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Evaluation of the Environmental Impacts of Bahr Al Baqar Drain on Manzala Ecosystem; using Rapid Impact Assessment Technique

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ABSTRACT

To evaluate Bahr Al Baqar Drain's impacts on the surrounding ecosystem, the present research used Rapid Impact Assessment Matrix (RIAM) involving a total of 195 parameters to provide a complete environmental assessment. Physical-chemical (41 parameters), biological-ecological (51), social-cultural (46), and economical-operational (57) were used for the evaluation. According to RIAM results, 36.6% of physical-chemical parameters induced moderate negative changes in the drain environment, while 27.5% of biological-ecological parameters displayed moderate negative impacts. For social-cultural parameters, 34.8% showed no environmental change to the drain, while other parameters were subjected to the negative side of RIAM. Economical-operational parameters recorded slight negative changes by 42.1%. Totally, all the recorded parameters in RIAM induced negative significant impacts on the environmental status of Bahr Al Baqar Drain except 27% of those parameters. The research indicated that RIAM is a very useful tool for decision-makers as it is able to demonstrate the environmental situation of different projects in order to offer the best environmental solutions.

INTRODUCTION

Bahr Al Baqar Drain carries about 650 million m^3/year of discharged wastewater to Lake Manzala, with high loads of hazardous compounds.

In Shoubra El-Khema, Bahr Al Baqar Drain receives untreated waste water from metal production and food processing factories. In Zagazig, detergents and soaps manufacturing, textile finishing and paper production provided different sources of wastes. Also, Bahr Al Baqar Drain receives wastewater discharged from Belbeis drain of industrial and domestic activities from rural areas (Omran and El Razek, 2012). Generally, about 58% of wastewater of Bahr Al Baqar Drain comes from agricultural drainage, 40% from commercial and domestic and 2% from industrial drainage (Saad, 1997). Discharges of municipal and domestic wastes make the use of this water even after mixing with fresh water for irrigation risky for public health (El-Sherbeny and Ramadan, 2016; Ramadan *et al*., 2016).

Bahr Al Baqar Drain pours into Lake Manzala which is an important source of fisheries (Mohamed, 2001), its water used in fish farming and irrigation (Ali *et al.,* 1993; Abdel-Azeem *et al.,* 2007), the heavy metals and major environmental hazardous components may cause serious harmful impacts on human, thus its water must be evaluated ecologically, (Ezzat, 1989; Hamed *et al.,* 2013).

Rapid Impact Assessment Matrix (RIAM) is a transparent judgment method developed for the environmental impact assessment practise. The method was settled by Cristopher Pastakia (Pastakia, 1998; Pastakia and Jensen, 1998) in 1990s ends, and since then it has been vastly implemented in many case studies assessment (Pastakia and Jensen, 1998; Al Malek and Mohamed, 2005; El-Naqa, 2005; Haie, 2006).

RIAM has been already applied to many environmental issues (Al Malek and Mohamed, 2005; El-Naqa, 2005; Robu *et al.,* 2007; Ijas *et al.,* 2010; Suditu and Robu, 2012), public water supply issues (Kankam *et al.,* 2005; Kuitunen *et al.,* 2008), geothermal energy supply issues (Arevalo, 2003; Yousefi *et al.,* 2009; González *et al.,* 2015), transportation, urban planning and tourism issues (Wei *et al.,* 2014).

One of the main targets of Ministry of Water Resources and Irrigation is to follow-up and evaluate the environmental situation of all water streams in Egypt. In this study, RIAM had been constructed for Bahr Al Baqar Drain to assess and provide reliable information about the current conditions of environmental impact of the drain.

MATERIALS AND METHODS

Site description

Bahr Al Baqar Drain is locating between 32° 05’ to 32° 16’ longitude and 30° 56’ to 31° 07’ latitude (Fig. 1). Its length is 170 km conducts about 650 million m^3/year wastewater from Zagazig City and ended in Lake Manzala located on the Northern edge of the Nile Delta. Bahr Al Baqar Drain assembles the wastes from two tributary drains: Bilbeis Drain and the Qalubeya Drain. They are transitory through Qalubyia, Sharkia, Ismailia and Port Said Governorates (Taha *et al.,* 2004; Stahl *et al.,* 2009; Omran and El Razek, 2012).

Rapid Impact Assessment Matrix (RIAM)

In the present study, RIAM has applied for Bahr Al Baqar Drain to measure risk quantification and potential hazards. To evaluate the impact of the drain, definite criteria in quantification the environmental impact were used according to the evaluation of Kuitunen *et al.* (2008), as shown in Table 1.

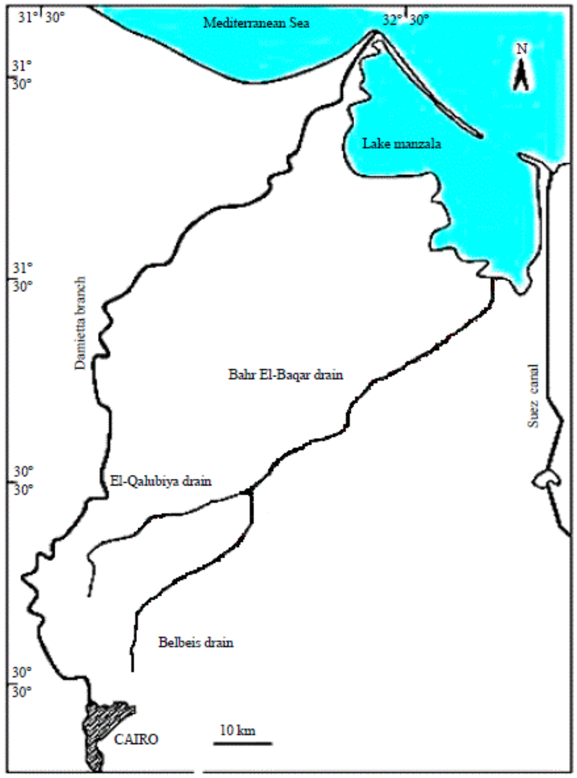

Fig.1: Location map of Bahr Al Baqar Drain

Table 1. Description of RIAM Criteria

Criterion	Scale	Description
A1 - The importance of the condition	+4	Important for the national/international interests
	+3	Important for the regional/national interests
	+2	Important only for the zones found near the local zone
	+1	Important only for the local condition
	0	No importance
A2 - The magnitude of the changing/effect	+3	Major importance benefit
	+2	Meaningful benefit of the quo status
	+1	Benefit of the quo status
	0	Lack of change/status quo / no influence
	-1	Negative change of quo status
	-2	Significant disadvantages or negative changes
	-3	Major disadvantages or changes
B1 - Permanence	+1	No changes
	+2	Temporary
	+3	Permanence
B2 - Reversibility	+1	No changes
	+2	Reversible
	+3	Irreversible
B3 - Cumulatively	+1	No changes
	+2	Non-cumulative/unique
	+3	Cumulative/synergetic
B4- Susceptibility	+1	No impact, No Change to Status Quo
	+2	Environment stable
	+3	Environment sensitive to change

RIAM used specific criteria in quantification the environmental impact, as follows:

a) Criteria that could individually modify the obtained score (group A), and

b) Criteria that couldn't individually modify the obtained score (group B).

Each group of criteria (A and B) was calculated considering the specific Eqs. 1 and 2. The Environmental Score (ES) was calculated as the value resulted by multiplying the grades from group A with the sum of grades from group B (Eqs. 1-3) (Kuitunen *et al.*, 2008; Suditu and Robu, 2012).

$$(A1) \times (A2) = AT \quad (1)$$

$$(B1) + (B2) + (B3) + (B4) = BT \quad (2)$$

$$(AT) \times (BT) = ES \quad (3)$$

Where:

A1: The importance of the condition

A2: The magnitude of the changing/effect

AT :the result of multiplication of all (A) scores

B1: Permanence

B2: Reversibility

B3: Cumulatively

B4: Susceptibility

BT :the result of summation of all (B) scores

ES: Environmental Scores

In order to assure an evaluation system with more certainty, the environmental scores (ES) were classified so that a comparison of quantified impacts for various situations can be done, Table 2.

Table 2. Description of the environmental scores - calculated (ES)

Environmental Score	Class	Description of the category
+72 to +108	+E	Major positive changes/ impact
+36 to +71	+D	Significant positive changes/ impact
+19 to +35	+C	Moderate positive changes/ impact
+10 to +18	+B	Positive changes/ impact
+1 to +9	+A	Slight positive changes/ impact
0	N	Lack of change/status quo/ no impact
-1 to -9	-A	Slight negative changes / impact
-10 to -18	-B	Negative changes / impact
-19 to -35	-C	Moderate negative changes / impact
-36 to -71	-D	Significant negative changes / impact
-72 to -108	-E	Major negative changes / impact

RIAM components

To evaluated the interaction of biotic and non-biotic services that performed the ecosystem, totally 195 parameters were involved in RIAM; PC; physical-chemical environmental criteria (41 parameters), BE; biological-ecological (51 parameters), SC; social-cultural (46 parameters) and EO; economical-operational (57 parameters). These criteria reflected the description of the environmental status of any project related to human beings, (Pastakia, 1998; Pastakia and Jensen, 1998).

RESULTS AND DISCUSSION

Physical-Chemical Environmental Criteria (PC)

PC includes all physical and chemical aspects related to finite and infinite resources including impacts of potential hazards and risks for the studied stream. RIAM was applied for 41 water PC environmental criteria, (Table 3). Susceptibility performance description for each criterion was explained according to equations (1, 2, and 3).

The RIAM present results of PC environmental criteria did not expressed any positive impacts in Fig. 2. The ES value of nine PC criteria was zero, which expressed lack of change/status quo/ no impact (Class N) for the environment status of Bahr Al Baqar Drain by 22%. Five PC criteria recorded slight negative changes (Class –A) as ES=-1 to -9, by 12.2%. The value of ES tends to be more negative to equal -10 to -18 for five PC criteria by 12.2% (Class –B). The largest contribution to the physical and chemical environment of Bahr Al Baqar Drain was through 15 PC criteria which cause moderate negative changes by ES = -19 to -35 (Class –C) by 36.6%. Three PC criteria performed Significant negative changes with ES=-36 to -71 (Class –D). The major negative environmental changes induced by four PC criteria with ES=-72 to -108 (Class –E) by 9.8%. The environmental impact assessment performed by using RIAM method showed that all the studied PC criteria recorded in the negative side of RIAM. These reflected that physical and chemical criteria triggered environmental risk of Bahr Bahr Al Baqar Drain. The results emphasized by many authors measured the bad physical and chemical status of Bahr Al Baqar Drain water, (El-Sherbeny and Ramadan, 2016; Ramadan *et al.*, 2016; El-Bady, 2014).

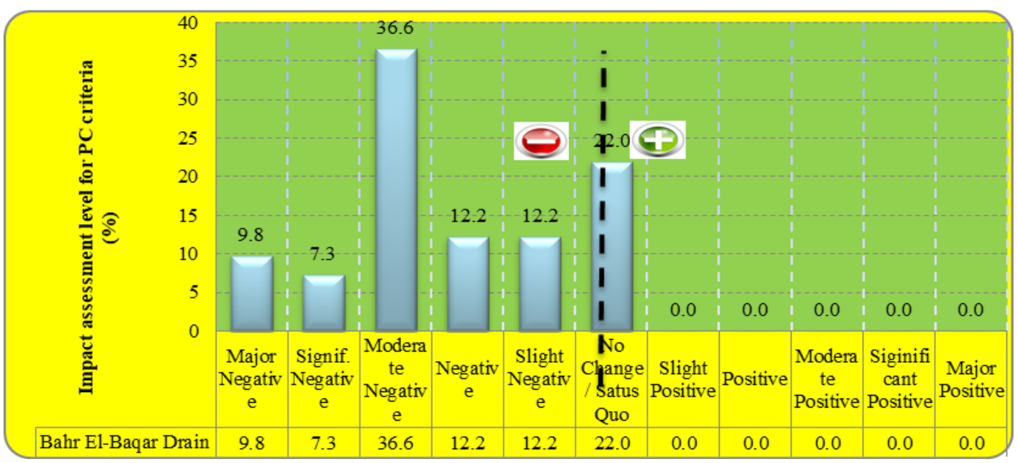

Fig. 2. Level of Impact assessment for 41 physical-chemical environmental parameters on Bahr Al Baqar Drain

Table 3. Rapid impact assessment matrix for 41 Physical – Chemical components

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
PC1	Biological Oxygen Demand (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC2	Chemical Oxygen Demand (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC3	PH (Hydrogen Ion content)	2	-1	2	2	2		-12	Negative
PC4	Total dissolved solids (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC5	Cations (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC6	Anions (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC7	Nitrogen/Phosphorus Ratio	2	-2	2	2	2	2	-32	Moderate Negative
PC8	Lead (mg/l)	2	-2	1	1	1	2	-20	Moderate Negative
PC9	Copper (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC10	Iron (mg/l)	2	-2	1	1	1	2	-20	Moderate Negative
PC11	Zinc (mg/l)	2	-2	1	1	1	2	-20	Moderate Negative
PC12	Boron (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC13	Manganese (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC14	Nickel (mg/l)	2	-2	2	2	2	2	-32	Moderate Negative
PC15	Sediment (quantity)	1	-1	1	1	2	2	-6	Slight Negative
PC16	Sediment (quality)	1	-2	3	2	2	2	-18	Negative
PC17	Geological Features	0	0	1	1	1	2	0	No Change / Status Quo
PC18	Bed Load	1	-1	1	1	1	1	-4	Slight Negative
PC19	Evaporation Rate (mm/day)	1	-3	1	1	1	3	-18	Negative
PC20	Temperature (ºC)	1	-2	2	2	2	3	-18	Negative
PC21	Seepage	2	-3	3	3	3	3	-72	Major Negative
PC22	Bank erosion	2	-3	3	3	3	2	-66	Significant Negative
PC23	Impact on Irrigation Canals	0	0	1	1	1	1	0	No Change / Status Quo
PC24	Dissolved Oxygen	2	-3	3	3	3	3	-72	Major Negative
PC25	Transparency	1	-1	2	2	2	3	-9	Negative
PC26	Evaporation	1	-2	3	3	3	2	-22	Moderate Negative
PC27	Water Circulation	1	0	1	1	1	2	0	No Change / Status Quo
PC28	Suspended Sediment Load	1	-1	2	2	2	2	-8	Slight Negative
PC29	Wind Speed	0	0	1	1	1	1	0	No Change / Status Quo
PC30	Earthquake probability	0	0	1	1	1	1	0	No Change / Status Quo
PC31	Barrage and Hydraulic Structures Safety	0	0	1	1	1	1	0	No Change / Status Quo
PC32	Hydraulic Structure Safety	0	0	1	1	1	1	0	No Change / Status Quo
PC33	Hydropower Stations safety	0	0	1	1	1	1	0	No Change / Status Quo
PC34	flood plain safety	0	0	1	1	1	1	0	No Change / Status Quo
PC35	Navigation in the stream	1	-2	3	3	3	2	-22	Moderate Negative
PC36	Odor	2	-3	3	3	3	3	-72	Major Negative
PC37	Color	1	-3	3	3	3	3	-36	Significant Negative
PC38	Infrastructure Impacts	1	-1	2	2	2	2	-8	Slight Negative
PC39	Land use efficiency	1	-1	2	2	2	2	-8	Slight Negative
PC40	Air Quality	2	-2	3	3	3	3	-48	Significant Negative
PC41	groundwater impacts	2	-3	3	3	3	3	-72	Major Negative

Biological-Ecological Environmental Criteria (BE)

The studied BE components were represented all aspects with impacts on aquatic and land biota, species preservation and conservations and the interaction with ecological and biological systems and sub-systems. Also, BE identified all the biological system inside and outside the body of Bahr Al Baqar Drain, either for terrestrial or aquatic system.

RIAM was applied for 51 water biological-ecological environmental criteria, Table. 4. Impact assessment performed by using RIAM method showed that 14 criteria displayed susceptibility performance with moderate negative impact with ES=-19 to -35 (Class –C) by 27.5%. ES value of two BE criteria was zero displayed lack of environmental impact (Class N) on Bahr Al Baqar Drain (3.9%). Moreover, 12 and 13 criteria displayed negative and significantly negative impacts (Classes –B and –D), with ES = -10 to -18 and -36 to -71, respectively. Seven ES BE criteria displayed slight negative environmental impacts with ES= -1 to -9 (Class –A), 13.3%. Three BE criteria expressed major negative impact (Class –E) as ES=-72 to -108 with 5.9%. As mentioned in the PC parameters, BE parameters expressed that Bahr Al Baqar Drain is environmentally hazards as it contains many pathogens and coliforms, especially Escherichia coli in the surface water, Stahl *et al.* (2009). Also as physical-chemical criteria, the Biological-Ecological criteria did not express the positive side impact, only 6.3% of the total measured components were expressed in the status quo of RIAM, Fig. 3. The Biological-Ecological negative impacts of Bahr Al Baqar Drain were reflected to the Lake Manzala fish production, Mehanna *et al.* (2014). Also, the lake's fish were chemically and microbially contaminated and dangerous for human health, Hamed *et al.* (2013).

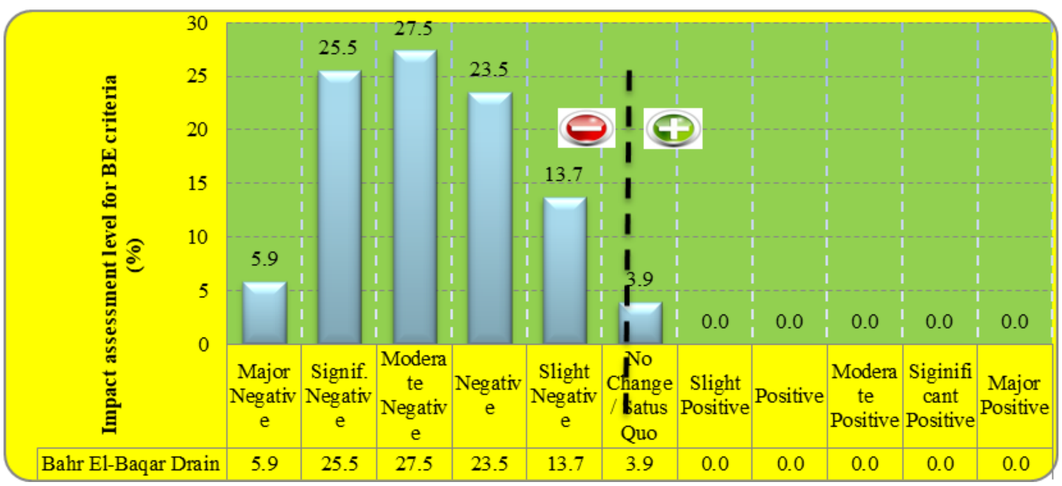

Fig. 3. Level of Impact assessment for 51 Biological-Economical Environmental Parameters on Bahr Al Baqar Drain

Table. 4. Rapid impact assessment matrix for 51 Biological-Ecological components

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
BE1	Particulate Organic Matter	1	-1	3	3	3	3	-12	Negative
BE2	Primary Productivity	2	-2	3	3	2	3	-44	Significant Negative
BE3	Photosynthetic Capacity	2	-3	3	2	2	3	-60	Significant Negative
BE4	Community Distribution	2	-1	3	2	2	2	-18	Negative
BE5	Shallow Zone Macrophytes	1	-1	3	2	2	3	-10	Negative
BE6	Fungi	1	-1	3	3	3	3	-12	Negative
BE7	Chlorophyll a	2	-2	3	2	2	3	-40	Significant Negative
BE8	Submerged Weeds	1	-1	3	3	3	3	-12	Negative
BE9	Merged Weeds	1	-1	3	3	3	3	-12	Negative
BE10	Floating Weeds	2	-2	3	2	2	2	-36	Significant Negative
BE11	Density of phytoplankton	1	-1	1	3	2	3	-9	Negative
BE12	phytoplankton distribution	1	-1	1	2	2	2	-7	Slight Negative
BE13	phytoplankton Migration	1	-1	1	2	2	2	-7	Slight Negative
BE14	Zooplankton Migration	1	-1	3	2	2	2	-9	Negative
BE15	Density of Zooplankton	1	-1	1	2	2	3	-8	Slight Negative
BE16	Distribution of Zooplankton	1	-1	1	2	2	2	-7	Slight Negative
BE17	Zoobenthos	1	-1	3	3	3	3	-12	Negative
BE18	Density of Zoobenthos	1	-1	1	3	3	3	-10	Negative
BE19	Aquatic Insects	2	-1	3	2	2	2	-18	Negative
BE20	Fish Species Diversity	2	-2	3	3	3	3	-48	Significant Negative
BE21	Fish Feeding Habits	1	-2	3	2	3	3	-22	Moderate Negative
BE22	Fish Age	2	-2	3	2	2	3	-40	Significant Negative
BE23	Fish Growth	2	-2	3	2	2	3	-40	Significant Negative
BE24	Fish Length	2	-2	3	2	2	3	-40	Significant Negative
BE25	Fish Production	2	-2	3	3	3	3	-48	Significant Negative
BE26	Commercial Fish Production	2	-2	2	3	3	3	-44	Significant Negative
BE27	Fish Mortality Rate	2	-2	3	2	3	3	-44	Significant Negative

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
BE28	Amphibian Fauna	1	-1	1	1	1	1	-4	Slight Negative
BE29	Reptilian Fauna	0	0	1	1	1	1	0	No Change / Status Quo
BE30	Avifauna	1	-1	1	1	1	1	-4	Slight Negative
BE31	Wheat crop	2	-2	2	2	2	2	-32	Moderate Negative
BE32	Barely Crop	2	-2	2	2	2	2	-32	Moderate Negative
BE33	winter vegetables	2	-2	2	2	2	2	-32	Moderate Negative
BE34	Palms	2	-2	2	2	2	2	-32	Moderate Negative
BE35	Berseem	2	-2	2	2	2	2	-32	Moderate Negative
BE36	Legumes	2	-2	2	2	2	2	-32	Moderate Negative
BE37	Maize	2	-2	2	2	2	2	-32	Moderate Negative
BE38	Bacteria	1	-2	3	3	3	3	-24	Moderate Negative
BE39	T. coli.	2	-2	3	3	3	3	-48	Significant Negative
BE40	F. Coli.	2	-2	3	3	3	3	-48	Significant Negative
BE41	Rice	2	-2	2	2	2	2	-32	Moderate Negative
BE42	Cotton	2	-2	2	2	2	2	-32	Moderate Negative
BE43	Summer Vegetables	2	-2	2	2	2	2	-32	Moderate Negative
BE44	Endemism	1	-2	3	3	3	2	-22	Moderate Negative
BE45	Biodiversity	2	-3	3	3	3	3	-72	Major Negative
BE46	Geodiversity	0	0	1	1	1	1	0	No Change / Status Quo
BE47	Soil Productivity	2	-3	3	3	3	3	-72	Major Negative
BE48	Ecological Stability	2	-3	3	3	3	3	-72	Major Negative
BE49	Land Aesthetics	1	-1	3	3	3	3	-12	Negative
BE50	Relicts	1	-1	2	2	2	2	-8	Slight Negative
BE51	Habitat	1	-2	3	3	3	3	-24	Moderate Negative

Social-Cultural environmental criteria (SC)

Social-Cultural components concerned human related aspects in the surrounding environment that determined human health, wealth, preservation, restoration for natural and cultural heritage, the better SC the good human needs and services, (Mihaiescu *et al.*, 2015).

RIAM was applied for 46 SC parameters on Bahr Al Baqar Drain, Table. 5. These cultural and social issues were affecting the environment status on the level of individuals and groups. Also, they might affect human development, activities, heritage and cultural conservation or preservation and food security. Fig. 4 displayed 16 out of the 46 SC components contributed 34.8% of susceptibility performance with no environmental change/ status quo to Bahr Al Baqar Drain, other components were subjected in the negative side of RIAM. Class –A expressed by eight SC components with ES=-1 to -9 and slight negative environmental impacts (17.4%). The negative impacts represented by 6 parameters (17.4%) as ES= -10 to -18 and class –B. ES equals -19 to -35 for 9 SC components displayed moderate negative environmental impacts (19.6). 7 SC parameters displayed significant negative environmental impacts on Bahr Al Baqar Drain (class –D). The social and human heritage in Bahr Al Baqar Drain were affected as a result of diffusion of some kinds of constituents that still have negative environmental and health impacts. The stream was incapable of recycling and or removing agricultural, municipal and industrial constituents for recovering due to the lack of continuous seasonal flushing floods, Stahl *et al.* (2009) and Attia (1999).

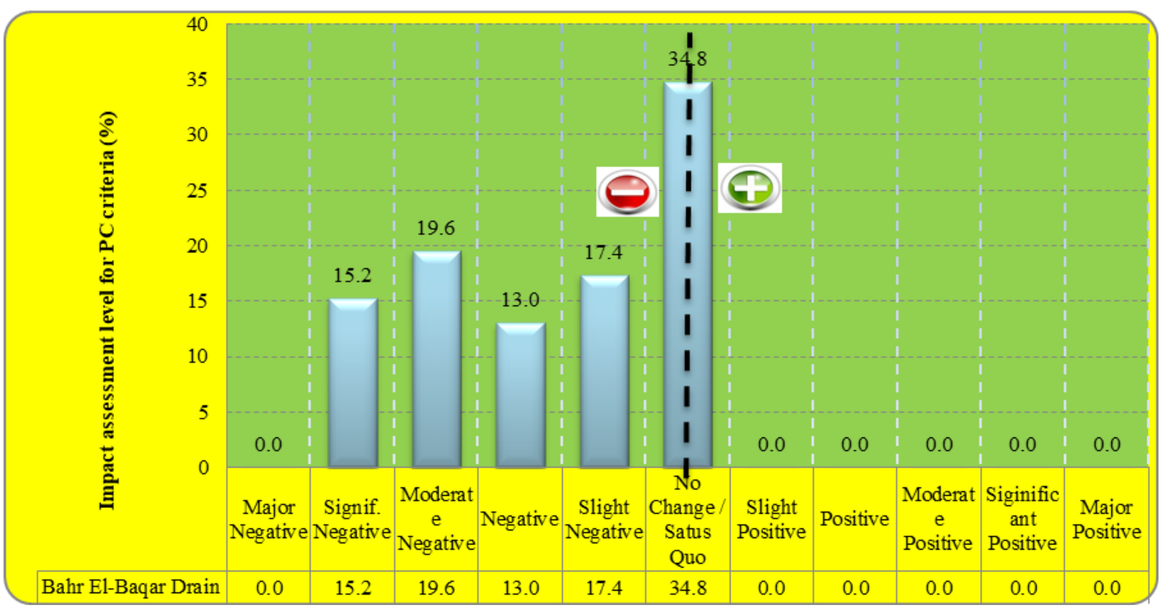

Fig. 4. Level of Impact assessment for 46 Social-Cultural Parameters on Bahr Al Baqar Drain

Table. 5. Rapid impact assessment matrix for 46 Social-Cultural components

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
SC1	Electricity Production	0	0	1	1	1	1	0	No Change / Status Quo
SC2	impact on rural population with access of water	1	-1	3	3	2	2	-10	Negative
SC3	Agricultural irrigated land	2	-1	3	3	3	3	-24	Moderate Negative
SC4	freshwater withdrawals for agriculture	1	-1	3	3	3	2	-11	Negative
SC5	Agricultural machinery	0	0	1	1	1	1	0	No Change / Status Quo
SC6	freshwater withdrawals for domestic	1	-1	2	1	1	1	-5	Slight Negative
SC7	freshwater withdrawals for industry	0	0	1	1	1	1	0	No Change / Status Quo
SC8	Arable land	2	-2	2	3	3	2	-40	Significant Negative
SC9	Cereal yield	2	-2	2	3	3	3	-44	Significant Negative
SC10	Children in employment	0	0	1	1	1	1	0	No Change / Status Quo
SC11	Children out of school	0	0	1	1	1	1	0	No Change / Status Quo
SC12	Crop production	2	-1	2	2	3	3	-20	Moderate Negative
SC13	Electric power consumption	0	0	1	1	1	1	0	No Change / Status Quo
SC14	Food production	2	-2	2	3	3	3	-44	Significant Negative
SC15	Employees, agriculture	1	-1	2	1	2	2	-7	Slight Negative
SC16	Employees, industry	0	0	1	1	1	1	0	No Change / Status Quo
SC17	Employees, services	0	0	1	1	1	1	0	No Change / Status Quo
SC18	Fertilizer consumption	1	-1	2	3	2	3	-10	Negative
SC19	Forest area	0	0	1	1	1	1	0	No Change / Status Quo
SC20	Improved sanitation facilities	1	-2	3	3	3	3	-24	Moderate Negative
SC21	Improved water source, rural	1	-2	3	3	3	3	-24	Moderate Negative
SC22	Improved water source, urban	0	0	1	1	1	1	0	No Change / Status Quo
SC23	Capita income	1	-2	2	2	2	3	-18	Negative
SC24	Land under cereal production	1	-2	2	2	3	3	-20	Moderate Negative
SC25	Livestock production	2	-2	2	2	3	3	-40	Significant Negative
SC26	Unemployment total	1	-1	2	2	2	2	-8	Slight Negative
SC27	Malnutrition prevalence	1	-2	2	2	3	3	-20	Moderate Negative
SC28	Mortality rate	1	-2	2	2	3	3	-20	Moderate Negative
SC29	Maternal mortality ratio	1	-2	2	2	3	3	-20	Moderate Negative
SC30	Permanent cropland	1	-1	2	2	2	2	-8	Slight Negative
SC31	Net migration	1	-1	1	1	1	1	-4	Slight Negative
SC32	Poverty gap	1	-1	2	2	2	3	-9	Negative
SC33	Impact on Archology	0	0	1	1	1	1	0	No Change / Status Quo

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
SC34	Impact on Navigation	0	0	1	1	1	1	0	No Change / Status Quo
SC35	Impact on fish Production	2	-2	3	3	3	3	-48	Significant Negative
SC36	Impact on Fishermen Income	1	-2	3	3	3	3	-24	Moderate Negative
SC37	Impact on Tourism	0	0	1	1	1	1	0	No Change / Status Quo
SC38	Cultural Heritage	0	0	1	1	1	1	0	No Change / Status Quo
SC39	Public Safety	1	-1	2	2	2	1	-7	Slight Negative
SC40	Public Health	2	-2	3	3	3	2	-44	Significant Negative
SC41	Natural Heritage	1	-1	2	2	2	1	-7	Slight Negative
SC42	Education	1	-1	3	3	3	2	-11	Negative
SC43	Therapeutics	2	-2	3	3	3	3	-48	Significant Negative
SC44	Research and Science	0	0	1	1	1	1	0	No Change / Status Quo
SC45	Public Adaptability	1	-1	1	1	1	1	-4	Slight Negative
SC46	Archeology	0	0	1	1	1	1	0	No Change / Status Quo

Economical-Operational environmental criteria (EO)

57 EO components in this research measured to express the environmental performance of Bahr Al Baqar Drain through its operational, technical and economical condition، Table. 6. Good EO conditions decreases and enhances human needs and reduces the consumption of natural resources, (Pastakia and Jensen, 1998).

The ES value of 26 EO criteria was zero, which expressed no environment impacts (Class N) of Bahr Al Baqar Drain by 45.6%. 24 EO criteria recorded slight negative changes (Class –A) as ES=-1 to -9, by 42.1%. The value of ES tends to be more negative to equal -10 to -18 for 4 EO criteria by 7% (Class –B). Three EO criteria expressed moderate negative changes by ES = -19 to -35 (Class –C) by 5.3%, Fig. 5. Similar to the previous criteria and components, from EO point of view, Bahr Al Baqar Drain displayed negative environmental assessment. Fishing considered as the main economic activities in the study area and in Manzala Lake which is an important resource of fishing in Egypt receives about 60 m^3/sec. of wastewater from Bahr Al Baqar Drain, Stahl *et al.* (2009). Furthermore, usage of Bahr Al Baqar Drain water for irrigation or raising fish for areas located on both sides of the drain has a very dangerous environmental effect on soil and ground water, Salem *et al.* (2015). These results show the hazardous environmental impacts on fishing activities, agriculture and fish farms around the drain.

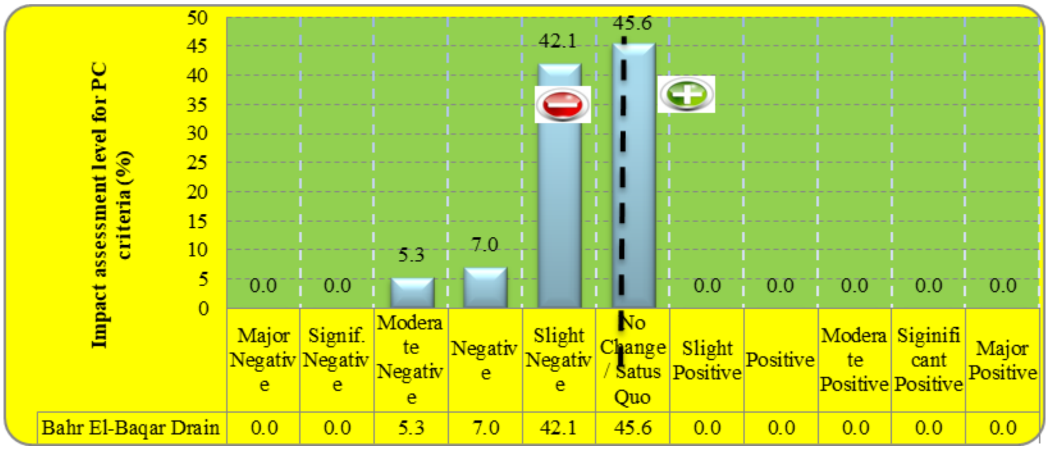

Fig. 5. Level of Impact assessment for 51 Economical-Operational Parameters on Bahr Al Baqar Drain

Table. 6. Rapid impact assessment matrix for 57 Economical-Operational components

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
SC1	Currency	0	0	1	1	1	1	0	No Change / Status Quo
SC2	Personal Savings	1	-1	2	2	2	2	-8	Slight Negative
SC3	Stock Market	0	0	1	1	1	1	0	No Change / Status Quo
SC4	Commodity	1	-1	1	1	1	1	-4	Slight Negative
SC5	Interest Rate	0	0	1	1	1	1	0	No Change / Status Quo
SC6	Interbank Rate	0	0	1	1	1	1	0	No Change / Status Quo
SC7	Loans to Private Sector	0	0	1	1	1	1	0	No Change / Status Quo
SC8	Money Supply	1	-1	1	1	1	1	-4	Slight Negative
SC9	Construction Output	0	0	1	1	1	1	0	No Change / Status Quo
SC10	Manufacturing Production	1	-1	2	2	2	2	-8	Slight Negative
SC11	Consumer Spending	1	-1	2	2	2	2	-8	Slight Negative
SC12	Government Budget	0	0	1	1	1	1	0	No Change / Status Quo
SC13	Government Debt	0	0	1	1	1	1	0	No Change / Status Quo
SC14	Government Spending	0	0	1	1	1	1	0	No Change / Status Quo
SC15	Credit Rating	0	0	1	1	1	1	0	No Change / Status Quo
SC16	Corporate Tax Rate	0	0	1	1	1	1	0	No Change / Status Quo
SC17	Personal Income Tax Rate	0	0	1	1	1	1	0	No Change / Status Quo
SC18	Sales Tax Rate	0	0	1	1	1	1	0	No Change / Status Quo
SC19	Social Security Rate	1	-2	3	3	3	3	-24	Moderate Negative
SC20	Consumer Confidence	1	-1	2	2	2	1	-7	Slight Negative
SC21	Gross National Product GDP	0	0	1	1	1	1	0	No Change / Status Quo
SC22	Unemployment Rate	1	-1	2	2	2	2	-8	Slight Negative
SC23	Labor Force Participation Rate	1	-1	2	2	2	2	-8	Slight Negative

Code	Description	A1	A2	B1	B2	B3	B4	ES	Susceptibility performance description
SC24	Employment	1	-1	2	2	2	2	-8	Slight Negative
SC25	Job Vacancies	1	-1	2	2	2	2	-8	Slight Negative
SC26	Labour Costs	1	-1	2	2	2	1	-7	Slight Negative
SC27	Population	1	-2	2	2	2	2	-16	Negative
SC28	Productivity	1	-2	3	3	3	2	-22	Moderate Negative
SC29	Personal Bank Lending Rate	1	-1	2	2	2	1	-7	Slight Negative
SC30	Wages	1	-1	2	2	2	1	-7	Slight Negative
SC31	Inflation Rate	1	-1	2	2	2	1	-7	Slight Negative
SC32	Core Consumer Prices	1	-1	2	2	2	1	-7	Slight Negative
SC33	Export Prices	0	0	1	1	1	1	0	No Change / Status Quo
SC34	Import Prices	0	0	1	1	1	1	0	No Change / Status Quo
SC35	Producer Prices	1	-1	2	2	2	1	-7	Slight Negative
SC36	Balance of Trade	0	0	1	1	1	1	0	No Change / Status Quo
SC37	Personal Income	1	-1	2	2	2	2	-8	Slight Negative
SC38	Exports	0	0	1	1	1	1	0	No Change / Status Quo
SC39	External Debt	0	0	1	1	1	1	0	No Change / Status Quo
SC40	Imports	0	0	1	1	1	1	0	No Change / Status Quo
SC41	Trade	0	0	1	1	1	1	0	No Change / Status Quo
SC42	Foreign Exchange Reserves	0	0	1	1	1	1	0	No Change / Status Quo
SC43	Investment	1	-1	2	2	2	2	-8	Slight Negative
SC44	Remittances	0	0	1	1	1	1	0	No Change / Status Quo
SC45	Tourism	0	0	1	1	1	1	0	No Change / Status Quo
SC46	Bankruptcies	0	0	1	1	1	1	0	No Change / Status Quo
SC47	Business Confidence	1	-1	2	2	2	2	-8	Slight Negative
SC48	Capacity Utilization	1	-1	2	2	2	2	-8	Slight Negative
SC49	Industrial Production	1	-1	2	2	2	2	-8	Slight Negative
SC50	Housing Index	0	0	1	1	1	1	0	No Change / Status Quo
SC51	Agricultural Production	1	-1	2	2	2	2	-8	Slight Negative
SC52	Health Coast	1	-2	3	3	3	3	-24	Moderate Negative
SC53	Local Prices	1	-1	2	2	2	2	-8	Slight Negative
SC54	Housing Quality	1	-2	2	2	2	2	-16	Negative
SC55	Energy losses	1	-2	2	2	2	2	-16	Negative
SC56	Infrastructure built-up	1	-2	2	2	2	2	-16	Negative
SC57	State Donation	1	-1	2	2	2	2	-8	Slight Negative

Total environmental criteria score:

Totally 195 parameters were involved in RIAM; PC (41 parameters), BE (51 parameters), SC (46 para meters) and EO (57 parameters). These criteria reflected the description of the environmental status of any project related to human beings. The results displayed that all the 4 criteria occupied the negative side of the RIAM, Fig. 6. The present results described that physical, chemical, ecological, economic, social and biological status of Bahr Al Baqar Drain displayed a great destructive interaction with the environment. Almost, all the measured components varied from moderate negative to significantly negative environmental impact. These interactions caused decline in natural resources, inhibited human activities that will reflected to the food security and human health and sustainability of resources and human capacity building. RIAM performed for the total 195 environmental parameters, 53 of 195 parameters (about 27%) represented no environmental impacts. The Major negative changes displayed by 7 parameters of physical-chemical and biological ecological components with 3.5%. Significant negative changes displayed by 23 (11.7%) parameters of physical-chemical, biological ecological and social-cultural components. All the four measured components participated in negative changes (moderate and slight impacts) with impact level 22.6%, 13.8% and 21%.

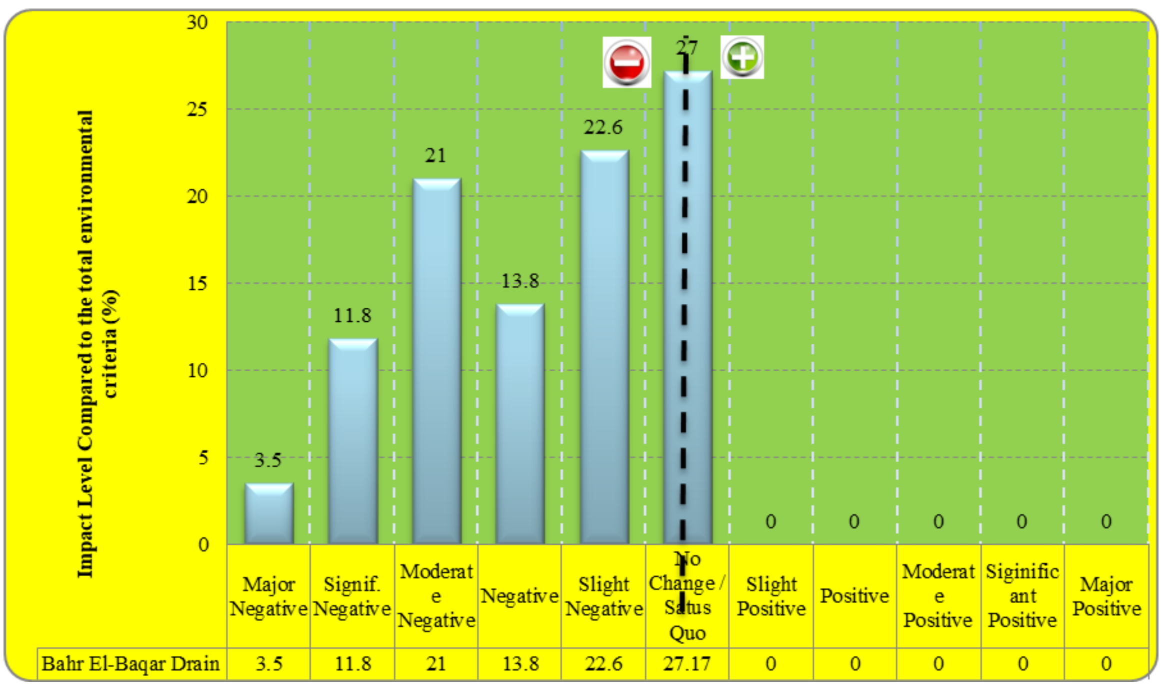

Fig. 6. Level of Impact assessment for 195 PC, SC, BE and EO Parameters on Bahr Al Baqar Drain

CONCLUSION

The study concluded that RIAM is a useful tool for decision makers as it is able to display the results of different development scenarios and produce transparent environmental solutions, even with very complex options.

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