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Environmental Impact Assessment for touristic activities on the Arabian Gulf, Case study: Saudi Arabia

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ABSTRACT: The numerical matrix, as an environmental impact assessment technique was applied to study the different environmental impacts of the proposed resort in the Eastern Region of Saudi Arabia Kingdom. The different physicochemical, biological, and socioeconomic factors have been subjected to detailed studies and data collection. It was found that the construction phase of the project has recorded -36 as the highest negative impacts in all the project's processes. While, after the resort will be fully functional; the total impacts have been estimated to be + 34. In comparison with the cumulative impacts of the area prior to the project which have recorded -4, it is proved that the construction phase will impose severe impacts upon the project site, which has been caused through some permanent changes to the environment as in the soil nature factor. The landfilling process was found to be the most negatively affecting process, unless a restricted mitigation measures will be enforced to secure a positive or as less negative impacts as possible.

INTRODUCTION

The Eastern Region of the Saudi Arabia kingdom is one of the most attractive regions in the kingdom that attracts the investment and the development. The beautiful nature of the gulf coastal region attracted some major investments to build resorts on the costal zone. In some cases, landfilling was a tool to add some man-made architecture changes to the nature on the costal zones. Some of these changes have added some positive impacts to the landscape of the region while some others have impacted the biolife the terrestrial and the marine ones adversely.(1)

The Eastern Region is the most extended and the largest region in the Kingdom with a total area of more than 497.3 thousand square kilometers which is

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equivalent to 26% of the Kingdom's area. Excluding the area of the Empty Quarter, the Eastern Region is approximately 194,000 square kilometers accounting to 10.14% of the total area of the Kingdom. It is located between longitudes (44-56 E) and latitudes (19- 29 N).(1)

The environmental impact assessment, EIA, as a management tool for the future of the sound sustainable environment; has been lunched as a governing mechanism inside the Saudi's environmental legislations. The environmental impact assessment Act has been issued at 2002, to secure a sustainable development in the kingdom.(2)

Saudi Arabia has declared an EIA decree, to assure the sustainable development in the whole Kingdome. Article 11th has detailed the specifications of the EIA' studies and followed by App 2. The Decree has been applied since then on all the new projects while has allowed the existing activities to coop with the obliged national standards through the followed five years; i.e. till 2007.(2)

Historically, Brown; 1994, stated that the environment has been abused at the expense of the technological and industrial advances which are considered the ideal and much desirable than ecological factors. The EIA , has been lunched global wide to assure the sustainability of the sound environment locally and globally.(3)

Matrices are methodologies that incorporate a list of the case study's activities and their alternative activities in a comparison to the potentially impacted environmental parameters. Various methods and techniques have been devised to assist in making comprehensive impact analysis. Each method is adapted to the particular project or action under consideration to properly reflect the action and assess its impact.(4)

The environmental impact matrix

provides a convenient inventory and display of these impacts. The pioneering work in this area was done by Leopold *et al*. (1971) and has been reviewed by Munn (1979).[4]

A major residential and touristic development project in the northern portion of A1-Khobar Cornice in the Eastern Province of Saudi Arabia was in planning phase, 2006. According to the national environmental regulation an EIA' study has to be carried out to make sure that environmental values are protected in the area and to comply with regulatory requirements.

The regional study area for this project has been arbitrarily defined as the Arabian Gulf coastal area of Saudi Arabia between the borders with Kuwait and Qatar. This regional study area also extends offshore to the international boundary and inshore of the Half Moon Bay. The area is located along the south central coast of the western Arabian Gulf. The regional study area is predominantly a shallow marine environment.

This study aims at assessing and tailoring an environmental impact assessment of the project, in Al-Khobar City in the Eastern Region of the Kingdom, applying the environmental matrix as a tool, to assure the most suitable alternative for securing a sound sustainable environment.

MATERIAL AND METHODS

The plant's environmental factors have been identified, listed, reviewed, and screened. The screened factors have been sampled and studied for the key of physicochemical and biological factors. While those socioeconomic factors' data have been collected and studied through the published data and the professional meetings. Those data have been indulged into the matrix to assess the project's impacts as positive and negative ones to secure the soundest alternatives' environmentally.

The study is divided into four phases:

Phase I: Collection of the background data:

The very first step in the study was collecting the whole project description and details. While some of the team member were reviewing all the published data about the regional characteristics of the studied area.

This step was aiming to identify all the possible environmental factors that should be studied. The environmental impacted factors' list was screened and scoped to the most relevant and those factors of a significance, magnitude and extent. Those factors have been divided into three major categories; physicochemical, biological, and socioeconomic.

Phase II: Field and Lab works:

The second phase was primarily concerned with all the field works that involved the following: a. site survey on and off-shore, b. samples collection, c. bio life observation, and d. air quality assessment.

Along three months duration, the samples from the gulf and the artificial lake have been collected from different sites, 11 sites, and in different depths. Those samples were covering the whole field study; also the samples were representing the whole project marine channel. Also, air sampling was performed to study the air quality before, during construction phase, and along with the project life-time.

The liquid samples were preserved and analyzed according the Standard Methods, Eaton *el al*., 2005[4] , for Water and wastewater Analyses. The samples were analyzed for the following parameters; pH, turbidity, conductivity, solids,…,etc. While; for the sediments the samples were analyzed microbiologically looking for the entirococci. Also, some of the samples were analyzed to determine some of the scoped trace metals.

Phase III. Data analysis: By the end of

phase II, the collected data, were all pooled together to be analyzed statistically.

Phase IV: The Environmental matrix:

Finally after analyzing the collected data, all the information were pooled together to be studied using the environmental numerical matrix. Where, the final out put of the matrix was either adverse, none, or positive impacts. The matrix results were studied to recommend what could be the possible mitigation measures to secure a sound sustainable environment of the studied project.

RESULTS AND DISCUSSION

Project description:

Planned facilities, as shown in Fig. (1), will cover approximately 1,150,000 m^2 of existing intertidal land. The development will include school of about 21,000 m^2 and 582 villas around of 600 to 3,200 m^2 each, mosque, mini-market and car service station along with extensive gardens, landscape, artificial lake, and playground areas. Clean sand will be used as backfill material which will be cleaner than the existing sediments at the study area. Therefore, a minimum or no risk of additional contamination by importing such material from outside. Also the development itself will not involve any industrial activities.

The project site is located on the coastline of the Arabian Gulf in the northeast part of Al-Khobar along with the planned Cornice road of Al-Khobar-Dammam in the Eastern Province of Saudi Arabia. The major population center closest to the site is Al-Khobar City, which lies about 5 kilometers to the south and Al-Dammam City which lies about 15 kilometers to the north. King Faisal University and the Navy Technical College are located 3-4 kilometers to the northwest along the Cornice road. A gas fuelling station from the sites is 1-2 Kilometers in the southwest. The project site has been

characterized by sediment dune/deposition with beach grasses and dead corals.

The proposed project is planned to include the landfilling in the first phase of the proposed site and in second phase the construction of the different pre-mentioned facilities.

The site survey has allocated the sampling sites and the frequency for collection for these samples. As shown in figure 2; the sampling sites were determined to cover the scoped physicochemical factors. Also, some air pollutants have been scoped to be studied in this study as: carbon monoxide, benzene, and nitrites. Meanwhile, the field observations have recorded the existing fauna and flora within the studied area.

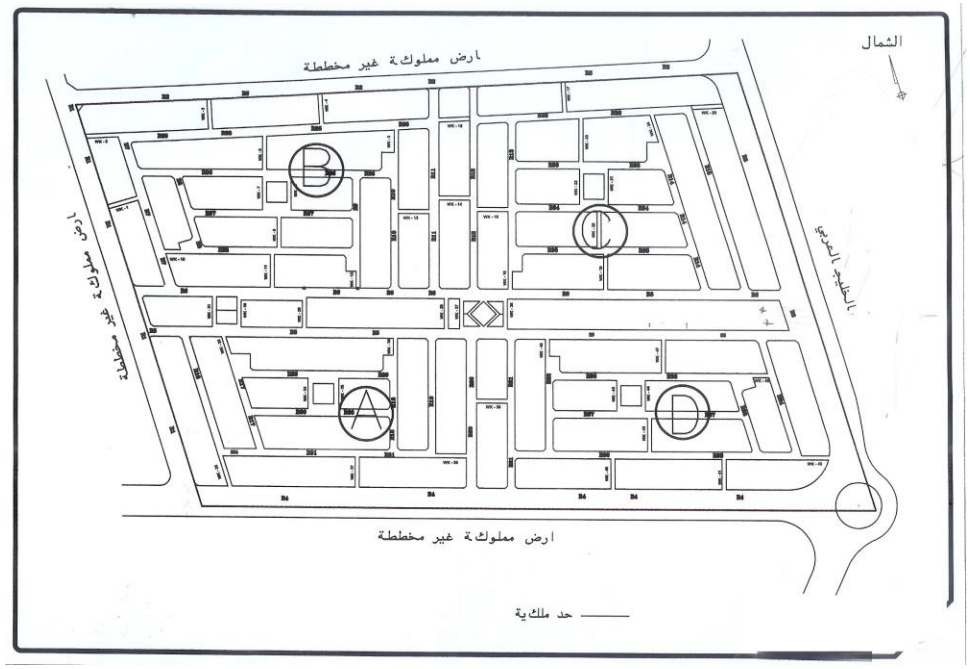

Fig (1): The proposed project map

Fig (2): Marine Chanel, the gulf, and lake marine water and sediments samples' sites.

Physicochemical factors

The results of the Gulf water samples analysis, as shown in table (1), were compared with the Gulf Water concentrations around Khobar area have shown that there were no major differences in water quality.

I.1. pH

pH is a governing factor for the fauna and flora environment. It has been scoped in this study to elaborate the impacts of the landfilling upon the marine environment, and also to study all the other impacts that may rise up during the construction phase.

As shown in table (1); the pH in the different sites had an average that is ranged from 8.06 to 8.15 and the maximum value for all the studied sites in the gulf was 8.24. It is obvious that there is some tendency toward the alkaline phase

and this could be justified by the soil and sediment nature that comes from the calcium and sodium bicarbonates and carbonates deposits.

While, those analyzed lake samples showed a minimum value of 7 and maximum value of 8.6, with an average of 7.65 and 7.88.This wide variation in the pH values in the lake could be referred to the nature of the deposits that have been found after the landfilling process. Also, it is recommended to study the deposits chemical nature that may explain this wide variation.

It is concluded from the pH analysis for all the different sites and samples that all the results are within the standards and also, there was not a significant change than the last study that has been recorded an average value of 8.21[6].

Turbidity:

Turbidity is one of those physicochemical factors that have many impacts on the different environmental components, e.g., light penetration, biolife, and ethically. The different analyzed gulf and lake sample as shown in table (1); showed an average of 1.89 and ranged from 3.94 and 0.83 NTU. This wide variation is attained cause of the tidal impact where at the inward tide the turbidity recorded high values while the outward records low values.

While for the lake's records, they were high ones as 27.03 in one site and 21.13 NTU in the other side of the lake. These high levels are explained by the nature of the closed lake and the air turbulence for the nature of the lake as a shallow one that could be severely impacted by the air currents.

So, it is so obvious that the landfilling has impacted negatively the project site during the preparation phase of the whole project.

Solids:

Solids are of important value for the different water bodies because they are the supplement of life for the different organisms; as long as their values are within the permitted standards.

As shown in table (1); the results for all the gulf water samples showed total solids that ranged between 93,860 and 55,060 g/l, with the same trend of high and low tidal effects upon the solid values. During the high tide the results trend go to the higher values, while go down during the low tidal times.

The lake samples showed as in table (1); higher total solids values, according to the nature of the lake of being closed one, where the total solids values recorded 159,284 g/l as higher values and 155,232 g/l as lower values.

The dissolved solids as in table (1); in all the collected samples from the gulf showed a range of 46,960 and 64,960 g/l. These results were higher than those results of the study that has been carried out during 1999[7] . While the lake's total solids recorded a range between 123,214 and 131,388 g/l.

Such difference could be between the current study and the 1999' study which recorded 46,990 g/l for the gulf water is justified by the elevation in the temperatures during the last decade. Also, the landfilling process is impacting adversely the total and consequently the dissolved solids during the project's preparation phase.[7]

The Gulf water suspended solids' samples showed, as in the table (1), a range of 4,970 and 28,900 g/l with an average of 13,509 g/l. The suspended solids have impacted indirectly the ethical values of the water quality of the gulf.

While those lake's samples showed, as in table (1), a higher vales that ranged between 23,844 and 36,082 g/l. These

values are referred to the landfilling process as an adverse impact.

Chlorides:

Chlorides are the major ions in the seas, mostly they are presented as sodium chloride. The different studied sites in the gulf showed, as in table (1), a range values as low as 28,741 and as high as 87,934 g/l. While, in the lake' samples the chloride ions recorded values between 101,642 and 103,420 g/l.

It is obvious during the last decade and the higher temperature trends helped the evaporation process in the Arabian Gulf are increasing to concentrate the chlorides ions in the water body, where the collected data from the water analysis for the gulf during 1999 [7] , showed values of 23,754 g/l. This could be an explanation for the wide difference in the chlorides values, but also the impacts of the landfilling is adding some justification for this difference in the chlorides values.

Conductivity:

As shown in table (1); the different sites in the gulf have shown an average of 65.28 µms/cm^2. The results revealed that the dissolved solids are in a high value even more than other semi-closed seas as the Red Sea and the Mediterranean Sea. This could be explained by the nature of the Arab Gulf and the low circulation trend in this water body. While the lake sites values as in table (1) showed higher values of 131.37 and 133.5 µms/cm^2. The lakes' results are justified by the nature of this artificial lake which is almost a closed one and not designed to be daily recycled water.

Anees *et al*., 1999 stated that conductivity recorded 58.6 µms/cm^2, as an average. The result is confirming that the nature of the water quality in the Arabian Gulf that concerns with conductivity has a significant change during the last decade.[7]

Dissolved oxygen:

The different sampling sites in the gulf showed an average of 6.56 mg/l as shown in table (1). The lake samples showed an average ranged from 4.5 up to 4.7 mg/l dissolved oxygen. These results are explained by the nature of the artificial lake of being a semi-closed one. So, it could be recommended to be a recycled water lake to maintain the biolife in the lake.

AIR QUALITY

From different location in and outside the project' site air samples have been collected to cover the whole project area and considering the up and down wind trends. As shown in table (2), the air quality measures during the study proved that all the sampling sites were within the National Ambient Air Quality Standards ; NAAQS[8].

Table (1): Physicochemical parameters' characteristics in the different studied sites

Sample	pH	Turbidity NTU	TS g/l	TDS g/l	TSS g/l	Chlorides g/l	Conductivity µms/cm^2	DO mg/l
I	8.09	1.44	70,650	59,536	11,114	40,237	64.33	6.60
I' *	8.10	0.86	65,110	50,140	4,970	30,241	65.95	NA
II	8.10	1.87	74,450	61,096	13,352	51,031	65.17	6.13
II'*	8.12	0.83	55,060	50,080	4,980	31,240	65.25	NA
III	8.13	2.22	83,878	60,116	23,762	43,697	64.87	6.40
III'*	8.14	0.88	58,090	51,080	7,010	29,491	65.45	NA
IV	8.15	2.19	78,364	63,432	14,932	38,389	65.20	6.70
IV'*	8.14	0.84	57,330	49,200	8,130	29,991	65.40	NA
V	8.12	2.02	76,206	56,224	19,980	43,764	64.87	6.13
V'*	8.13	1.06	58,340	50,763	7,577	28,741	65.85	NA
VI	8.13	2.29	77,402	59,784	17,618	43,205	64.47	6.67
VI'*	8.14	1.38	57,870	49,160	8,710	29,241	66.55	NA
VII	8.14	2.47	73,816	54,240	19,576	41,857	65.70	6.80
VII'*	8.09	2.17	59,720	50,000	9,720	43,989	66.20	NA
VIII	8.11	3.57	83,230	62,620	20,610	45,927	64.85	7.05
VIII'*	8.12	2.11	55,680	46,960	8,720	34,989	66.40	NA
IX	8.06	3.94	93,860	64,960	28,900	87,934	63.20	6.60
Average	8.12	1.89	69,356	55,258	13,509	40,821	65.28	6.56
Maximum	8.15	0.83	93,860	64,960	28,900	87,934	66.55	7.05
Minimum	8.06	3.94	55,060	46,960	4,970	28,741	63.20	6.13
L1 Average	7.65	27.03	155,232	131,388	23,844	101,642	131.37	4.73
L2 Average	7.88	21.13	159,284	123,214	36,082	103,420	133.5	4.48
R[6]	8.21			**46,990**		23,754	58.6	

*= The different depth for the same sampling site
R= WHO Guidelines for safe recreational

Table (2) Air quality concentrations in the studied project :

Sample site	NO2 ppb	CO ppm	PM10 ppb
1	2	22	12
2	19	12.8	97
3	18	10	92
4	23	18.16	116
5	25	23	123
6	23	17	112
Average	18.33	17.16	92.00
NAAQS*	100	40	150

* The Clean Air Act; US EPA[8]

Biological Factors

1 Microorganism

The microbiological analysis for all the liquid and sediment samples; showed negative results for any coli form a sewage contamination in the studied area.

2. Fauna…

2. a. Birds: The birds that have been observed , were mostly *Socotra cormorant* in abundance according the season.

2.b. Small fish:

Small fish were observed on the shoreline in small groups and they were in the sight which proved that the marine environment is very suitable f or these species of fish.

3. Flora

Sea weeds were floating on the surface, a lot were observed in the area . While, the sea grass was observed on the edge of the marine channel and associated with small fish in the area

4. Endangered species:

Mangroves weren't founded in the area because of land filling and dumping in the gulf area. Also, the coral Reefs: within the area of the study and by observation none has been recorded, because of the land filing and dumping process in the gulf area. The sea turtles: weren't founded in

the area by observation; neither the animals themselves nor their nests.

Socioeconomic factors:

As the project description and the future expectation the population density, public health, housing, employment, recreational areas, and transportation are the main social environmental factors to be assessed as directly affected factors of the project development in the site. The assessment proved that the municipalities' capacity will cover all the studied factors except that recreational areas that are covered within the project planning.

While, economically, the whole project will add to the area new manpower and jobs, and also; the economic value of the whole project will be multiplied positively according to the national growth rate and to the added values of the whole project.

CUMULATIVE IMPACTS

The cumulative impacts of the proposed project are the changes to physical, biological, and socioeconomic resources that are incremental to impacts from past, present, and reasonably foreseeable future actions. The objective of an evaluation of cumulative impacts is to consider potential effects of the proposed project within a broad environmental context. Some of those impacts are individually minor but collectively significant actions taking place over a period of time can result in cumulative impacts[9].

By evaluating the condition of the existing environment, which is largely affected by past cumulative impacts, the potential environmental consequences of the proposed program were assessed. Therefore, the study focused on relating the proposed project to the anticipated effects of other existing and foreseeable actions.

Environmental Matrix

The numerical matrices were used since the 1990's to achieve more precise values of the studied factors and their impacts .Where all the information about the activities and the different scoped

environmental factors are pooled and correlated together. The matrix is based on assuming cetrain numerical values as for ,-5 , for the severe adverse impacts and , +5, for the maximum positive impacts and all are passing by the ,0, the no value that represents neither positive nor negative impacts of the studied factor. This is one of the effected methods to overcome one of the deficiencies of the EIA sciences[10].

In the numerical matrix as it is shown in figure ``(3), the construction phase of the total impacts value has recorded -36, while after the resort will be functional the total impacts estimated to be + 34. In comparison with the cumulative impacts of the area prior to the project which have recorded -4, it is proved that the construction phase will impose severe impacts upon the project site, unless a restricted mitigation measures are to be enforced.

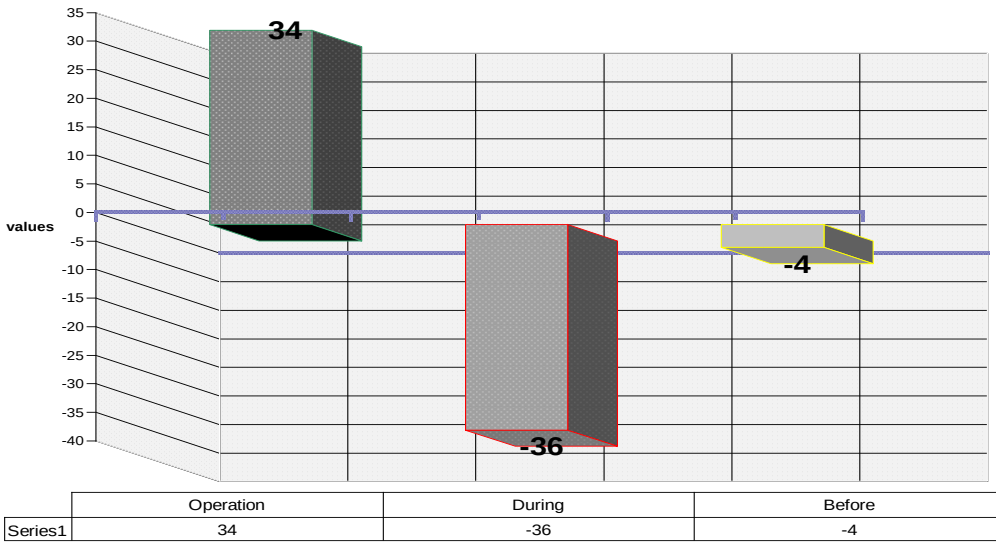

Fig. (3) The numerical Matrix data representing the impacts before, during construction, and the full operating phases

While, some of the studied factors as the biological factors and the socioeconomic factors will be positively impacted once the project will be in the operational phase.

The environmental factors in the matrix divided into 3 main factors: physiochemical, biological, and socioeconomic. Each one contains variables that affected through activities during construction period and operation.

Physiochemical factors included soil condition, erosion, ambient air quality, visibility, malodors, noise, and ground water quality. The soil condition, as an example for the numerical matrix, in the study area was natural before construction period while during construction period and operation the soil will be affected from land filling application, to be permanently changed. In such case, the degree of the impacts have to be -5.

While in the Biological factors study that included coral reef, see grass, fish and endangered fauna and flora. Fishery abundance before the construction period was not suitable for fish to live but after the channel will be functional, there will be good environment for fishing. While for the birds, during the landfilling process will be impacted severely as +3.

The socioeconomic factors included population, health facilities, educational facilities, recreational areas, and economic values. It was proved through the study as in table (3), that the project will record a positive impact on such factor.

Some of the studied factors have to be controlled through predesigned mitigation measures to minimize the adverse impacts that have been proved through the study.

Table (3) : The Numerical Matrix assessment for the different studied project's phases

Environmental factors	Activities	Construction period			
		Before	During	Operation	Total
physicochemical					
	land escape	-1	-2	3	0
	soil condition	0	-5	-5	-10
	Erosion	-1	0	2	1
	Ambient air quality	0	-3	1	-2
	Visibility	1	-1	0	0
	Malodors	-1	-1	3	1
	Noise	0	-3	0	-3
	Groundwater quality	0	0	0	0
Biological					
	Coral reefs	-1	-5	2	-4
	sea grass	-1	-5	2	-4
	Endangered Avifauna organisms	-1	-3	3	-1
	Fishery abundance	0	-2	3	1
	Endangered flora	0	-1	1	0
Socioeconomic					
	Population	0	0	2	2
	Health facilities	0	0	3	3
	Educational facilities	0	-3	5	2
	Recreational area	1	0	5	6
	Economic value	0	-2	5	3
	Total	-4	-36	34	-6

Mitigation measures

Since the concept of mitigation is central to the EIA process and critical to provision of adequate environmental protection coincident with the benefits of development, a clear understanding of mitigation of significant impacts as a management concept is important issue.

Reducing or eliminating the impacts over time through preservation and maintenance operations during the lifetime of an action; and compensation for the impact by replacing or providing substitute resources or environments, is the main target of applying the mitigation measures.

POTENTIAL MITIGATION MEASURES

It is assumed that the project is required and certain impacts cannot be

avoided. Therefore, emphasis herein is placed on minimizing impacts by limiting the degree or magnitude of the action. Suggested mitigation measures to either reduce water quality and biological resource impacts to insignificant (no impact) or to partially reduce impacts are discussed below.

Landfilling

The major activity that will upset the environmental balance in the project site is the landfilling. To avoid sediment erosion and resulting deposition on the outer coast during landfilling, a dewatering basin could be used during the process of water disposal. Release should be slow and subtidal rather than simply flowing the excess water across the beach. As mitigation measure if the landfilling could be done as a second scenario by the sand and soil from the remote areas in the desert, this will not affect the physicochemical and biological factors in the gulf water. This alternative will add some positive values for the impacts because the only environmental factor that will be affected from the landfilling will be the terrestrial life. This alternative should be studied as a cost-benefit study to assess the economic value against the environmental impacts

The turbidity plumes associated with the landfilling will likely cause substantial turbidity plumes in the local study area and, consequently will reduce water quality. Nearby the project area there are development plans along the shoreline that also include landfilling. These activities would introduce substantial quantities of suspended sediments into the water column that could interact with the turbidity plumes. The timing of backfilling should be coordinated with the developers of these projects that the system will not become overloaded with suspended sediment offshore. Therefore, it is proposed that the landfilling process has to be during the high tide that may absorb most of the negative impacts upon the marine life. Moreover,

after the landfilling process will be implemented and during the functional phase of the project, the marine environment will absorb those impacts by time to be back to the normal marine environment.

CONCLUSIONS & RECOMMENDATIONS

A. Conclusions:

From the study the following facts could be concluded:

According to the nature of the both regional descriptions and the project all along with the results that were found through the numerical matrix application; the following are concluded:

- The numerical method for evaluating the different impacts was found to be easier to understand the quantity of the expected impacts.
- The physicochemical factors will be impacted adversely with the value of -14 which are majorly affected by the project construction phase which recorded -15.
- The biological factors have recorded -8 numerical value and again the construction phase was the main reason for such negative impacts where it recorded -16 numerical value.
- The socioeconomic factors have recorded +16 as numerical value where the project operational phase has recorded +20 cause of the beneficial impacts that are expected after the completion and running of the project.
- Landfilling was found to be the major source of those adverse impacts to the whole project evaluation.

B. Recommendations

From the whole study the following are recommended:

- Such study needs more elaborate investigations and analysis, such as: a seasonal variation studies to be able to record those varieties that accompanied with the different seasons.
- The landfilling process needs more studies for the possibilities of changing

the source of the landfilling to be a remote desert' sands that could efficiently replace the used marine sediments because those sediments affect adversely the whole biological and physiochemical features.

- Finally, the study recommends the possibility of applying computer models to assess the expected impacts as a standard method for unifying the EIA studies.

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