



The role of environmental impact assessment in protecting coastal and marine environments in rapidly developing islands: The case of Bahrain, Arabian Gulf



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ARTICLE INFO

Article history:

Received 26 July 2014
Received in revised form
10 November 2014
Accepted 8 December 2014
Available online

Keywords:

Environmental impact assessment
Coastal development
Dredging
Reclamation
Bahrain

ABSTRACT

Bahrain, a group of islands, is facing several environmental challenges, including degradation of coastal and marine environments due to intensive dredging and reclamation activities. Presently, reclamation activities have resulted in adding around 110 km² representing an increase of 14% of the total land area of Bahrain. Recognizing the role of Environmental Impact Assessment (EIA) in protecting environment from degradation and pollution associated with coastal developments, Bahrain formally adopted EIA in its environmental system in 1998. The present study investigated the practice and effectiveness of EIA in protecting coastal and marine environments in Bahrain by reviewing selected EIA reports and soliciting views of EIA experts, consultants, academics and other relevant bodies. Shortcomings in environmental and ecological assessment practices related to coastal and marine developments were recognized and constrains that restrict the effectiveness of EIA in protecting coastal and marine environments in Bahrain were identified. Maintaining a sustainable use of coastal and marine natural resources in Bahrain requires measures to holistically address the interactions among the several dredging and reclamation projects and their additive and cumulative impacts. This could be achieved through enhancing the current practice of EIA process and adopting Strategic Environmental Assessment (SEA) for dredging and reclamation activities.

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1. Introduction

The Arabian Gulf is a semi-enclosed sea situated in the subtropical zone and characterized by marked fluctuations in sea temperatures and high salinities. Flora and fauna species in the Arabian Gulf inhabit one of the harshest marine environments due to natural stressors represented by higher levels of salinity and temperature, and more recently lower levels of pH (Uddin et al., 2012). Marine organisms in the Arabian Gulf are living close to the limits of their environmental tolerance (Sheppard et al., 2012).

Despite extreme climatic conditions, the Arabian Gulf supports a range of coastal and marine habitats such as mangrove swamps, seagrass beds, coral reefs, and mud and sand flats (Naser, 2014). However, these ecosystems are under ever-increasing pressure from anthropogenic activities that are associated with the rapid economic, social and industrial developments in the Arabian Gulf countries. Reclamation and dredging, industrial and sewage

effluents, hypersaline water discharges from desalination plants, and oil pollution are examples of anthropogenic stressors that contribute to environmental degradation in the Arabian Gulf, which is classified among the highest anthropogenically impacted regions in the world (Halpern et al., 2008). These threats warrant the designation of the Arabian Gulf, which constitutes part of the Arabian Sea Ecoregion, as “critically endangered” by the International Union for the Conservation of Nature (IUCN) and the World Wildlife Fund (WWF) (<http://wwf.panda.org>).

Coastal and marine environments in the Arabian Gulf are the prime target for most of the major housing, recreational, and economic developments. Coastal developments along the Arabian Gulf have accelerated at an unprecedented rate in the past decade to accommodate large-scale projects, including artificial islands, waterfront cities, ports and marinas. Consequently, the coasts of the Arabian Gulf are undergoing rapid construction activities that often associated with intensive dredging and reclamation (Naser, 2014). It is currently estimated that more than 40% of the coasts of the Arabian Gulf have been developed (Hamza and Munawar, 2009).

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The Kingdom of Bahrain is an archipelago composed of 40 islands in addition to several islets, shoals and patches of reefs located in the Arabian Gulf (Fig. 1) between latitude 25° 32' and 26° 20' north and longitude 50° 20' and 50° 50' east. The total land area of Bahrain in 2012 is about 777 km². With over than one million inhabitants (CIO, 2012), Bahrain is among the highest population densities in the world.

Like most of islands countries, Bahrain is facing several environmental challenges (Douglas, 2006), including degradation of coastal and marine environment due to various sources of anthropogenic activities. Nonetheless, the major environmental challenge for Bahraini coastal and marine environments is the increasing demand for urban infrastructures to sustain commercial, industrial, residential, and tourism developmental projects (Naser, 2010). Consequently, coastal reclamation is regularly carried out in Bahrain to meet the demand of rapid coastal developments.

The increasing rate of land reclamation has contributed significantly to the deterioration of marine habitats and resources, including coral, seagrass and mangrove ecosystems as well as fishing industry. Signs of environmental degradation in several ecosystems in Bahrain have been reported. Zainal et al. (1993) reported a loss of 10.2 km² of seagrass beds on the east coast of Bahrain detected by remote sensing imagery between the period of 1985 and 1992. Similarly, the same study recorded a loss of 218,700 m² of corals in Fasht Al-adhm (the largest reef in Bahrain). These losses were mainly attributed to dredging and reclamation activities and increasing levels of sedimentation and pollution. The marine area of Tubli Bay, which hosts the last remaining mangroves in Bahrain, has been reduced from 25 to 12 km² in 2008 due to intensive reclamation activities. These activities significantly destroyed mangrove stands and reduced their spatial distribution to 0.31 km² (Abido et al., 2011).

According to the Central Informatics Organization in Bahrain, reclamation activities have resulted in adding around 110 km² representing an increase of 14% of the total land area of Bahrain in 1963 (667 km²). Reclamation has been more marked in Muharraq; the second main island in Bahrain. The total land area of this island

has increased from 13 km² in 1951 to 56 km² in 2008 (Modara et al., 2014). The escalation of reclamation activities has resulted in altering more than 80% of the Bahraini coastlines (Fuller, 2005). It is likely that reclamation will accelerate in the coming decades in order to secure land for large-scale projects as population in Bahrain continues to grow. This is reflected in the Bahraini National Land Use Strategy 2030, which recognizes reclamation as the major option for securing the future needs for land (Naser, 2011).

Large-scale dredging and reclamation activities may affect both integrity and productivity of several coastal and marine ecosystems, which include seagrass beds, mangroves, coral reefs, and muddy shores. These ecosystems are considered Valued Ecosystem Components (VECs) because they provide important ecological, economic, cultural and aesthetic goods and services (Jenson and Bourgeron, 2001).

There are several potential physical, chemical and biological impacts on valued ecosystem components in coastal and marine environments that are associated with dredging and reclamation activities. The removal and deposit of marine sediment may lead to changes in topography and bathymetry, alterations of tidal currents and sediment transport pathways, and increases in suspended sediment concentration, organic material, heavy metals and other pollutants (Tillin et al., 2011).

Removal and destruction of habitats due to dredging and reclamation may reduce abundance, diversity and biomass of benthic organisms, degrade coral reef and seagrass ecosystems due to sediment runoff and turbidity (Erftemeijer and Lewis, 2006; Erftemeijer et al., 2012), and lead to the loss of spawning grounds, nursery and feeding areas for fish, crustaceans and waders (Doorn-Groen and Stephanie, 2007).

Environmental Impact Assessment (EIA) is considered a standard tool for decision-making in most countries throughout the world. EIA aims at integrating environmental considerations in the decision-making system, avoiding or minimizing adverse impacts, protecting natural systems and their ecological processes, and implementing principles of sustainable developments (Noble, 2012).

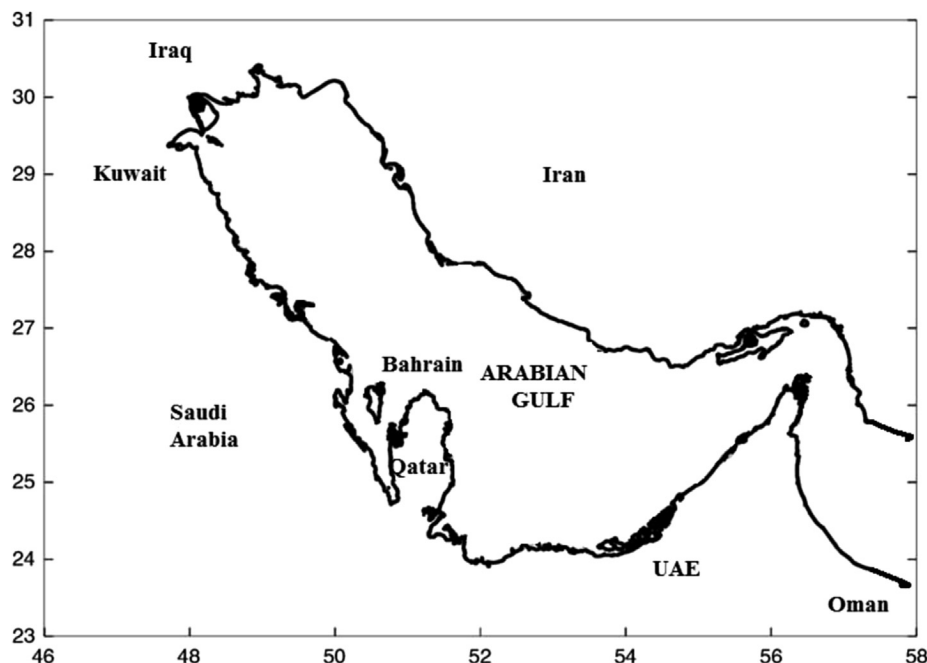


Fig. 1. A map showing the location of the Kingdom of Bahrain within the Arabian Gulf.

Recognizing the role of EIA in protecting environment from degradation and pollution associated with economic developments, Bahrain formally adopted EIA in its environmental system in 1998. According to Ministerial Order No. 1 of 1998 with respect to Environmental Evaluation for Projects, coastal development projects, including reclamation and dredging, are subjected to environmental impact assessment.

EIA is one of the frequently used approaches in coastal planning and management (Kay and Alder, 2005). It is considered as an effective tool to minimize anthropogenic impacts and to induce the implementation of protection measures of coastal environment (Price and Khan, 2002). The importance of EIA in protecting biodiversity and promoting the sustainable use of coastal and marine resources is represented in its fundamental role as a process for predicting the environmental effects of projects or programs in coastal areas. Additionally, EIA involves in facilitating consultation between various stakeholders as well as the public, considering alternatives for projects and locations, ensuring early identification of potential impacts and cumulative effects on coastal and marine environments, and implementing mitigation and compensation measures (Badr et al., 2004; Kay and Alder, 2005). However, the effectiveness of EIA in protecting coastal and marine environments and helping to achieve informed and balanced decision making is varied from one country to another due to differences in environmental, social, legislative, political, and economic contexts (Marara et al., 2011).

Giving the large-scale of coastal developments in Bahrain that are potentially associated with adverse environmental impacts on coastal and marine ecosystems, it is important to investigate whether the existing EIA system is contributing to the protection of coastal and marine environments. Therefore, the overall aim of this study was to investigate the role of EIA in achieving ecologically sustainable coastal developments in Bahrain. This aim could be achieved by 1) evaluating how well EIA reports concerned with coastal and marine environments that involve intensive dredging and reclamation activities comply with the requirements of best practice in ecological assessment as set by national and international criteria; and 2) identifying perceptions of experts and relevant bodies involved in the EIA process about its effectiveness in protecting coastal and marine environments in Bahrain.

2. Methods

The practice and effectiveness of EIA in protecting coastal and marine environments in Bahrain were investigated using two methods that complement each other; namely reviewing of EIA reports and soliciting views of EIA practitioners, consultants, academics and other relevant bodies.

2.1. Review of EIA reports

Reviewing EIA reports is important approach to investigate the practice and performance of EIA process. It typically provides quantitative data on the EIA system (Badr et al., 2011), the general quality of EIA reports (Phylip-Jones and Fischer, 2013) or insights into the performance of specific procedures or measures within the EIA process (Briggs and Hudson, 2013; Drayson and Thompson, 2013).

Twenty Bahraini EIA reports (Table 1) related to major housing, recreational, financial investment, and causeway projects were obtained officially from the environmental authority, and personally from relevant environmental consultants. The EIA reports concern the coastal and marine environments and are associated with large-scale dredging and reclamation activities. They represent most of the major projects that were carried out on or off the northern and eastern coastlines of Bahrain during the period between 2004 and 2014. A previous study revealed shortcomings related to the quality of fifteen Bahraini EIA reports concerning coastal and marine developments that produced between 1996 and 2004 (Naser et al., 2008). Therefore, the period of the present study (2004–2014) was selected to reflect on the recent practice and effectiveness of EIA in coastal and marine environments in Bahrain.

Several environmental statement review packages were explored, including the commonly used environmental statement review package produced by Lee et al. (1999), the Guidance on environmental statement review produced by the European Union (EC, 2001), and the environmental statement review package produced by Impact Assessment Unit at Oxford Brookes University (Glasson et al., 2005). These review packages have been successfully employed in EIA studies in several countries throughout the world (Badr et al., 2011).

Table 1
Project types and year of preparation of the Bahraini EIA reports reviewed in this study.

No	Year	Type of project	Dredged material m ³	Reclaimed area km ²
1	2004	Housing developments and their associated infrastructures	30 × 10 ⁶	7.4
2	2004	Housing developments and their associated infrastructures	15 × 10 ⁶	4
3	2004	Resort city, including housing, recreational and commercial facilities	34 × 10 ⁶	20
4	2004	Causeway	2.0 × 10 ⁵	0.22
5	2004	Commercial and recreational developments	2.0 × 10 ⁵	0.47
6	2006	Mixed-use developments, including housing and commercial facilities	77.1 × 10 ⁶	12
7	2006	Waterfront bay, including economic and commercial facilities	2.9 × 10 ⁶	0.45
8	2006	District cooling system, including marine installation	–	–
9	2007	Resort hotel	–	0.0047
10	2008	Mixed-use developments, including healthcare, housing and commercial facilities	10 × 10 ⁶	1.25
11	2008	Recreational resort	5.0 × 10 ⁵	0.05
12	2008	Causeway	20 × 10 ⁶	0.85
13	2009	Mixed-use developments, including housing and commercial facilities	32 × 10 ⁶	4.16
14	2009	Commercial waterfront, including a marina and waterside promenades	2.4 × 10 ⁶	0.45
15	2009	Commercial, light industrial and retail facilities	3.3 × 10 ⁶	0.60
16	2010	Housing developments and their associated infrastructures	30 × 10 ⁶	3.90
17	2010	Housing developments and their associated infrastructures	18 × 10 ⁶	2.24
18	2010	Borrow areas (fill materials will be derived from new borrow areas to ensure completion of an existing reclamation project)	22 × 10 ⁶	–
19	2013	Mixed-use developments, including housing and commercial facilities	20 × 10 ⁶	3.2
20	2014	Expansion of industrial facility	10 × 10 ⁶	1.1
Total			327.6 × 10 ⁶	62.34

Due to the nature of the coastal developments that are associated with dredging and reclamation, reviewing ecological impacts assessment component in EIA reports may provide insights on the practice and effectiveness of EIA in protecting coastal and marine environments in Bahrain.

Environmental and ecological guidelines related to the EIA process in Bahrain are generally limited (Naser, 2012). Therefore, specific criteria to systematically review EIA reports of major projects related to coastal and marine environments were formulated based on the widely used ecological guidelines in the United Kingdom produced by Institute of Ecology and Environmental Management (IEEM) in 2006 as well as the guidelines of ecological impact assessment in Britain and Ireland (marine and coastal) produced by the IEEM in 2010. These guidelines were developed to promote best practice in ecological impact assessment relating to a wide range of habitats, including coastal and marine environments. These guidelines have been reflected positively on the practice and effectiveness of ecological impact assessment in the United Kingdom (Briggs and Hudson, 2013).

However, the adopted criteria were modified to accommodate the environmental contexts in Bahrain. These include legislative and regularity frameworks of EIA in Bahrain, valued ecosystem components in Bahrain, nature of projects associated with coastal and marine environments (i.e. dredging and reclamation), and the

expected impacts of these projects on valued ecosystem components. The evaluation criteria used in this study were based on 24 review questions that were divided into nine review areas; namely description of existing ecological environment likely to be affected, determination of the importance of valued ecosystem components, identification and evaluation of impacts, consideration of alternatives, cumulative effects, evidence of stakeholder involvements, mitigation, compensation and enhancement, monitoring measures, and communication and presentation (Table 2).

Rating the quality of the reviewed EIA reports was based on the quality index used by Soderman (2005) and Khera and Kumar (2010) according to the following formula:

$$QI = A + 0.5 \cdot B / 24$$

Where

QI = Quality Index

A = number of review questions fully met

B = number of review questions partially met

24 = total number of review questions

According to this formula, the highest value of the quality index will be 1, which is the case when all of the review questions are fully met. The reviewed EIA reports were grouped based on the scores of the quality index into four categories. The index scores were divided between 0.0 and 0.25 (poor), 0.26 and 0.50 (borderline), 0.51 and 0.70 (satisfactory), and 0.71 and 1.00 (good).

This quality index has some limitations that should be noted when interpreting the results. The index is generally subjective and the results inevitably reflect the evaluator's understanding of what constitutes a satisfactory treatment of a review question. Additionally, the relative strengths and weaknesses of the reviewed EIA reports might not be reflected in this index. However, this index is a useful tool for overall comparison of the EIA quality (Khera and Kumar, 2010).

2.2. Views of EIA practitioners and professionals

Views of relevant bodies involved in the EIA process on the effectiveness of EIA in protecting coastal and marine environments in Bahrain were solicited using a questionnaire survey. Efforts were made to include most of the concerned bodies from different sectors that may directly or indirectly involved in EIA process. The target population of the survey consisted of members from the environmental authority, environmental consulting firms, and environmental non-governmental organizations (NGOs). Additionally, marine biologists, marine ecologists, and environmentalists from the main universities in Bahrain (University of Bahrain and Arabian Gulf University) as well as bachelor and master students or graduates who completed a course in EIA at the University of Bahrain were included in the questionnaire survey.

The survey questionnaire was composed of three main sections. The first part was related to the effectiveness of EIA process in Bahrain. Participants were asked to indicate their opinions on the effectiveness of the main stages of EIA namely; consideration of project and location alternatives, prediction of impacts, assessment of impacts, consideration of cumulative impacts, mitigation and monitoring measures, and public and stakeholders involvement.

The second part measure the extent to which the experts in EIA agreed or disagreed with statements related to the achievement of EIA goals in coastal and marine environments in Bahrain. These statements were derived from the general objectives of EIA including, minimizing adverse impacts of dredging and reclamation, contributing to the protection of ecosystems and marine

Table 2

Review criteria for environmental impact assessment reports in Bahrain that were derived from IEEM (2006, 2010).

Description of existing ecological environment likely to be affected

1. Is the zone of influence expected to be affected by the project indicated?
2. Are the boundaries of assessment and ecological study (spatially and temporally) identified?
3. Are designs and methods of ecological surveys explained?
4. Are the valued ecosystem components likely to be affected by the project identified and sufficiently described?

Determination of the importance of valued ecosystem components

5. Are ecological, economic, recreational, educational and cultural importance of species, ecosystems and habitats considered?
6. Is the conservation status of habitats or species within a geographical area specified?

Identification and evaluation of impacts

7. Are methods or approaches of impact identification and prediction described?
8. Are potential impacts on species, ecosystems and habitats identified?
9. Is significance of impacts appropriately assessed?
10. Are uncertainties in impact prediction and evaluation indicated?

Consideration of alternatives

11. Are appropriate project locations considered?
12. Are appropriate project alternatives considered (e.g. dredging and reclamation options)?

Cumulative effects

13. Are cumulative effects on valued ecosystem components addressed directly in the EIA report?
14. Are any other existing or planned developments with which the project could have cumulative effects identified?
15. Are cumulative effects on the environment of the project together with other existing or planned developments in the locality described?

Evidence of stakeholder involvements

16. Are appropriate stakeholders involved?
17. Are the public involved?

Mitigation, compensation and enhancement

18. Are appropriate mitigation, compensation and enhancement measures proposed?
19. Are details of mitigation implementation incorporated?

Monitoring measures

20. Are appropriate environmental monitoring measures proposed?
21. Are environmental monitoring programmes committed by relevant bodies?

Communication and presentation

22. Are EIA reports informative for decision-makers?
23. Are maps of habitat sensitivity included?
24. Are appropriate references and consultants involved incorporated?

resources, facilitating planning and management of coastal areas in Bahrain, informing decision makers with threats to biodiversity and ecosystems, and achieving ecologically sustainable developments in coastal and marine environments in Bahrain.

The third part was devised to examine the extent to which the experts in EIA agreed or disagreed with statements related to constraints that may restrict the effectiveness of EIA in Bahrain. These constraints or barriers were formulated based on the general shortcomings of EIA that are recognized in most of the developing countries (El-Fadl and El-Fadel, 2004; Naser, 2012). These shortcomings include inadequate legislations, limited guidelines in procedural EIA or ecological assessment, late implantation of EIA in the project cycle, inadequate consideration of alternatives, limited involvement of public, limited influence of EIA in decision-making and limited integration of EIA in higher-level policy-making.

3. Results

3.1. Key findings of EIA review

3.1.1. Overall quality of reviewed EIA reports

The quality index ratings of the reviewed EIA reports in this study indicated that 35% of the reports were assessed as satisfactory or good quality (0.51–1.0) compared with 65% of unsatisfactory or borderline quality (0.0–0.5) (Fig. 2). However, there were variations in the extent to which the review areas and their attributes were met between the reviewed EIA reports.

3.1.2. Description of existing ecological environment likely to be affected

The zone of influence of dredging and reclamation projects could extend beyond the specified dredged or reclaimed areas due to sedimentation and erosion. Therefore, the spatial boundaries of the baseline ecological studies should include surrounding areas that are directly or indirectly affected by dredging and reclamation activities. However, the spatial boundaries of assessment and ecological studies were only limited to the actual footprints of the projects in all of the reviewed EIA reports.

Typically ecological survey will identify the main habitat types and their associated biological communities that might be affected by the project. Although all of the reviewed EIA reports conducted ecological surveys, the comprehensiveness of these survey techniques in providing full picture about the affected biological communities was variable. The majority (60%) of the reviewed EIA reports used both quantitative semi-quantitative survey methods. The first method involved sampling of flora and fauna in the field and subsequent microscopic sorting and taxonomic identification in the laboratory. The second method relied on the estimation of the percentage cover of major biotopes such as seagrass meadows

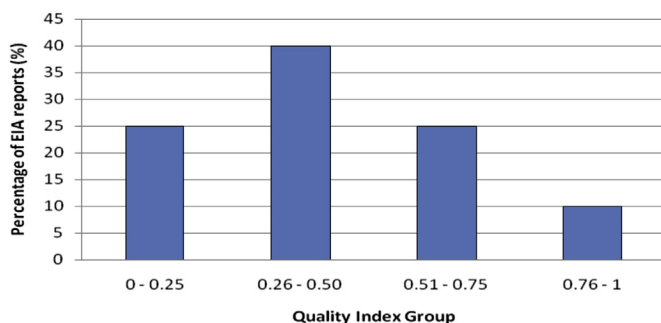


Fig. 2. Percentages of reviewed EIA reports distributed over the four groups of the quality index.

and algal mats or presence of keystone organisms. Only two reports (10%) quantitatively characterized the major biotopes and their associated assemblages. The remaining 30% of the reviewed EIA reports adopted only semi-quantitative approach, which was reflected on the poor quality of the baseline data. These reports mainly adopted the ecological descriptions of the affected areas from the pioneer work of Vousden (1988). This valuable technical report documents the ecological status of marine environment in Bahrain in the early 1980s. However, coastal and marine environments in Bahrain have remarkably been transformed and influenced by dredging and reclamation as well as pollution in the past two decades. Therefore, the baseline information provided in the reviewed EIA reports might not necessarily reflect the current ecological status in the Bahraini coastal and marine environments.

Rough taxonomic resolution and cryptic identification of species may restrict the effectiveness of the ecological assessment process. Approximately 90% of the reviewed EIA reports provided coarse taxonomic resolutions for macrobenthic assemblages. The shortages of taxonomic guides and keys related to macrobenthos of the Arabian Gulf were reflected in the reviewed EIA reports. For instance, while an EIA report identified 31 species out of 115 benthic organisms, another EIA report only identified 30 species out of 407 benthic organisms.

3.1.3. Determination of the importance of valued ecosystem components

Bahraini seagrass beds, coral reefs, mangrove swamps, sand and mudflats, and designated marine protected areas are valued ecosystem components that are at risk from the intensive dredging and reclamation activities. Additionally, Bahraini territorial waters hosts some of the world's most critically endangered species such as dugongs, dolphins, and turtles. In addition to their intrinsic biological value, these ecosystems and species represent important economic, recreational, educational and cultural values. While 85% of the reviewed EIA reports mentioned the designated marine protected areas in Bahrain, only two of these reports described the impacts that are likely to interfere with the conservation objectives of these marine protected areas. Similarly, 85% of the reviewed EIA reports reflected on the general importance of seagrass and coral ecosystems. However, only five of these reports described fully the goods and services of these ecosystems. It is important to describe endemic or endangered species that could be affected by dredging and reclamation activities. Only two reports provided sufficient information related to endemic Socotra cormorant, and engendered marine mammals that could be affected by the proposed projects. Avifauna populations were fully investigated in 55% of the reviewed EIA reports with their conservation status fully described.

3.1.4. Identification and evaluation of impacts

The direct potential impacts of dredging and reclamation were identified and described in all the reviewed EIA reports. However, 40% of the reviewed EIA reports failed to address how these direct potential impacts could affect the species and habitats of the project areas. Only two EIA reports fully described the physical, chemical and biological impacts of dredging and reclamation on the marine environment. These EIA reports quantified the loss of habitats and their associated assemblages due to dredging and reclamation activities. For example, one EIA report indicated that around 1.3 km² of seagrass meadows and macroalgal beds will be lost due to dredging activities, and 4.98 km² of mudflats and 0.019 km² of live corals will be buried as a result of reclamation process.

The significance of the impacts was addressed in 70% of the reviewed EIA reports, while in the remaining 30% of the reports the significance was described only superficially. Indeed a particular

EIA report showed conflicting conclusions with respect to the ecological significance of the investigated area. In this report the ecological survey of macrobenthos concluded that the project area was not ecologically significant due to the lower levels of diversity and abundance of macrobenthic assemblages. Conversely, the avifauna section of this EIA report recorded 450 of flamingos and numerous numbers of wader birds feeding in the intertidal area of the proposed project. The avifauna report concluded that the investigated area was vital mudflats for bird populations. It is recognized that only high levels of diversity and abundance of macrobenthic assemblages can sustain large population of wader birds (Colen et al., 2014). Therefore, this discrepancy in the significance assessment of the investigated area in that particular EIA report could be attributed to shortages in the ecological survey related to macrobenthos, which subsequently influenced the effectiveness of significance assessment.

Ecological indices including, diversity index of Shannon–Wiener, Margalef's index of richness and Pielou's index of evenness were utilized by 70% of the reviewed EIA reports to evaluate the ecological status of the proposed project areas. The PRIMER (Plymouth Routines in Multivariate Ecological Research) statistical package was employed by 60% of the reviewed EIA reports to characterize the community structure of macrobenthic assemblages inhabiting the project areas. However, the results of these analyses were superficially interpreted (i.e. not linked to the impacts of the proposed projects). Identifying uncertainties associated with prediction methods allows for an informed decision-making process. Only two EIA reports described the uncertainties associated with impact prediction of sediment blooms utilizing hydrodynamic models.

3.1.5. Consideration of alternatives

The consideration of alternatives is an integral part of EIA procedure that allows for a comprehensive approach to investigate the most appropriate design, process and location for a proposed project. Investigating feasible site alternatives for reclamation was found lacking in all of the reviewed Bahraini EIA reports. Most of the projects were in late stages of implementation and their sites were allocated or purchased by the project proponents upon before the EIA was commenced. For instance, one EIA report indicated that the reclamation site is already designated for development under the National Land Use Strategic Plan 2030. Typically, sand and mud are extracted from borrow areas within the territorial waters of Bahrain and dumped to reclaim shallow coastal and subtidal areas. No alternatives for borrow areas were proposed by the majority of the reviewed EIA reports (85%). These reports indicated that the selected sites are approved governmental borrow areas. Three EIA reports provided filed material alternatives, which include importing sand from terrestrial area. However, these reports superficially stated that environmental implications could be occurred due to this alternative.

3.1.6. Cumulative effects

Adverse environmental effects may result not from the direct effects of a particular project, but from the combination and interaction of individually minor effects of multiple projects over time (Ma et al., 2009). Planning and implementing of reclamation and dredging activities are typically carried out in Bahrain on a case-by-case basis, without assessing environmental impacts in relation to other similar existing or planned developments. This approach was evident in all of the reviewed EIA reports. Several dredging and reclamation projects have been carried out simultaneously along or off the north and north-east coastlines of Bahrain within relatively small geographical ranges that extend 22 and 20 km, respectively. However, cumulative impacts that may result

from these projects were completely neglected in the reviewed EIA reports.

Additionally, cumulative impacts from multiple dredging and reclamation projects depend not only on their numbers, but also on the relative severity of impacts and vulnerability of valued ecosystem components (Crain et al., 2008). Only two of the reviewed EIA reports indicated that the allocated sites of their projects were already impacted or degraded due to surrounding existing and ongoing projects. Particularly, these reports referred to patches of coral reefs that were degraded due to high levels of turbidity, and large area of a seagrass bed that was intensively covered with silt. These reports indicated that the continued threats from coastal and marine developments in Bahrain should be viewed in a regional and not local context, which could be considered as an implication for cumulative impacts.

3.1.7. Evidence of stakeholder involvements

Consultation process in the all of the reviewed EIA reports was restricted to concerned governmental bodies. These may include Marine Recourses Directorate, Water Recourses Directorate, Central Planning Directorate, Roads Planning Directorate, and relevant Power and Desalination Plants. However, there was no evidence of any input by these authorities or coordination between them. Meetings were held with major industrial companies in case of dredging and reclamation activities were close to their premises or may interfere with the companies' maritime activities. Four of the reviewed EIA reports concerned with housing projects indicated that Parliament Representatives as well as Members of Municipal Council Constituencies were consulted. These reports pointed out that representatives had no objections to these projects as they will provide housings for the public. However, there was no evidence that the wider public was consulted in the EIA process.

3.1.8. Mitigation, compensation and enhancement

Generally, mitigation measures in the reviewed EIA reports were restricted to the physical characteristics of the projects, including minimizing the water turbidity due to dredging and reclamation processes by using silt curtains. Artificial reefs were proposed as a compensation measure to restore the damaged ecosystems in 50% of the reviewed EIA reports. However, no evidence of commitment to the proposed mitigation measures was observed. One of the EIA reports suggested that the project area is ecologically impacted by the nearby activities, including dredging and reclamation of other projects. This could be considered as an evidence of the limited effectiveness of proposed mitigation and monitoring measures of pervious similar projects.

3.1.9. Monitoring measures

Ecological monitoring of the project and surrounding areas is an important process in examining the accuracy of the predicted impacts and their associated mitigation measures. All of the reviewed EIA reports proposed the continuous monitoring of Total Suspended Solids (TSS) during the dredging and reclamation processes. Water and sediment quality monitoring was proposed by 70% of the reviewed EIA reports. However, the numbers of parameters to be monitored (e.g. temperature, dissolved oxygen, depth, visibility, salinity, nutrients, total coliforms, sediment particle size, total organic carbon, total hydrocarbon, and selected heavy metals) were variables in these reports. Some EIA reports (35%) proposed pre- and post-dredging ecological surveys. However, these proposals only emphasized on the general habitat descriptions and were an iterative for the methodologies of these reports. Environmental management plans that include ecological monitoring were proposed by four EIA reports. Nonetheless, these plans were not specifically tailored to the investigated project areas

(i.e. not site-specific). Environmental laws in Bahrain require the monitoring of air emissions and wastewater effluents for the large industrial facilities. There are no legal obligations in the EIA related laws and regulations for ecological monitoring (i.e. it is not mandatory), therefore, the commitments of the project proponents are generally limited to monitoring TSS during the dredging and reclamation phases.

3.1.10. Communication and presentation

Typically, an informative EIA report should provide information in a form useful to decision makers. One particular EIA report provided keywords for each paragraph in the side margin. These keywords may facilitate the reading and provide an overview of the content of each paragraph. Another EIA report provided a glossary of terms; explaining environmental and ecological terms. Non-technical summaries were included in 80% of the reviewed EIA reports. However, the focus on the main issues of the proposed project in these reports was found variable.

Visual presentation of the spatial distribution of valued ecosystem components and identified habitats and vulnerable species is important for a well-informed decision-making process. Even though 85% of the reviewed EIA reports provided habitats mapping, they majority of these reports (11 reports) provided sketchy maps capturing only sampling sites and providing only information related to substrate types (i.e. mud, sand, sand-silt, and rock substrates). The remaining six EIA reports provided comprehensive details of habitats mapping covering the whole project area. However, none of the reviewed EIA reports provided spatial distributions of identified vulnerable species that were likely to be affected by proposed projects.

Citing the sources of data and information in the EIA report and providing a list of the relevant references are essential for verifying the credibility of the environmental and ecological assessment processes. References of the reviewed EIA reports were generally outdated grey literature that composed of notes and technical reports. For instance, two EIA reports that produced by the same consulting firm in 2011 listed 55 references of which 25% were dated between 1970 and 1980, 23% between 1981 and 1990, 36% between 1991 and 2000, and 16% between 2001 and 2010.

An effective EIA should reflect the environmental context in which the proposed projects are taken place. Approximately 60% of the references of the reviewed EIA reports were not directly relevant to the environmental setting of the Arabian Gulf. These studies addressed ecological and environmental aspects in Europe and North America, which might not necessary reflect the ecological and physical settings of the Arabian Gulf environment. For instance, an

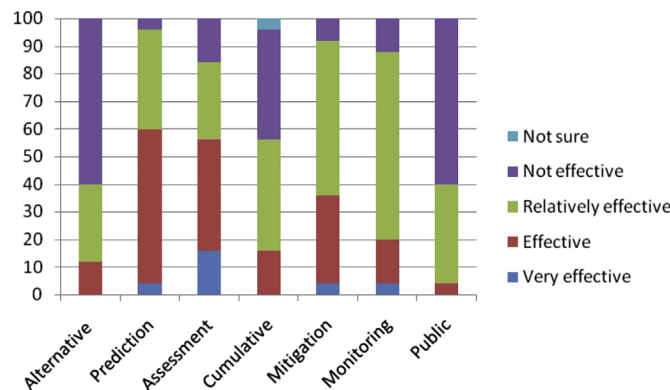


Fig. 3. Views of the EIA experts and practitioners on the effectiveness of the main stages of EIA process in Bahrain when considering development in coastal and marine environments.

EIA report discussed the temporal and spatial distribution of macrobenthic assemblages in context of estuarine ecosystems in temperate regions. Large volumes of scientific literature dealing with physical, ecological and biological aspects of the marine environment in the Arabian Gulf have been published in recent years. However, such references were rarely observed in the reviewed EIA reports.

3.2. Views of EIA practitioners and professionals

Initially 41 experts involved in the EIA process in Bahrain were identified and contacted. Twenty five respondents completed the survey questionnaire (response rate = 61%). The respondents were mainly from academic institutions (56% academic researchers and students), the environmental authority (20%), environmental consulting firms (20%), and non-governmental environmental societies (4%). The experience of surveyed experts in EIA ranged from one to 20 years (mean = 9.48 years). The educational level of the surveyed experts included bachelor (36%), master (32%), and philosophy of doctor (32%) degrees.

3.2.1. Effectiveness of EIA process in Bahrain

Fig. 3 presents the views of experts on how effectively the main stages of EIA are addressed in the current EIA practice in Bahrain when considering development in coastal and marine environments. The majority (60%) of the surveyed experts indicated that consideration of alternatives for the proposed projects or their locations is not effective under the current practice of EIA in Bahrain. Bahrain is witnessing a rapid transformation in its coastlines, which enforced the wide perception among experts that the lack of feasible alternatives for coastal and marine projects is a major problem in the Bahraini EIA system.

Generally, there is an assumption among the EIA experts indicating that the prediction of potential direct physical, biological and chemical impacts associated with dredging and reclamation is effective under the current practice of EIA in Bahrain (56%). Similarly, high proportion of the EIA experts (40%) considered the assessment of environmental impacts in the Bahraini EIA system as an effective one.

The majority of the EIA experts believed that the consideration of cumulative impacts in the Bahraini EIA system is not effective (40%) or relatively effective (40%). Likewise, high proportion of the EIA experts indicated that mitigation and monitoring measures associated with coastal and marine projects are relatively effective (56% and 68%, respectively). The majority (60%) of the EIA experts stated that public and stakeholders involvements in EIA process are not effective, which is consistent with the main findings of the reviewed EIA reports in the present study.

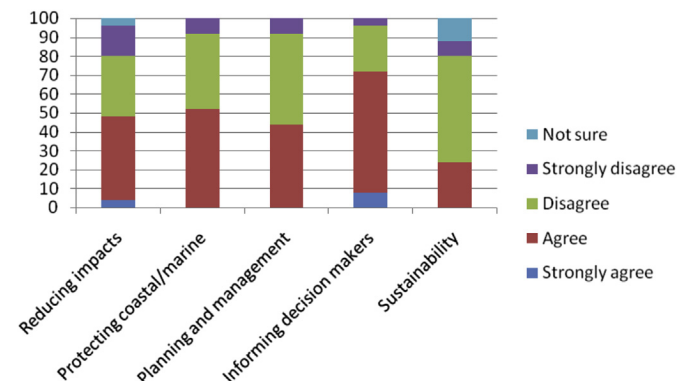


Fig. 4. Views of the EIA experts and practitioners on the achievement of EIA objectives in coastal and marine environments in Bahrain.

3.2.2. Achievement of EIA objectives

The EIA experts' opinions concerning the achievement of EIA objectives in coastal and marine environments in Bahrain are presented in Fig. 4. Avoiding or minimizing adverse environmental impacts associated with dredging and reclamation is an essential role of EIA process. Almost half (48%) of the EIA experts considered that EIA in Bahrain is effective in reducing adverse impacts of dredging and reclamation on marine ecosystems. Conversely, another 48% of the EIA experts think that the effectiveness of EIA in reducing adverse environmental impacts might be limited.

One objective of EIA is to protect coastal and marine natural systems and their ecological processes. The EIA experts' opinions on whether EIA is contributing to the protection of marine ecosystems and resources in Bahrain were divided between those who agreed (52%) and those who disagreed (48%) with this statement.

EIA is also one of the frequently used environmental tools in coastal planning and management (Kay and Alder, 2005). Over than half (56%) of the EIA experts indicated that EIA might not effectively contributing to the planning and management of coastal developments in Bahrain. This may reflect the fact that most the proposed projects are in their late phases of planning when EIA is conducted.

Integrating environmental considerations in the decision-making system is a prime objective of EIA. The majority (72%) of the EIA experts believed that EIA is generally effective in informing decision-makers of the direct impacts that threaten the biodiversity in the coastal and marine areas in Bahrain.

EIA may contribute towards achieving sustainable development through adopting the precautionary approach in development planning, which consequently contributes to avoiding loss of irreplaceable and high value environmental stock, and addressing global environmental change. Therefore, EIA could assist in promoting the principles of sustainable development (Noble, 2012). The majority (64%) of the EIA experts believed that EIA is not successfully contributing to the principles of sustainability in coastal and marine environments in Bahrain. This highlighted the critical need to incorporate EIA and environmental sustainability principles into higher levels of policy-making at various governmental bodies and relevant stakeholders in Bahrain.

3.2.3. EIA constrains in Bahrain

The EIA experts' views concerning the main barriers and constraints that may restrict the effectiveness of EIA in coastal and marine environments in Bahrain are presented in Fig. 5. The overwhelming majority of the EIA experts recognized that the effectiveness of EIA in Bahrain is restricted due to several constraints, which are also prevalent in the Arabian Gulf as well as in many

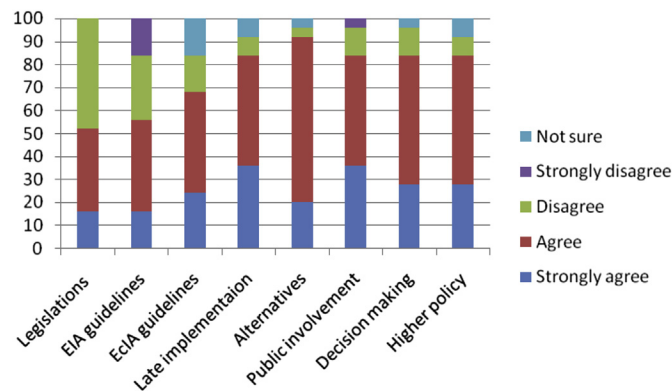


Fig. 5. Views of the EIA experts and practitioners on constraints that may restrict the effectiveness of EIA process in Bahrain.

developing countries in the world (El-Fadl and El-Fadel, 2004; Al-Azri et al., 2014; Heaton and Burns, 2014). Nearly half (52%) of the EIA experts identified the inadequate legislations related to EIA process as a main obstacle restricting the effectiveness of EIA in Bahrain. Therefore, legislative amendments detailing the whole aspects of EIA process, including public participations, cumulative impacts and consideration of alternatives may strengthen the EIA system in Bahrain.

High proportions of the EIA experts recognized limitations of guidelines on procedural EIA (56%) and ecological assessment (68%) in coastal and marine environments as major barriers for effective EIA in Bahrain. Dynamic guidelines on procedural EIA as well as guidelines for best practice in ecological assessment in coastal and marine habitats could improve the quality of EIA.

Most of the EIA experts believed that effective EIA in Bahrain is restricted due to the late implementation of EIA at the project life cycle (84%) as well as the inadequate consideration of project alternatives (92%). Applying EIA process at early stages of project life cycle and considering feasible alternatives could be achieved by integrating environmental concerns into higher levels of policy-making in Bahrain.

Limited stakeholder involvement and public participation in the EIA process is widely recognized as a major constraint for EIA effectiveness in many developing countries (El-Fadl and El-Fadel, 2004). Likewise, limited involvement of public in the EIA process in Bahrain was highlighted as a major obstacle for effective EIA by 84% of the EIA experts.

Generally, data and information gathered in EIA reports are considered by environmental authority in Bahrain, but do not necessarily determine the final decision with respect to the proposed projects. The majority (84%) of the EIA experts agreed that limited influence of EIA in decision-making process as well as limited integration of EIA in higher levels of policy-making are restricting the effectiveness of EIA in Bahrain.

4. Discussion and recommendations

In the light of the rapid development and urbanization of coastal and marine environments in the Arabian Gulf countries, effectiveness of EIA systems in protecting the environment and preventing ecosystems degradation are increasingly being investigated (Van Lavieren et al., 2011; Naser, 2012; Al-Azri et al., 2014; Heaton and Burns, 2014; Cotton and Mahroos-Alsaiari, 2015).

As a small archipelago, habitat destruction due to intensive dredging and reclamation activities is a prime cause for biodiversity loss and ecosystem degradation in coastal and marine environments in Bahrain. Within a decade, approximately 237 million m³ of dredged material were used to reclaim around 62 km² of coastal and shallow subtidal areas in Bahrain (Table 1). The present study investigated the role of EIA in achieving ecologically sustainable developments in Bahrain through evaluating the quality of selected EIA reports and identifying the perceptions of EIA experts about the effectiveness of EIA process in protecting coastal and marine environments in Bahrain.

A previous study investigated the ecological input in fifteen Bahraini EIA reports concerning coastal and marine developments that produced between 1996 and 2004 revealed major shortcomings including, limited new ecological surveys, inadequate evaluation of impacts, neglecting cumulative and long-term impacts, and failing to address adequately mitigation and monitoring measures (Naser et al., 2008). The quality ratings of the ecological input in that study indicated that 53% of the reviewed EIA reports were assessed as borderline quality and the remaining 47% as poor quality (Naser et al., 2008). In the present study, general improvement in the overall quality of the reviewed EIA reports was

observed (25% poor, 40% borderline, 25% satisfactory, and 10% good quality). Despite this general improvement in the overall quality of the reviewed EIA reports, the main findings of the present study also identified a number of shortcomings in environmental and ecological assessment practices related to coastal and marine developments in Bahrain.

Even though with varying levels, most of the reviewed EIA reports suffered from weaknesses in ecological surveys, consideration of project alternatives, cumulative effects, stakeholders involvement and public participation, compensation and mitigation, and monitoring. These limitations are very similar to those that have been identified in ecological and environmental assessments in several developing and developed countries (Ramjeawon and Beedassy, 2004; Soderman, 2005; Samarakoon and Rowan, 2008; Khera and Kumar, 2010; Panigrahi and Amirapu, 2012; Briggs and Hudson, 2013; Drayson and Thompson, 2013; Karlson et al., 2014).

Generally, the EIA experts indicated that consideration of alternatives and cumulative impacts for the proposed projects or their locations is not effective under the current practice of EIA in Bahrain. Most of the bachelor and master students who completed a course in EIA at the University of Bahrain viewed impacts prediction and assessment as effective, which could be attributed to relatively short experience in the EIA process (1–3 years), and their focus on the direct impacts of dredging and reclamation rather than indirect and cumulative ones.

The EIA experts also identified major barriers that are restricting the effectiveness of EIA in protecting coastal and marine environments in Bahrain, which include inadequate EIA legislations, limitations in procedural EIA and ecological assessment guidelines and limited influence of EIA in decision-making process. Overall the surveyed EIA experts in the present study confirmed the shortcomings of EIA process in Bahrain are similar to major critiques of many EIA systems in developing countries (Toro et al., 2010; Al-Azri et al., 2014; Zvijakova et al., 2014).

Two strategies can be suggested to address the above deficits in the Bahraini EIA system namely, 1) enhancing the current EIA practice and 2) adopting a strategic approach to dredging and reclamation environmental assessment. The first strategy primarily focuses on strengthen the EIA legislation, EIA administration, and EIA process in Bahrain. The second strategy emphasizes the critical need for a strategic approach when conducting environmental and ecological assessments for dredging and reclamation projects in Bahrain.

Bahrain has achieved significant progress in developing a legal framework for EIA system that specifies duties and responsibilities of relevant bodies involved in the EIA process. However, legislative amendments detailing the whole procedural aspects of EIA process, including consideration of alternatives and cumulative impacts, public participation, and ecological monitoring may further strengthen the EIA system in Bahrain.

Public participation in the EIA process is influenced by the cultural, social and political contexts, and available methods of communication as well as public environmental awareness (Cotton and Mahroos-alsaiari, 2015). It is recognized that considerable efforts are carried out by the Supreme Council for Environment to engage the public and stakeholders in the EIA process in Bahrain. However, effective public participation in the EIA process may require further integration into both the legal and the environmental institutional systems in Bahrain. Therefore, amendments in the relative EIA regulations are required to provide provisions for public participation in the EIA process. Several approaches could be utilized to disseminate information related to dredging and reclamation activities among stakeholders and the public (Cutroneo et al., 2014). These may include web-based information system that supports the technical aspects of dredging and reclamation as

well as several communication products, including posters, article publication, websites, and media coverage. Additionally, providing better access to EIA related documents could enhance public involvement in EIA process in Bahrain.

There are several legal, social and environmental implications for dredging and reclamation in Bahrain, which generate a lot of debate about positive and negative aspects of these activities. Therefore, forming a national intergovernmental body from relevant stakeholders namely, the Coast Guard, the Ministry of Housing, the Ministry of Works, the Ports Authority, the Supreme Council for Environment, the Urban Planning Directorate, and the Municipalities to holistically plan and implement dredging and reclamation activities as well as involving the public could improve the overall governance and management of dredging and reclamation in Bahrain.

Spatial mapping for sensitive coastal and marine environments may help in understanding how multiple threats are cumulatively affecting coastal and marine ecosystems. Similarly, environmental sensitivity mapping could facilitate the consideration of alternatives for project locations that are in harmony with the Bahraini National Land Use Strategy 2030. Additionally, such mapping can help in the allocation of suitable borrow areas for sand extraction that is in line with the Law No. 37 of 2014 with respect to Extraction and Selling of Marine Sands.

Due to the ongoing large scale of dredging and reclamation activities, an integrated environmental monitoring approach that involves biological, physical and chemical aspects of dredging and reclamation could be reflected positively on the effectiveness of EIA in Bahrain. Scientific research institutions should play an important role in studying ecological succession in newly created coasts and of recovery of marine organisms in burrow pits and surrounding environments. This could allow for a better understanding of biological and ecological changes associated with dredging and reclamation activities in coastal and marine environments in Bahrain.

Maintaining a sustainable use of coastal and marine natural resources in Bahrain requires measures to holistically address the interactions among the several reclamation and dredging activities and their additive and cumulative impacts on valued ecosystem components. Therefore, Strategic Environmental Assessment (SEA) may contribute toward achieving an environmentally sound development in coastal and marine environments in Bahrain. SEA is defined as the process of evaluating and integrating the environmental consequences of proposed policies, plans and programs, and integrating them into higher-level decision making systems (Acharibasam and Noble, 2014). The mandate of the Supreme Council for Environment form the foundation to strategically integrating environmental considerations among all governmental and private sectors in Bahrain. The legislative Decree No. 47 of 2012 with respect to establishing and organizing the Supreme Council for Environment explicitly indicates that decisions of the Council are binding to all ministries authorities and institutions in the Kingdom.

There is a rapid increase in magnitude and frequency of proposed dredging and reclamation projects over adjacent coastal and subtidal areas in Bahrain. Therefore, SEA has the potential to promote sustainable development in coastal and marine environments through implementing EIA process at early stages of project life cycle, identifying cumulative impacts of exiting or planned projects, investigating feasible alternatives to coastal developments that are in line with National Land Use Strategy, and implementing effectively mitigation and compensation measures (Lamorgese and Geneletti, 2013). Furthermore, SEA can identify social, economic, and environmental issues associated with coastal developments, and subsequently contribute to environmental sustainability in Bahrain (Rachid and El Fadel, 2013).

Partidario and Gomes (2013) and UNEP (2014) provide, respectively, a methodology to allow the consideration of ecosystem services in SEA and a guide to integrate ecosystem services in SEA. The operational guidelines in these studies could be broadly applied to the sector of coastal development in Bahrain, which is influenced by dredging and reclamation activities. UNEP (2014) propose practical steps that may include identifying and mapping valued coastal and marine ecosystems and establishing their services, reviewing existing regulations related to EIA and dredging and reclamation in Bahrain, determining priority ecosystems services and assessing baseline conditions, identifying alternatives, predicting and evaluating impacts of dredging and reclamation on valued ecosystem components.

5. Conclusions

In Bahrain, as in many other countries in the world, coastal and marine environments will continue to be a major focus for development activities, including housing, recreational, economic, and industrial projects. Therefore, there is a critical need to maintain a balance between coastal development, which typically associated with dredging and reclamation, and the ecological function of coastal and marine ecosystems. It is proposed that an effective environmental and ecological impact assessment may achieve this delicate balance between development and the environment. EIA is increasingly contributing to the overall environmental policy and promoting sustainable development in Bahrain. However, several measures are required to further strengthen the EIA system in Bahrain. SEA is a promising tool to integrate environmental considerations of coastal development in higher-level decision making process and improve the understanding of the consequences of dredging and reclamation activities on the integrity of coastal and marine ecosystems in Bahrain.

Acknowledgements

Logistical support provided by the Department of Biology and the Library and Information Services at the University of Bahrain is highly appreciated. The contributions by the EIA experts/practitioners and relevant environmental bodies are greatly acknowledged.

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