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Effect of Urbanization Development on Coral Reef at Marsa Alam Coast, Southern Egyptian Red Sea

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Abstract. Assessment and distribution of coral reefs at three sites located at the coast of Marsa Alam city southern Egyptian Red Sea were surveyed for the biotic and abiotic components of the sea bottom in order to evaluate the impacts of the urbanization development. The survey was conducted using diving equipment in summer 2020. Line intercepted transect was used to determine corals and other benthic components. The average percentage cover of live corals was 63.27± 7.16. Site 3 has the highest percent cover of live corals (67.6 %) whereas site 1 has the lowest value of live coral reef (55%). Higher degraded reefs above the 2 m and 5 m depth zones characterize coral reefs in the studied sites, dead coral at Study sites coverage was 27.8%, 22.9% and 20.6% at sites 1, 2 and 3, respectively. However, the newly broken colonies were highest at site 1 (2.7%) than at sites 2 (1.4 %) and site 3 (0.9 %). Shannon diversity index H` ranged from 0.65 at site 1 to 0.67 at site 3; The current study revealed that the coral reef was threatened from urbanization development in studied sites, in comparison to other sites that restricted from urban activity. Our conclusion to decision maker is to do the strategic planning and manage to the integrated coastal zone management in future at the Red Sea coast.

Keywords: Coral Reef, Urban Development, Marsa Alam, Red Sea, Egypt.

1. Introduction

The Egyptian coastline of Red Sea extends for about 1800 km of fringing reef covering an area of about 3800 km2 (PERSGA,2010). A widely cited report on tourism and economic development warns that coral reefs along the Egyptian coast have been damaged as a result of coastal urban development (Hilmi *et al*., 2012). Coral reefs in the Red Sea attract both foreign and domestic visitors and generate revenue, including foreign exchange earnings in Egypt. The diverse coastal and marine ecosystems of Marsa Alam are an important community resource that can serve as recreation and enjoyment for visitors and tourists, as well as research materials for scientists conducting monitoring and conservation initiatives (Ammar *et al*., 2011). Although the rapidly expanding tourism industry is considered as an extremely important economic activity, it caused increasing pressure on coral reefs of Egypt. Damage occurs from both direct and indirect impacts of tourism activities on coral communities. Understanding the complete economic worth of coral reefs to tourists, as well as the spatial distribution of these values, is a powerful motivator for long-term reef management (Spalding *et al*., 2017). Unfortunately, tourism and the environment have an unbalanced relationship: tourism is environmentally dependent, and the environment is vulnerable to tourism's impact (Wong, 1993; Al-Hammady and Ahmed 2013).

Coastal tourism near coral reefs is not always benign: Negative impacts can include degradation and loss of marine life from activities such as diving and snorkeling, as well as indirect impacts from poorly planned coastal development, such as dredging, building on intertidal spaces, and increases in pollution and solid waste (Watson *et al*., 2000). Despite these risks, tourism may pose a less significant threat than fishing, land-based runoff, or coral bleaching, and may even aid in the reduction of some threats, such as overfishing, by providing financial or social incentives for sustainable management. Coral Reefs are of particular importance to the Egyptian economy due to their proximity to the millions of tourists from Europe. Around 2.5 million visitors a year enjoy the tropical coastal areas of Egypt, of which 23% come specifically to dive and a further 33% participate in snorkeling activities (Cesar *et al*., 2003). Almost 75% of tourism activity in Egypt was leisure orientated and mostly concentrated on the Sinai and Red Sea (Smits *et al*., 1998). Red Sea is one of the best scuba diving locations (Ibrahim and Ibrahim 2003). The web site "Scuba travel 2 classifies 13 Egyptian diving sites among the 100 best dive sites of the world (Hilmi *et al*., 2012). The diversity and distribution of these natural resources, especially coral reefs, and the extent to which these resources are affected by human activities, especially tourism activities (Ghallab *et al*., 2020). The proper Egyptian Red Sea coast at south Hurghada area did not have his share of surveying until recently, due to the remoteness of this area. Recently a few research projects were internationally funded through GEF and USAID for studying the reefs on the southern Red Sea coast, e.g., (GEF, 1998). Most of these projects concerned mainly with single subject (reef protection) without detailed studies of the reef communities itself. (Ammar,2004) studied the zonation of coral communities and environmental sensitivity offshore site at Marsa Alam, Red Sea, Egypt and found that Millepora sp. (a hydrocoral) prefers high illumination and has a strong skeletal density to tolerate strong waves. (Ammar and Emara 2004) reported that, Stylophra pistillata can withstand the flood sediments, whereas Millepora dicotoma cannot. The future of coral reefs in the Red Sea depends on rates of acidification and warming, but also on more local anthropogenic disturbances, Population growth rate in the Red Sea region is high and it is predicted that the population will nearly double within one generation (United Nations, 2017; Fine *et al*., 2019). Light of the challenges in developing value transfer approaches, as well as the benefits of understanding not only global values but also their spatial distribution, this paper proposes a novel method for accurately quantifying global reef values and delivering these values to specific reefs at local scales. In studying coral reefs, the abundances of key organisms have frequently been used as indicators of reef health. For example, a low abundance of corals or fishes, or a high abundance of algae, sea grass, or other soft bodied organisms, have been taken to indicate the degradation of a reef area (Bellwood *et al*., 2004; Bahartan *et al*., 2010; Goatley *et al*., 2016).

The present work aims to evaluate the status of coral reef at Marsa Alam coast, Red Sea, Egypt under different levels of urban development.

2. Materials and Methods

2.1 Study Sites

Three sites of Marsa Alam, Red Sea, Egypt, were surveyed principally for sensitivity significance of coral reef to urban activities (Table1 and Fig. 1).

2.1.1 Site 1: (Marina Mars Alam)

The fringing reef has been extended tidal flate reach 1km suurouded by wide internal lagoons to reach the exoposed reef. It is characterized by a sandy bottom with somesea grass and seaweed, alot of safari boatsanchore in the lagoons, thera are concrete platform inside the tidal falt paralle to the exposed reef (Table 1; Fig. 1,2).

2.1.2 Site 2: (Desalination Plant of Marsa Alam)

It is bay with fringing reef separated by channel-like lagoons. The intertidal zone is rocky that receives the discharge of desalination plant through pipeline Table1, Fig. 1,2).

2.1.3 Site 3: (Fishing club)

A wide lagoon with muddy and sandy bottom that is covered with many patches of reef. This iste is used for anchoring of fishing boats, the area of the seabed of the intertidal zone is characterized by sandy bottom that is composed of a thick layer of soft sand.There are some species of algae and in the presence of dense sand deposits led to the water turbidity and scarcity of biodiversity from marine environments. This area extends about 85 meters into the water and isfollowed by three closed lagoons. Due to the high sedimentation rate with many coral reefs die, Table 1, Fig. 1,2).

2.2 Field Work

The survey was conducted using SCUBA equipment in summer 2020. For corals and other benthic fauna, the transect line method was used by using a 30 m long tape for surveying the percent cover that applied (*Rogers et al.*,1983). Two transects were surveyed at depths 1m, 5m, or till the end limit. Go Pro underwater camera used to document the habitat components at each site.

2.3 Statistical Analysis

Percentage cover of coral species and other taxa underlying was calculated using the formula: % cover = (intercepted length/transect length) * 100. Three transects were used per depth zone and the average was calculated for all transects. Sensitivity significance of the study area is derived from internationally known criteria; however, the key words of each criterion and a brief description of its use can be described as follow:

Diversity (IEEM, 2006): A high species diversity consider a high diversity of variation communities, which show difference in environmental conditions. Different indices of coral diversity were calculated using the computer software Biodiversity Professional Version 2 (McAleece *et al.*,1997). Diversity was measured by seven different indices (Shannon diversity index (H\`), Shannon evenness index (J\`), Berger-Parker dominance (d), Simpson diversity D, Margalef M Base, Mackintosh diversity (D) and Mackintosh evenness (E).

Rarity (Edwards-Jones *et al.*, 2000): Applied to species or habitats are limited in distribution. Each 1% of rare species, relative to the total abundance, was assigned a significance sensitivity score of 10, so 0.2% rare biota or habitats = 2 (0.2*10) and so on.

Fragility (IEEM, 2006): Species or habitats susceptible to disturbance or loss. Each 1% fragile species, relative to the total percent cover, was given an optimal score of 10, so each 0.3% fragile habitats = an estimated score of 3 (0.3*10).

Ecological functions (IEEM, 2006): Loss of ecological function can be calculated by measuring the area of near shore habitat that is removed or covered by the pier structure. Each 6.66% vital ecological function (vegetation or habitats not removed by physical conditions) was assigned a score of 1 (6.66/6.66), thus a vital ecological function of 26.64% will have an estimated score of 26.64/6.66 = an estimated score of 4 and so on.

Typicalness (Fandiño, 1996; Edwards-Jones *et al.*, 2000): measuring of how a site will reflect all the habitats that are expected to occur in that geographical region. The more representative a site is of a region, the better. A site representing 80% of the number of the characteristic ecosystems of a geographical area was assigned a score of 10% (80/8), thus a site having 24% characteristic ecosystems will have an estimated score of 24/8=3% and so on.

Naturalness (Ratcliffe, 1977; IEEM, 2006): Habitats largely unmodified by human activity. A 10% virgin area (with no human caused alteration) was assigned a score of 1 (=10/10), thus a 30% virgin area has an estimated score of 30/10=3 and a virgin area of 50% has an estimated score of 50/10=5 and so on.

Environmental Sensitivity: Methods of how values have been assigned to each site per criterion is described as (Ammar *et al.*, 2011). Optimal sensitivity score was assumed for each criterion; This was the score at which the site could be optimal. In addition, an estimated score was assigned to each criterion depending on how much the site meets the conditions of the optimal score, then all sensitivity scores for each site were gathered to get the total sensitivity significance.

3. Results

The result of Percentage covers of live corals and other habitats in the study sites is shown in (Table 2 & Fig. 3). The mean cover of sites was 63.27± 7.16 where Site 3 has the highest percent cover of live corals 67.6 % (Table 2 and Fig. 3a) and site 1 has the lowest value of live coral reef 55% Table 2 & Fig. 3(a) while the site 2 was 67.2% of living cover (Table 2 & Fig. 3a).

Percent covers of dead corals were 27.8 %, 22.9 % and 20.6 % at sites 1, 2 and 3, respectively (Table 2 & Fig. 3c). However, the newly broken colonies were highest at site 1 (2.7%) Table 3, than at sites 2 (1.4 %) Table 4, and site 3 (0.9 %) Table 5.

The values of seven distinct diversity indices were compared to each other and to the health state of the locations. Averages of different indices of diversity are shown in Table 6. Shannon diversity index (H`) ranges from 0.65 at site 1 to 0.67 at site 3; however, Shannon evenness index (J`) is in the range between 0.5 at site 1 and 0.8 at site 3. Berger-Parker dominance d represents higher variations between sites ranging from 0.25 at site 1 to 0.3 at site 3. Simpson diversity) D) has lower values ranging from 0.13 at site 1 and Canyon to 0.14 at sites 1 & 2. Margalef diversity M has higher values of diversity but in contrast to other indices, it is lowest in site 1 (0.13) and highest in sites 2 & 3 (0.14). Although Mackintosh Diversity) D) and Mackintosh evenness index) E) has values lower than those of Margalef, they have a similar variation between sites having lowest values in site 1 and highest value in site 3. Similarity matrix of different diversity indices is shown in Table 6.

Total assigned value of sensitivity significance is given in Table 6. Total assigned value of sensitivity significance was less than 50 at the study sites. This lower value is related to the extensive anthropogenic impact at the study site. The maximum value of sensitivity was recorded at site 3 (38) and the lowest value was recorded at site 1 (28). Moreover, site 1 recorded the highest value of fragility (11), and the lowest value of naturalness (2).

Table 1. GPS coordinate of sites.

Site	Sites name	Coordinates	
		Latitude	Longitude
Site 1	Marina Marsa Alam	34°53'55.70" E	25° 4'59.24" N
Site 2	Desalination Plant of Marsa Alam	34°53'51.48" E	25° 4'33.76" N
Site 3	Fishing Club	34°54'18.00" E	25° 4’ 5.90" N

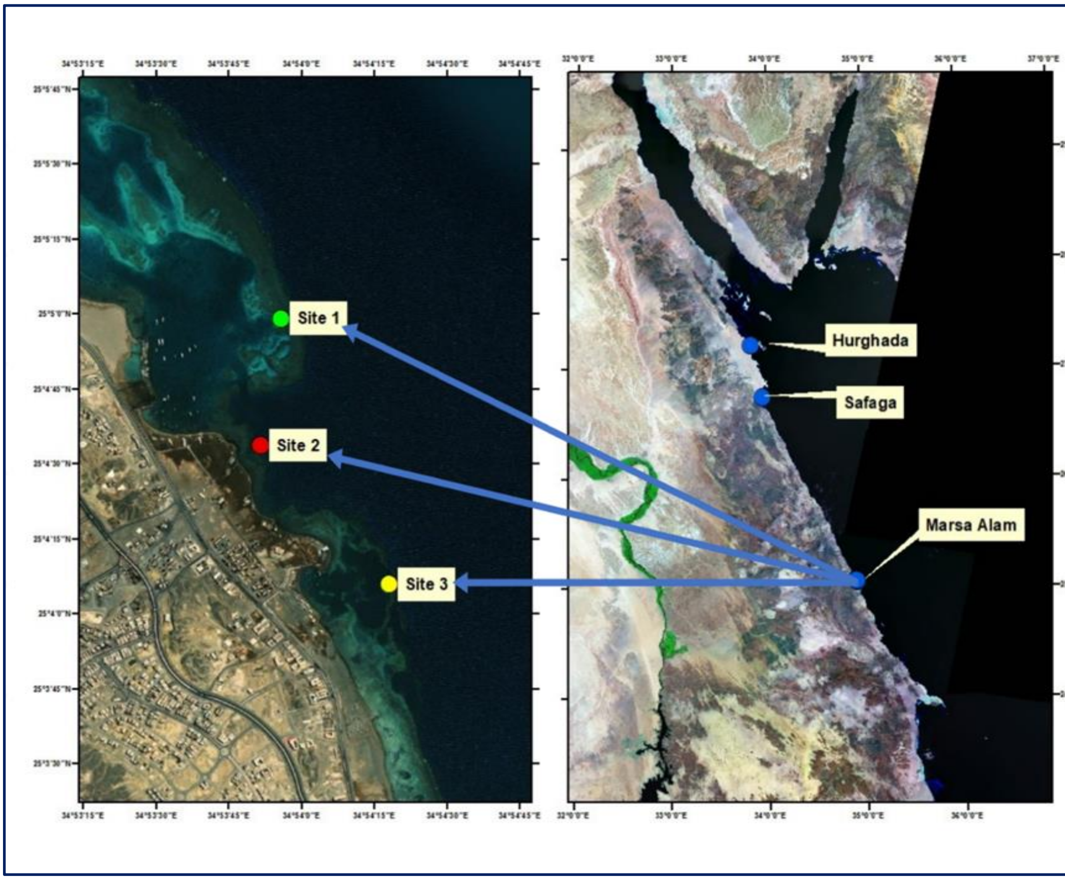

Fig. 1. Arc GIS Map to the study sites.

Fig. 2. Overview and underwater of the study sites where the site (1) safari boat and grovels for old landfilling (b& d) site 2 pipeline discharge of desalination plant, (c) related to throwing of materiel fishing net the site where a lot of fishing boats anchoring.

Table 2. The percentage cover of biotic and abiotic substrate at study sites.

Percent Cover %	Site 1	Site 2	Site 3	Mean ±SD
Live hard corals	55	67.2	67.6	63.27±7.16
Live soft corals	10.8	5.6	6.4	7.6±2.8
Dead corals	27.8	22.9	20.6	23.7±3.67
Other Categories	6.9	3.9	5.8	5.5±1.5

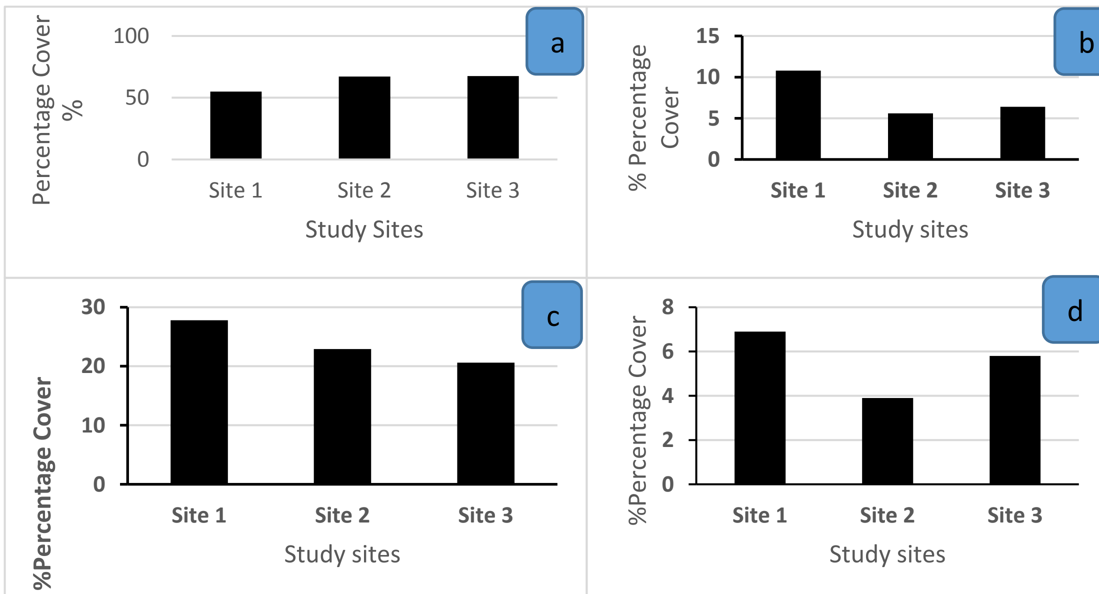

Fig. 3. The percentage cover of biotic and abiotic components of study sites where is a) is the % cover of living substrate, b) % of soft living cover, c) % Dead coral substrate and d) % other abiotic substrate.

Table 3. Percent cover of coral species and other categories at Site 1.

Categories	Species name	Reef flat	2m	5m
Branching hard coral	*Acropora squarrosa*	0.2	0.3	0.4
	Acropora nasuta	0.1	0.2	0.2
	Acropora granulosa	0.2	0.5	0.4
	Acropora pharaonic	0.2	0.3	0.3
	Acropora digitefera	0.2	0.4	0.2
	Acropora humilis	0.5	1.5	0.3
	Stylophora pistillata	0.9	1.3	2.5
	Pocillopora verrucosa	0.4	0.5	0.6
	Pocillopora damicornis	0.3	0.4	0.5
	Seriatopora hystrix	0.1	0	0.1
	Lobophyllia corymbose	0.2	0.2	0.3
	Total	**3.3**	**5.6**	**5.8**
Massive hard coral	*Platygyra daedalea*	0.1	0.9	1.7
	Leptoria phyrigia	0.3	0.2	0.1
	Favia amicorum	0.2	0.5	0.8
	Favia stelligera	0.1	1.1	2.5

	Favia pallida	0.3	1.6	1.8
	Porites lobate	0.5	2.3	4.5
	Porites solida	0.3	2.9	3.8
	Montipora meandrina	0.1	0.8	0.9
	Montipora spogiosa	1.1	1.2	1.3
	Montipora circumvallate	1.1	0.5	1.3
	Total	**4.1**	**12**	**18.7**
Encrusting	*Hydnophora micronos*	0.2	0.1	0.3
	Alveopora daedalea	0.1	0.2	0.2
	Echinopora lamellose	1	0	0.2
	Echinopora gemmacea	0.1	0.1	0
	Cyphastrea microphthalma	0	0	0.2
	Total	**1.4**	**0.4**	**0.9**
Solitary	*Trachyphyllia geoffroyi*	0.1	0	0.1
	Fungia repanda	0	0.5	0
	Fungia scutaria	0.5	0	0
	Fungia klunzingeri	0	0	0.1
	Fungia fungites	0.2	0	0
	Total	**0.8**	**0.5**	**0.2**
Soft coral	*Dendronephthya* sp.	0.9	1.1	1.5
	Sinularia gardineiri	0.6	0.5	0.2
	Hicksonella sp.	0	0	0.3
	Sarcophyton sp.	1.1	1.5	1.5
	Nephthea molle	0.2	0	0.3
	Heteroxenia fuscescens	0.1	1	0
	Total	**2.9**	**4.1**	**3.8**
Hydrocorals	*Millepora dichotoma*	0.2	0.2	0.3
	Millepora platyphylla	0.1	0.1	0.4
	Total	**0.3**	**0.3**	**0.7**
Other categories	Dead Corals	13.5	7.8	6.5
	Algae	0.1	0.1	0.1
	Sea Urchins	0.1	0	0
	Sediments	2.1	1.2	0
	Newly broken colonies	2.1	0.5	0.1
	Total	**4.4**	**1.8**	**0.2**

Table 4. Percent cover of coral species and other categories at Site 2.

Categories	Species name	Reef flat	2m	5m
Branching coral	*Acropora Formosa*	0.1	0.3	0.6
	Acropora squarrosa	0.2	0.4	0.3
	Acropora cytheraea	0.2	0.8	0.7
	Acropora digitifera	0.3	0.1	0.4

	Acropora eurystoma	0.2	0.8	1.2
	Acropora humilis	0.1	0.6	1.4
	Acropora hyacinthus	0.4	0.6	1.4
	Pocillopora verrucose	0.3	1.2	2.6
	Pocillopora damicornis	1.2	1.3	2.5
	Stylophora pistillata	2.3	2.5	3.1
	Lobophyllia corymbose	0.1	0.1	0.4
	Total	**5.4**	**8.7**	**14.6**
Massive hard coral	*Favia pallida*	0.5	0.3	2.4
	Favia stelligera	0.3	1.5	2.6
	Goniopora somaliensis	0	1.2	1.2
	Goniastraea palauensis	0	0.2	0.1
	Porites solida	1.2	2.1	3.1
	Porites undulate	2.5	1.9	2.8
	Porites rus	0.5	1.4	1.8
	Porites compressa	1.5	2	2.8
	Porites lutea	0.5	2.5	3.1
	Favia amicorum	0.1	0.9	1.9
	Montipora meandrina	0	2.5	2.1
	Total	**7.1**	**16.5**	**23.9**
Encrusting	*Hydnophora micronos*	0.1	0	0.1
	Alveopora daedalea	0.1	0	0
	Echinopora lamellose	0	0.5	0.5
	Total	**0.20**	**0.50**	**0.60**
Solitary	*Fungia repanda*	0.1	0.1	0.1
	Fungia fungites	0.1	0	0
	Total	**0.2**	**0.1**	**0.1**
Soft coral	*Dendronephthya* sp.	0	0.5	0.3
	Sinularia gardineiri	0.1	0.1	0.4
	Hicksonella sp.	0.2	0	0.3
	Sarcophyton sp.	0.8	0.5	0.6
	Nephthea molle	0	0.1	1.5
	Heteroxenia fuscescens	0.1	0	0.1
	Total	**1.2**	**1.2**	**3.2**
Hydrocorals	*Millepora dichotoma*	0.5	0.2	1.5
	Millepora platyphylla	0.8	0.4	1.6
	Total	**1.3**	**0.6**	**3.1**
Other categories	Dead Corals	9.6	7.2	6.1
	Sediments	1.7	0.8	0.5
	Newly broken colonies	0.8	0.6	0.5
	Total	**12.1**	**8.6**	**7.1**

Table 5. Percent cover of coral species and other categories at Site 3.

Categories	Species name	Reef flat	2m	5m
Branching hard coral	*Acropora hyacinthus*	0.8	0.2	0.3
	Acropora hemprichii	0.2	0.4	0.8
	Acropora corymbosa	0.1	0.2	0.7
	Acropora valenciennesi	0.1	0.7	0.4
	Acropora clathrata	0.4	0.2	0.3
	Acropora brueggmanni	0.5	0	0.2
	Acropora nasuta	0.3	0.1	0.4
	Acropora eurystoma	0.1	0	0.3
	Acropora pharaonis	0.1	0.5	0.2
	Acropora granulosa	0.4	0.6	0.5
	Acropora nobilis	0.6	0.3	0.2
	Stylophora pistillata	0.9	0.8	1.2
	Pocillopora verrucosa	0.3	1.5	1.7
	Pocillopora damicornis	0.2	1.6	1.9
	Total	**5**	**7.1**	**9.1**
Massive hard coral	*Montipora verrucosa*	0	0.7	0.8
	Montipora monasteriata	0.2	0	1
	Montipora stilosa	2.1	1.5	0.5
	Platygyra sinensis	0	1.6	0.8
	Platygyra daedalia	1.2	0	1.3
	Porites lobata	3	2.1	3.1
	Favia stelligera	0.6	0	0.6
	Favia speciosa	0.8	1.2	1.8
	Favites persi	0.1	2.1	1.5
	Porites solida	3.5	1.5	2
	Goniastrea retiformis	0	0.5	1
	Galaxea fascicularis	0.2	0.4	0.3
	Total	**11.7**	**11.6**	**14.7**
Encrusting	*Echinopora lamellose*	0	0.3	0.2
Solitary	*Ctenactis ecchinata*	0	1.2	0
Soft coral	*Xenia* sp.	1.8	1.3	0.4
	Sarcophyton sp.	1.6	0.2	1.1
	Total	**3.4**	**1.5**	**1.5**
Hydrocorals	*Millepora dichotoma*	1.7	2.1	0.5
	Millepora platyphylla	0.6	1	0.4
	Total	**2.3**	**3.1**	**0.9**
Other categories	Dead Corals	10.1	5.6	4.9
	Mollusca shells	1.7	0.8	0.5
	Tridacna sp.	0.8	0.6	0.5

Sediments	0.4	0.2	0.1
Newly broken colonies	0.4	0.1	0
Total	**15.6**	**7.8**	**5**

Table 6. Summery of percent cover, indices of diversity and environmental sensitivity in the studied sites.

		Site 1	Site 2	Site 3
Percent Cover	No. sp. (intercepted)	39	35	34
	% Live hard corals	55	67.2	67.6
	% Live soft corals	10.8	5.6	6.4
	% Dead corals	27.8	22.9	20.6
	% Other Categories	6.9	3.9	5.8
Indices of Diversity	Shannon H' Log Base 10.	0.65	0.66	0.67
	Shannon J'	0.5	0.7	0.8
	Berger-Parker Dominance (d)	0.25	0.26	0.3
	Simpsons Diversity (D)	0.13	0.14	0.14
	Margalef M Base 10.	28.9	29.1	29.2
	Mackintosh Diversity (D	1.12	1.12	1.3
	Mackintosh Evenness (E)	1.31	1.35	1.38
Environmental Sensitivity	Rarity	8	9	9
	Fragility	11	10	9
	Ecological functions	4	7	8
	Typicalness	3	5	7
	Naturalness	2	3	5
	Total 100%	**28**	**33**	**38**

4. Discussion

The current study revealed that the coral reef was threatened from urbanization development in studied sites, in comparison to other sites that restricted from urban activity. While the percentage cover of live coral reef ranged from 55% at site 1 to 67.2% at site 3 in the fact that the decline of coral reef cover was observed at the studied site linked to increased human activity because of urban development. (Al-Hammady *et al.*, 2005) showed a decrease in coral reef percent cover of 30% at Hurghada, Safaga and Marsa Alam (Kotb *et al.*, 2004) recorded a similar result that the percent cover of live coral in the Gulf of Aqaba decreased from 37% to 13% between 1997 and 2002. (Ghallab *et al.*, 2020) recorded degradation of northern coral reef related to fishing and petroleum and touristic activity, yet coral cover in the Egyptian Red Sea has declined by over 30% in some places during recent decades, coupled with a significant increase of broken and damaged colonies (Jameson *et al.*, 1999). Red Sea coral reefs are still facing a range of serious anthropogenic threats that may significantly alter their ecological composition and reduce their capacity to deliver essential ecosystem services. Enhanced anthropogenic disturbances and their interaction with natural stressors could be the main factor for this dramatic degradation (Al-Hammady *et al.*, 2015). The interaction between anthropogenic activities and natural stressors is thought to cause coral diseases, coral bleaching, and finally leading to a loss of coral cover (Ammar 1998; Pandolfi *et al.,* 2003; Al-Hammady, 2005 and Côté *et al.,* 2005) link global decreases in coral covering and overall reef deterioration to a variety of anthropogenic and natural reasons. Our results reveals the value of sensitivity significance was less than 50 at the study sites, where the site 1 28, 33 at site2 and site 3 was 38 This lower value is related to the extensive anthropogenic impact at the study site that agree with (Ammar *et al*., 2011), they study 20 sites at the south red sea and they find the sensivity significant score ranged from 9 to 86 they recommended that the sites have the score less than 50 to be suitable for management purpose. Another explanation for the deterioration of the coral reefs in the study sites is that they are onshore reefs, which are more exposed than offshore locations, which are many in front of Marsa Alam City and provide excellent diving opportunities. This explanation agreed with the finding of (AL-Hammady and Mahmoud 2013) that onshore reefs of the Red Sea are subjected to a larger scale of anthropogenic damage than offshore reefs. (Burke *et al.,* 2011) reported that landfilling and dredging, port activities, sewage, pollution, and other tourism activities threaten roughly 60% of the onshore Red Sea reefs. However, information about the susceptibility of decline between onshore and offshore reefs, and the degree of impacts on the Red Sea corals is still few (Al-Hammady *et al.,* 2015). The values of seven distinct diversity indexes were compared to each other and to the health state of the locations. The Shannon index, according to (Stirling and Wilsey 2001; Reitalu *et al*., 2009; Johnston and Roberts 2009), is superior for analysis since it reflects the effects of evenness and richness components as well as their inter correlations. There are some variances in variety between sites in this study, which can be explained by the varying pressures that the sites are subjected to (Boumeester, 2005). Site 3 is considered as the healthiest site (based on Shannon species diversity H`). Surprisingly, places like site 3 have a lower number of species. One probable reason for this finding is the fact that site 1 has the highest percent cover of dead corals. Site 1 was exposed to damage in the past due to poor protection that has created enough substrates (dead corals and rocks). Based on the total assigned value of sensitivity significance and assuming a sensitivity significance score of less than 50 to be suitable for management purposes. The following site priorities are indicated for management reasons. Site 3 has significant scores of environmental sensitivities (38%) followed by site 2 (33%) and then site 1 (28%). Evaluation of sensitivity significance criteria in the previous studies dealt just phonetically with each criterion separately like for example (Ratcliffe, 1977; IEEM, 2006) for evaluation of diversity as high, medium or low, fragility as reversible or irreversible, naturalness as virgin, semi virgin or altered, size as large, medium or small. Other criteria were phonetically evaluated like Tubbs and for evaluation of rarity*;* (IEEM, 2006) for ecological functions*;* (Fandiño, 1996) and (Edwards-Jones *et al.*, 2000) for typicalness; (Wright, 1977) and (Edwards Jones *et al*., 2000) for scientific value; (IEEM, 2006) for environmental significance; (Ratcliffe, 1977) for scenic value . Even though Site 1 has a high level of fragility across all categories, it is recommended as a managed resource protected area since it contains fishing communities and activities critical to protect fisheries resources by limiting fishing seasons or temporarily to allow areas to recover.

5. Conclusions

The fringing red sea coral reef announced as a hope spot as the final refuge of reef at the world during cop27 at Sharm El Sheikh, the Marsa Alam coast recognize the best destination site as a world for the ecotourism, un planning urban development at Marsa Alam city like landfilling, desalination plant and un management of solid waste and marine litter could be explained by the fact that the decline of coral reef cover. Enhanced anthropogenic disturbances and their interaction with natural stressors could be the main factor for this dramatic degradation. Despite the high revenue of tourism to the national income, it is only for the short term. If this tourism movement continued unmanaged, the continuous degradation of reef sites will be unsatisfied the touristic ecotourism and effect on direct income and the loss of corals will be dramatic and unrestored. Action must be taken to manage the unleashed tourism activities in Egyptian Red Sea. Our conclusion to decision maker is to do the strategic planning and manage to the integrated coastal zone management in future at the Red Sea coast.

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تأثير التنمية العمرانية على الشعاب المرجانية في ساحل مرسى علم جنوب البحر الأحمر – مصر

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المستخلص. تم إجراء مسح لتقييم وتوزيع الشعاب المرجانية في ثلاثة مواقع تقع على ساحل مدينة مرسى علم جنوب البحر الأحمر المصري، وجمع بيانات عن المكونات الحيوية وغير الحيوية لقاع البحر، من أجل تقييم آثار التنمية العمرانية على هذه المناطق. وتم إجراء المسح باستخدام معدات الغطس، والمشاهدة، والتصوير تحت الماء باستخدام كاميرا ديجيتال في صيف ٢٠٢٠. كما تم استخدام شريط متري وعمل خط مقطعي تم اعتراضه لتحديد نسبة وكثافة الشعاب المرجانية والمكونات القاعية الأخرى بالثلاث مناطق التي تمت دراستها. كما كان متوسط النسبة المئوية للغطاء للشعاب المرجانية الحية ٦٣,٢٧ ± ٧,١٦ لمواقع الدراسة، والموقع الثالث يحتوي على أعلى نسبة تغطية للشعاب المرجانية الحية (٦٧,٦٪)، بينما يحتوي الموقع الأول على أقل قيمة للشعاب المرجانية الحية (٥٥٪). كما تم رصد الشعاب المرجانية المتدهورة في المناطق المدروسة عند العمق ٢م و٥م، حيث بلغت نسبة الشعاب المرجانية الميتة في مواقع الدراسة ٢٧,٨٪، و٢٢,٩٪، و٢٠,٦٪ في المواقع: الأول، والثاني، والثالث، على التوالي. ومع ذلك، كانت الخلايا المكسورة حديثًا من الشعاب المرجانية أعلى في الموقع الأول، حيث سجلت (٢,٧٪) مقارنة بالموقع الثاني، حيث سجلت (١,٤٪)، كما سجلت بالموقع الثالث (٠,٩٪). تراوح مؤشر تنوع شانون H` من ٠,٦٥ في الموقع الأول إلى ٠,٦٧ في الموقع الثالث؛ وكشفت الدراسة الحالية أن الشعاب المرجانية كانت مهددة من جراء التطور العمراني في المواقع المدروسة، مقارنة بالمواقع الأخرى المحظورة من النشاط الحضري. استنتاجنا لصانع القرار هو القيام بالتخطيط الاستراتيجي والإدارة المتكاملة للمناطق الساحلية في المستقبل على ساحل البحر الأحمر.

الكلمات المفتاحية: الشعاب المرجانية، التنمية العمرانية، مرسى علم جنوب البحر الأحمر، مصر.