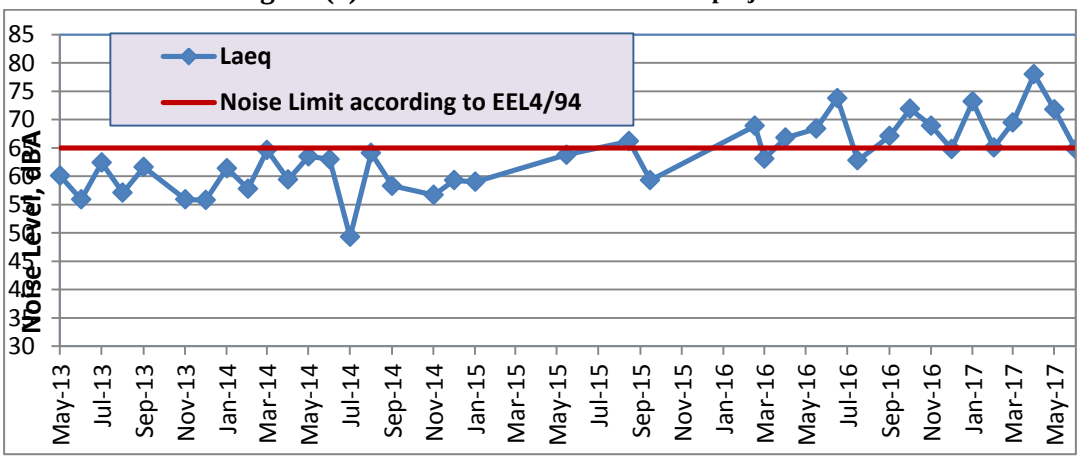

Figure (3): Measured noise level outside the project

Table (2): Surface water quality during the construction stage

Sampling Site	pH	TDS, ppm	Cond. µs/cm	DO, ppm	Turb. (NTU)	Pb, mg/L	Cd, mg/L	Zn, mg/L	Fe, mg/L	Hg, mg/L	Oil & Grease, ppm	Nitrate (NO_3-N), ppm
1	8.1	172	743.7	11.6	2.45	0.0369	0.004	0.04	0.8329	0.0012	0.06	0.641
2	7.91	176	1617	10.38	3.11	NM	NM	NM	NM	NM	0.04	0.626
3	8.47	190	1691	10.57	3.21	NM	NM	NM	NM	NM	NM	NM
4	7.78	196	660	10.87	3.15	NM	NM	NM	NM	NM	NM	NM
5	9.26	196	1021	9.17	4.16	0.084	0.006	0.08	0.9337	0.0013	0.11	0.721
6	8.88	196	1980	9.21	5.1	NM	NM	NM	NM	NM	0.1	0.679
7	8.88	196	920	9.26	4.21	NM	NM	NM	NM	NM	0.07	0.655
8	9.02	196	756	10.39	4.03	NM	NM	NM	NM	NM	NM	NM
Allowable limit	6.5-8.5	<500	1500 to 2000	< 6		0.01	0.001	0.01	0.5	0.001	0.1	2

NM: Note Measured

3.2. Quantitative Matrix of EIA

The best-known type of quantified matrix is the Leopold Matrix, which was developed for the US geological survey by Leopold et al (Leopold, 1971). In the upper left-hand corner of each box with a slash, a number from 1 to 10 have to be placed which indicates the Magnitude of the possible impact; 10 represents the greatest magnitude of impact and 1, the least. Before each number the sign + (id the impact would be beneficial for this item). In the lower right-hand corner of the box, a number 1 to 10 should be selected which indicates the importance of the possible impact (e.g. regional vs local); 10 represents the greatest importance and 1 the least. The following factors are studied for the New Assiut Barrage. Some of these factors are valid during and after construction stage. The Matrix was designed to study the EIA of the project during the construction stage and the operating process as presented in table (3). The following environmental factors are considered in this study:

- **Irrigation system**
- **Navigation system**
- **Produce clean electrical energy with a capacity of 32 MW**
- **Saving greenhouse gases by producing hydropower energy**
- **The traffic from west bank of river Nile to the west bank and vice versa**
- **Erosion of the soil for the downstream island**
- **Rise of water level behind the barrage**
- **Groundwater level**
- **Surface Water quality of the river Nile**
- **Drop of water level in downstream of the dam**
- **Surface water seepage from adjacent lands toward the river**
- **Effects of silt trapping behind the new barrage**
- **Effects of the new barrage on the fish number, size, and species**
- **How much saving of CO_2 to produce 32 MG if we used fossil fuel**
- **Effects of the cultivated areas on banks**

Table (3): Leopold EIA matrix of New Assiut Barrage during and after the construction stages

Project actions Environmental Characteristics	Blasting Drilling	Excavation	Foundation	Construction bit	River Dumping and loading	Solid waste disposal	Total	Operation process
Soil	-3 / 7	-8.5 / 9	-2 / 6	-1 / 2	-6 / 5	-5 / 7	**-24.5 / 27**	**-3 / 3**
Land farms	-1 / 3	-7 / 3	-1 / 3	-1 / 3	-6 / 4	-7 / 6	**-23 / 22**	**4 / 9**
Surface water	-7 / 8	-7 / 8	-4 / 8	-2 / 7	-1 / 4	-1 / 1	**-22 / 36**	**-2 / 5**
Groundwater	-1 / 1	-1 / 2	-1 / 1	-1 / 1	-1 / 1	-1 / 1	**-6 / 7**	**-1 / 8**
Traffic	-2 / 6	-5 / 5	-5 / 7	-4 / 7	-4 / 7	-1 / 2	**-21 / 34**	**+5 / 1**
Navigation	-5 / 9	-5 / 9	-5 / 9	-5 / 9	-5 / 8	-1 / 1	**-26 / 45**	**+8 / 7**
Irrigation	-1 / 2	-1 / 2	-1 / 2	-1 / 2	-1 / 2	-1 / 2	**-6 / 12**	**+9 / 9**
Noise	-2 / 7	-2 / 7	-2 / 7	-2 / 5	-2 / 5	-4 / 2	**-14 / 33**	**+2 / 1**
TSP	-4 / 8	-4 / 8	-4 / 5	-4 / 4	-5 / 7	-3 / 3	**-24 / 35**	**+1 / 2**
Greene House Gases	-4 / 4	-5 / 5	-4 / 4	-5 / 4	-6 / 4	-7 / 2	**-31 / 23**	**+6 / 4**
Fisheries	-4 / 5	-5 / 5	-5 / 5	-5 / 4	-5 / 2	-1 / 2	**-25 / 23**	**-2 / 5**
Fauna and Flora	-2 / 3	-3 / 3	-3 / 4	-3 / 3	-3 / 2	-3 / 3	**-17 / 15**	**-1 / 2**
Social effects	+4 / 5	+5 / 5	+5 / 7	+5 / 7	+5 / 7	-5 / 5	**+19 / 36**	**+6 / 7**
Total							**-220 / 348**	**+32 / 63**

For the operating stage of the new barrage, the environmental benefits are much greater than the negative impacts as presented in the Quantitative Matrix in Table (3). The effect of the new project on the traffic and navigation are increased dramatically by facilitating new roads, double ways traffic, and tow sluiceways as presented in Fig (1). Instead of one runway for the Old Barrage, the new NAB contains two runways for traffic as shown in Fig (4). Also, the facility roads from west to east banks and vice versa is transported away from the traffic jam of ElFath area of the old barrage. The effects of ANB on the groundwater several piezometers were drilled as illustrated in Figure (4). As the distance between Old and New barrage is small (300 m), the effects of NAB on groundwater levels is limited and if there are any variation of water tables, the reasons may be different than the effects of NAB.

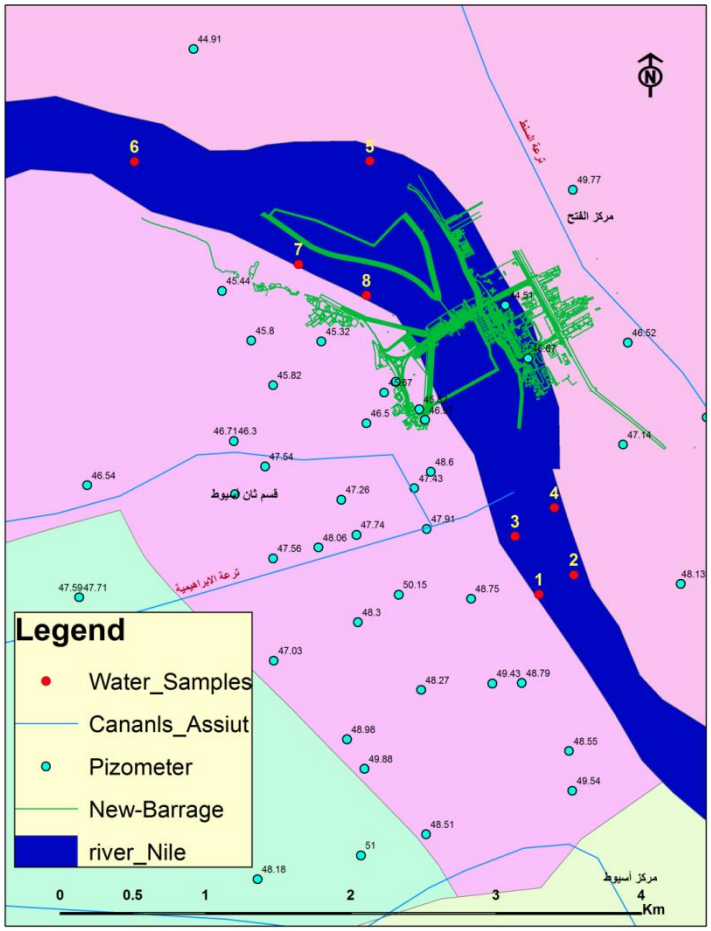

Figure (4): **Sites of surface water and groundwater samples**

4. CONCLUSION

The New Assiut Barrage (NAB) is mainly an environmental project installed to serve a huge area of farms and cultivated lands in Assiut city and to control half of river Nile water. There are several benefits of environmental impacts of the project to the neighborhood community and to the rest of river Nile sector. The NAB controls the amount of water flow from Assiut to the river's end (enters the Mediterranean Sea). The main benefits are the improvement of the irrigation system, navigators in the river and traffic on the new bridge. The additional benefit of the NAB project is the producing of clean hydropower electrical energy with 32 megawatts. This produced energy serves at least 16000 homes in Assiut city that covers the demand for energy due to the natural increasing of Population. Although the negative impacts of the NAB project during construction stage, the environmental benefits of the project after the operating process are obvious for the community. Using check list methods is a primly assessment of the EIA of the project activities. It gives a simple vision of the environmental factors and their effects on the local or global environment, while quantitative matrices such as |Leopold method are accurate and professional methods to study the environmental impacts of the projects. They help the decision makers to control the impacts of work activities on the environments.

5. RECOMMENDATIONS

For any new project, study the environmental impacts of the planned project is essential. The check list methods gives a primary vision of the environmental impacts of the proposed project but the quantitative matrices are recommended to study the effects in details. Protecting surface water and groundwater of the neighborhood the project should be taken seriously. In the construction stages measurements of environmental factors such as noise, dust, gases, and other emissions can save the area from harmful elements. Wastes of different materials should be managed and disposal in the proper sites. More care is required for the hazardous materials disposed from any project. Hazardous material should disposal in the assigned areas for these wastes.

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تقييم الاثر البيئي لقناطر اسيوط الجديدة باستخدام طريقة المصفوفات الكمية

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الملخص

تقييم الاثر البيئي هو إجراء يستخدم عند إنشاء المشروعات الكبيرة لدراسة تأثيراتها السلبية والإيجابية على البيئة المحيطة. خزان أسيوط الجديد بدأ إنشائه ليحل محل الخزان القديم ولإنتاج طاقة كهرومائية نظيفة لتنمية محافظة أسيوط. المشروع الجديد لخزان أسيوط سوف يساهم بشكل فعال في تنمية البيئة المحيطة وتسهيل حركة المرور من الشرق الى الغرب والعكس والى تحسين عمليات الري. تم دراسة الأثر البيئي لهذا المشروع القومي باستخدام طريقة المصفوفات الكمية. المصفوفات الكمية عبارة عن مصفوفة جدولية والتي تعرف وتضع اوزان للعوامل البيئية الناتجة من انشاء المشروع وتفاعلها مع البيئة المحيطة. كما قامت الدراسة بالمقارنة بين طرق دراسة التأثير البيئي للمشروعات باستخدام أكثر من طريقة مثل أوزان المصفوفات والمصفوفات الكمية. وقد تم دراسة العوامل البيئية المختلفة مثل التأثير على المياه الجوفية والمياه السطحية والنحر والتربة والنباتات والحيوانات البرية والطيور و جودة الهواء. وكان من اهم نتائج هذه الدراسة ان مشروع قناطر أسيوط قد كانت له تأثيرات بيئية جيدة وأخرى سلبية في مرحلة الأنشاء أما في مرحلة التشغيل فأشارت النتائج الى زيادة العوامل الايجابية على حساب السلبي منها. يمكن إستخدام هذه الدراسة في تحسين التخطيط وزيادة الوعي البيئي في المشاريع النهرية المستقبلية. كما أوضحت الدراسة أن طريقة المصفوفات الكمية تعطي تفاصيل أكثر عن التأثيرات البيئية للمشروعات على البيئة المحيطة.

الكلمات الدالة: **المشروعات الإنشائية – الأثر البيئي – جودة الهواء – خزان اسيوط الجديد – البيئة المحيطة**