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Dredging and reclamation activities in Bahrain

Dragage et terrain récupéré sur la mer à Bahrain

Ausbaggerungen und Landgewinnungsaktivitäten in Bahrain

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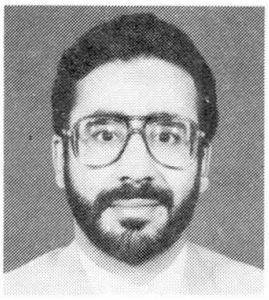

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SUMMARY

Over the last sixty years, considerable parts of the intertidal areas along the coasts of Bahrain have been either reclaimed or dredged. These operations, which were not preceded by effective planning and proper assessment led to drastic effects on the coastal marine ecosystem and environment, resulting in siltation, increased turbidity of the sea water and salinity of the island's ground waters. They have further degraded the biosystem, with many coral colonies, mangroves and sea grass beds destroyed. Furthermore, these have several social and economic impacts. Various dredging and reclamation activities and their environmental, social and economic impacts are reviewed.

Dragage et terrain récupéré sur la mer à Bahrain

Résumé

Au cours des 60 dernières années, d'importantes zones côtières ont été draguées ou récupérées sur la mer. Ces opérations, réalisées sans études approfondies, ont eu des effets catastrophiques sur l'écosystème et l'environnement marins côtiers. Ils ont causé un envasement et une augmentation de la turbidité de l'eau de mer et de la salinité de la nappe phréatique dans l'île. Le biosystème a subi une dégradation importante dans les palétuviers, les colonies de corail et les algues. En outre il y a eu des conséquences sociales et économiques négatives. Différentes activités de dragage et de récupération de terrains sont présentées avec leurs conséquences sur l'environnement, la société et l'économie.

Ausbaggerungen und Landgewinnungsaktivitäten in Bahrain

Zusammenfassung

Während der vergangenen 60 Jahre wurden beträchtliche Teile der Küstenzone Bahrains entweder aufgefüllt oder ausgebaggert. Diese Arbeiten, die nicht effektiv geplant und abgeklärt worden waren, führten zu drastischen Folgen für das maritime Oekosystem und die Umgebung. Sie verursachten Verschlammung, steigerten die Trübung des Seewassers und den Salzgehalt des Grundwassers der Insel. Sie haben das Biosystem weiter verschlechtert, Mangroven, Korallenkolonien und Seegras zerstört. Ausserdem hatten sie etliche soziale und wirtschaftliche Auswirkungen. Mehrere Ausbaggerungs- und Landgewinnungsaktivitäten und ihre Folgen auf Umwelt, Sozialgefüge und Wirtschaft werden dargestellt.

1. INTRTODUTION

The State of Bahrain is an archipelago composed of 33 islands located in the Arabian Gulf, with the Kingdom of Saudi Arabia to the West and Qatar to the East.

Bahrain island which measures 587 km² (86% of the total state land area), is the centre of most activities: it has the capital city (Manama), the primary port (Mina Salman), oil fields, and the oil refinery. Muharraq, the second largest island in the northeast, is connected to Manama by a causeway 2.4 km long, involving the area's first reclamation and dredging activities (1930). In addition, the international airport, iron pelletizing plant, and the drydock are located on this island. To the east of Bahrain is Sitra, the third largest island and also connected to the mainland by a causeway. Sitra, mainly an industrial centre has oil reservoires, a port for the export of oil, and an electricity-generating station and a desalination plant. Um-al-Nassan is another large island that is located in the northwest. It is now almost uninhabited but this is destined to change due to the Bahrain-Saudi Causeway. More detailed general information on the State of Bahrain is provided elsewhere (1).

The population of Bahrain, according to the 1981 census was 350798, and the estimated population in 1989 was 488545. The average annual growth during the period 1941-1981 is 7% which is considered very high compared to other countries, as shown in Table 1 (2).

Year	Population	Population density
Jan 1941	89970	
Mar 1950	109650	
May 1959	143135	
Feb 1965	182203	
Apr 1971	216078	326
Apr 1981	350798	517
1983*	390559	
1988*	473296	683
1989*	488545	705

* Estimated Values.

Table 1. Population of Bahrain (1941 - 1989), and population density per Km²

The discovery of petroleum in 1932 marked a turning-point in the economy of the state, and attracted people from their traditional industries. Unfortunately, by 1981 oil production had fallen significantly. This situation forced the country to adopt a policy of economic diversification in order to increase

and vary sources of income. The main emphasis was on industry, and later on commerce, fisheries, tourism, and agriculture. The need to industrialize urged the government to create industrial zones away from the centres of population, and this has created difficulties due to the limited area of Bahrain. The rapid development and the shortage of land became a problem. This problem was addressed by dredging and reclamation operations.

During the last 60 years, a number of sites along the coast of Barhain down to the coast of Sitra island have been either dredged or reclaimed. These activities increased significantly in the 1970s, serving both industrial and residential purposes, and lead to clear Changes in the area of Bahrain, as shown in Table 2.

Year	Area (km^2)
1975	661.87
1981	669.29
1983	684.98
1984	687.75
1985	690.86
1986	691.24
1987	692.39
1988	692.52
1989	693.15

Table 2. Changes in the area of Bahrain due to reclamation activities

In the early years of reclamation and dredging activities, only financial considerations were studied, and environmental and social factors were not taken into account. Thus, the areas reclaimed were selected randomly and based on convenience. Unfortunately, most of the reclamation activities have been carried out in the north-eastern and north-western coasts which are known to be the most productive from the fisheries point of view. This indicates the adverse effects of reclamation on one of the important economic sectors, namely fisheries. Moreover, some dredging activities have been carried out in areas where groundwater was low lying.

The main objective of this paper is to discuss briefly and highlight some of the effects of dredging and reclamation activities carried out in Bahrain, and introduce an integrated approach for the future planning of such acivities so that it takes into consideration social, economic and environmental aspects.

2. AREAS RECLAIMED

Reclamation of land by dredging marine sand from the sea is relatively inexpensive in Bahrain because the sea is very shallow for a considerable distance from the shoreline.

Approximately two meters of fill, readily available from dredging off-shore, is sufficient to raise the level above the high-water mark and permit development. Moreover, sea bed consists of hard sandy rocky bottom which facilitates development. The government in some reclaimed land follows a policy of renting the land to the industries for economic gain. The rent ranges from US $2.1 to 3.1 per m^2 or $1590.00 to 4750.00 per Year depending on the area and location of the site. By making a simple cost-benefit analysis, and looking at the jobs gained through industrial development, this operation seems very profitable. But this may not be the case if long term adverse environmental and social impacts are also investigated and compared. The following section presents a summary of the various sites that are reclaimed and the ultimate use of each site. Details of reclaimed areas and dredgers employed are reported elsewhere (3,4). Table 3 provides the sites reclaimed, while Figure 1 shows their locations.

2.1. North Sitra Industrial Area

This area was initially reclaimed in 1973 for the construction of Sitra power station and desalination plant. It was reclaimed by dredging in the immediate vicinity to form a deeper underwater intake channel. The reclamation was 180m wide by 300m long in an average water depth of 1m, and dredging was in a channel 40m wide and 5m long in an average predredging water depth of 3m. Other industries are located now in the area as presented in Table 3.

2.2. Mina Salman Port

The development of Mina Salman Port was possible through dredging associated with the deepening and re-alignment of the navigation channel

2.3. GIIC and ASRY Area

The total reclaimed area of Gulf Industries Investment company (GIIC) and Arab Ship Building and Repair Yard (ASRY) located southeast of Al-Hidd is approximately 2.5 km^2. The material required for reclamation was taken from an area south of the site, dredged to depths of 13.7m. The reclamation was accomplished by first forming retaining bunds with tipped landfill in order to enclose the area, then by hydraulic infilling with dredged material using caprock and limestone which are typical of the Bahrain coastal geology. Pipes were placed in the retaining bunds for the expulsion of water from the hydraulic filling which would carry with it certain amount of fine material including silt.

Area Reclaimed	Area (km^2)	Purpose of Recalmation
North Sitra	2.5	Industrial area (Power and desalination plant, sulfuric acid, aluminium extrusion and rolling mill, sand and gravel companies, sewage treatment, plastic and food factories), roads.
Mina Salman		Port, industrial area (paint factories, metal and plastic fabrication, soap and detergent plant).
Tubli bay	17	Sewage treatment, domestic waste pulverizing plant, housing, roads.
Manama south		Islamic center (0.3 km^2) and civic center (0.2 km^2).
Sanabis		Housing, government building, recreation (4.5 km^2).
GPIC	0.6	Methanol and ammonia plant, Jetty.
Budaiya	0.6	Housing, recreation.
Al-Dar Islands	0.033	Recreation.
Al-Muharraq	4	Airport, housing, recreation.
Arad and Al-Hidd	6	Industrial area (garages, fabrication), housing.
ASRY and GIIC	2.2	Ship repairing Yard, iron ore pelletizing plant, Workers housing, roads.
King Fahad Causeway	2.0	Roads.
Jaww	0.18	Police training centre.
Askar	0.0075	Avoid nuisance smell from the coast.

Table 3. Areas and purpose of reclamation in Bahrain

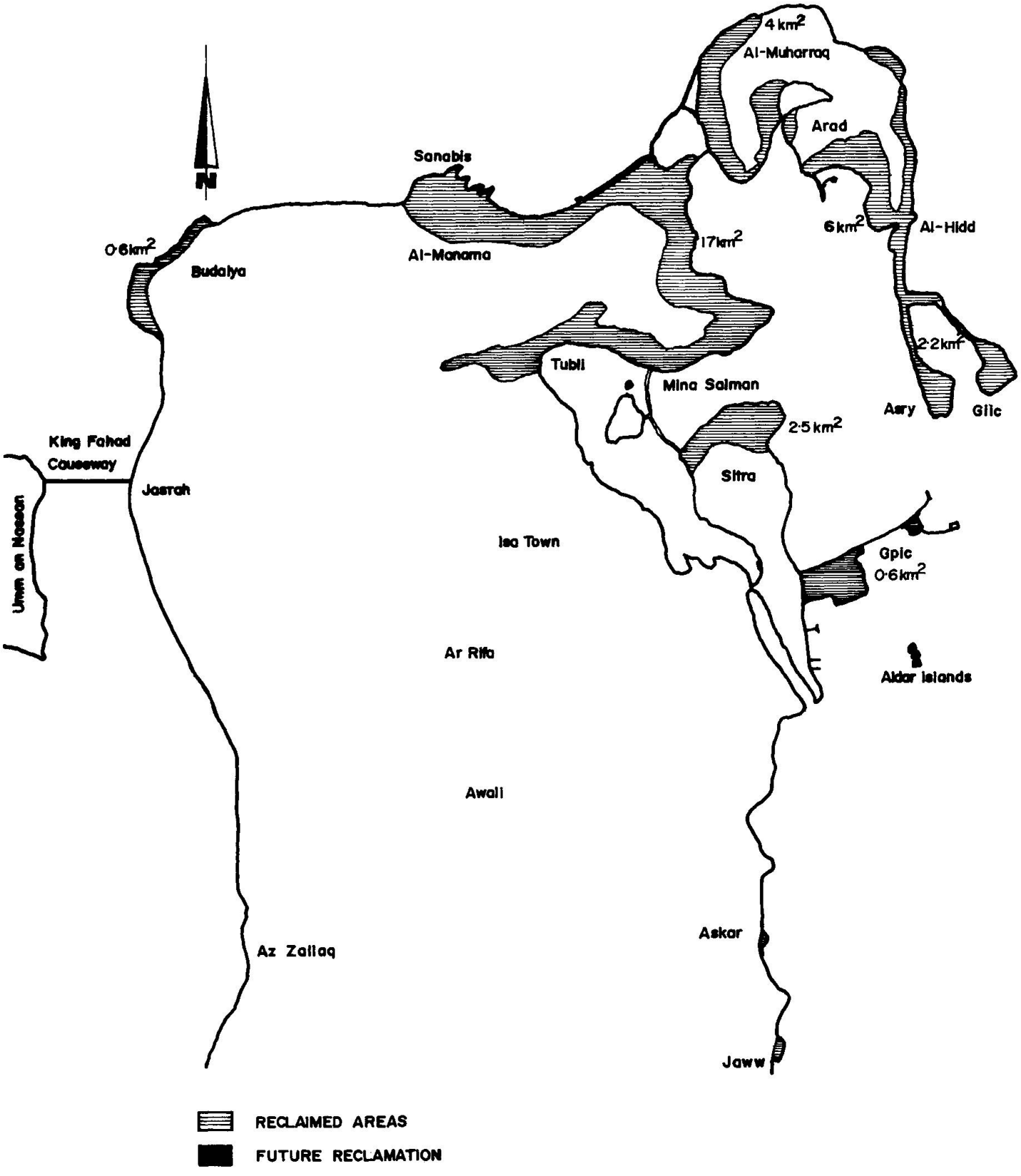

Fig. 1. RECLAIMED AREAS IN BAHRAIN.

2.4. Gulf Petrochemical Industries Co. (GPIC)

The petrochemical site reclamation was approximately 0.6 km^2. Two channels were dredged, one was for cooling water, in this case the depth of the water was about 7m, and the length was about 3.5 km, and the other channel is an alternative to the existing fisherman's channel which, in some parts was filled with the reclamation material. Part of the dredged material was dumped into the sea making three artificial islands known as Al-Dar islands, with total area of approximately 0.033 km^2, as shown in Figure 1.

2.5. Bahrain - Saudi Arabia Causeway

The 25 km causeway represents a major engineering achievement in terms of cost, amount of materials involved and technology. The causeway comprises five bridges and seven embankments, 12 km in length. The bridges vary in length between 950 and 5150m, with solid embankments having been made between the spans in the shallower reaches of the Gulf.

A project of this size might have a profound effect on the environment and marine life. The shallow and almost landlocked Arabian Gulf is especially vulnerable (5).

2.6. Sanabis Area

The method of reclamation employed was by dredging and direct discharge to a bunded area which was constructed ahead of the reclamation. The operation resulted in an outslip to the sea estimated to be 250,000 m^3 of silt. This silt affected hadrah grounds (fish barrier traps) which means that the fishermen have lost their only source of income. In this case, the fishermen should be allotted alternate site and given adequate compensation. Moreover, there are several evidences showing the increase of salininty of groundwater in the area and rise in their level. This situation could destroy coastal vegetation, especially date palms, and this actually happened in Tubli reclamation work.

2.7. Budiya Coast

A study dealing with the outslips from dredging and reclamation activities at Budaiya area was carried out pre, during and post the operation (6). The results showed that dredging outslips were much less in quantity in comparison to those of the reclamation fill. The primary damage to fish is through silting of hadrah and mooring areas of fishing crafts. However, this project avoided some of the mistakes done in earlier projects. Moreover, the study proposes alternative methods of reclamation to be considered in future projects in order to reduce silt outslip such as the use of waterboxes.

These methods, however have other disadvantages of higher cost and concentration of silts in one area. In any case, it is not possible to carry out dredging and reclamation projects and avoid silt outslip totally.

2.8. Askar Coast

Askar reclamation was carried out for the purpose of avoiding the smell generated from dead algae and seagrass on the coast. Other coastal areas were developed in the north of the island mainly for recreational purpose.

2.9. Future Projects

A major reclamation project approved by the government which is under detailed study, is the new Muharraq-Manama Causeway. The length of the causeway will be approximately 2.5 km comprising one bridge and an average width of 30m. A total of 3-4 million m^3 of fill will be used (7). The project will serve the purpose of reducing the increasing traffic density on the exiting causeway. This reclamation also include constructing several small islands for recreational pruposes.

Several coastal areas are undergoing reclamation by the private sector using building rubbles and domestic waste, and desert fill as top soil. These reclamation activities are not properly managed and not well controlled. The coast of reclamation is approximately US \$0.80 per ft^2, while the selling price ranges from US \$8.00 to 8.50 per ft^2. Economically, this is a profitable operation, but might have significat impact on the marine environment.

In general, it can be concluded that recent governmental reclamation projects were studied more carefully than previous ones prior to execution, taking into consideration economic as well as social and environmental aspects reflected from the activity. Also, authorities have gained more experience in dealing with dredging and reclamation works. However, some reclamation are carried out randomly by the private sector without governmental control.

3. ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS

No doubt that dredging and reclamation have both negative and positive social, economic and environmental impacts. This study will consider negative as well as positive impacts but it will concentrate more on negative impacts because it was ignored in Bahrain and their effects are more profound.

To account for such impacts, these should be integrated in decision making at the early stages of planning and appraising of dredging and reclamation activities, and a continuous monitoring program should be introduced to account for any changes during and after completion of the project. Thus, follow up monitoring, which is seldom carried out, must be an essential part in impact assessment.

Although a number of methods could be used to assess these impacts, yet the most relevant mehtods are Environmental Impact Assessment (EIA), and Social Coast-Benefit Analysis (SCBA). The purpose of these methods is to determine, before implementation, the socio-economic and environmental impacts of a proposed action and to ensure that full considerations are given to all potential impacts of the action. The concensus of opinion among researchers show that the social, economic and environmental impacts of proposed actions can not be assessed comprehensively by the conventional planning procedures and techniques.

It is not very difficult to identify and describe qualitatively the possible social, economic and environmental impacts of dredging and reclamation activities, however, it is difficult to quantify most of these impacts, since many are indirect and have long term effects, and could be elaborated only in descriptive terms. In this section, a discussion of the environmental, social and economic impacts will be presented and the checklists approach is used to list potential impacts observed in Bahrain.

3.1. Environmental Impacts

The adverse impacts of uncontrolled and poorly managed dredging and reclamation activities on the marine habitats is well documented world wide. For example, in Singapore reclamation for housing and industry is one of the main coastal development acitvities, and is a major cause of the loss of Singapore's coastal vegetation. In the last 17 years, about 31 km^2 have been added to the land area of Singapore through reclamation. This increase was accompanied by a dramatic reduction in mangrove area from 12 percent of the total land area in 1922, to only three percent in 1987 (8). Dredging activities has also taken place along the west coast of Thailand and in the tin islands off the east coast of Sumatra, Indonesia. Reefs in the vicinity of the dredging activities were damaged due to smothering as well as by the increase in turbidity. Moreover, these operations have led to conflict with local fishermen by loss of fishing grounds (9,10). In Japan, after the 1960's, tremendous coastal areas were reclaimed for industrial purposes. These activities reached their peak in 1974 with 40.5 km^2 of the sea being reclaimed, and now registers between 10 and 15 km^2 per year. This caused the disappearance of shoaling and natural beaches and consequently resulted in loss of sites for bathing, fishing and gathering shellfish (11). Reclamation acitvities in the coastal areas of Jiddah in Saudi Arabia and Kuwait, also caused the loss of the ecosystem and death or migration of several coastal organisms (12,13).

Similarly, land reclamation and dredging in Bahrain have caused irreparable damage to the inshore bio-system, with many corals being killed (3). Some of the largest corals are over a hundred years old and will probably never manage to re-establish on silted sites.

The potential environmental impacts of coastal activities, such as dredging and land reclamation operations presently

carried out in a concentrated area, seriously threatens the fishery of coastal and offshore waters, and could harm the productivity and quality of the marine ecosystem as a whole. The shallow nearshore areas that are presently destroyed by dredging and recalmation are the most diverse and productive ones in the sea; the sea-grass beds and the coral reefs. It is not only the limited areas actually dredged or reclaimed that are affected, but impacts are felt over much larger areas where siltation or changes in currents takes place. It seems likely that the death of extensive coral reef areas beyond the northern coast have been caused, at least partly, by increased turbidity of water due to dredging and recalmaiton far away from these reefs. The extensive beds of sea-grass along the coast have a central role as nurseries for shrimp and a number of fish species. Destruction of these sea-grass beds is bound to affect coastal fishery in affected areas.

The shallow sea bed around Bahrain consists mainly of sea-grass beds (by percentage cover, sea-grass beds represent the major soft and mobile habitat type within a 2-12 meter subtidal zone covering most of the east coast and some parts of the west coast), mixed rocks and sand bottoms. This is especially the case between Muharraq and Manama and around the coast of Sitra where extensive development activities have occurred (14).

Large areas of shallow sea bed have been directly affected by dredging and land reclamation operations, which are expected to continue.

In the coastal areas of Bahrain in particular, sea-grass have a sepcific role. They play host to the juvenile stages of commercially important penaeid shrimp and to several adult fish species such as Siganus spp. Moreover, they provide an important feeding ground for turtles and dugong (14). Mixed rock and sand bottoms provide an extremely wide variety of environments. They form habitats for a large number of organisms including shellfish such as crabs and a variety of fishes such as Moharras, Breams and Goatfish.

In additon to the above impacts, such activity has increased the salinity of groundwater, due to the mixing of sea water with groundwater in the dredged areas. This made groundwater unsuitable for domestic or agricultural uses. Reclamation activities in some of the coastal areas have disconnected naturally existing drainage channels causing the water table to rise. This caused flooding in the low lying areas leading to destruction of coastal vegetation.

The degree of environmental impacts of dredging and reclamation projects discussed above depend greatly on three major factors; (1) characteristics of the area dredged or reclaimed; (2) method of disposal employed and quality of fill material; and (3) type of dredger equipment used. Dredging and reclamation at biologically and commercially important areas will enhance the negative impacts caused by such activities. Choice of disposal method whether unconfined, partly-confined, or confined will determine the degree of destruction of the environment. Moreover, particle size and type of fill material can play a major role in this operation. Type of dredgers

employed whether mechanically operating or hydraulically operating, will also decide the extent of the impacts (15).

The major adverse environmental effects of dredging and land reclamation activities carried out in Bahrain are summarized below:

1. Damage to the spawning grounds of the various marine species that lay their eggs on the bottom.
2. Damage to the sea-grass beds, mangroves and coral reefs.
3. Removal or alteration of the benthos that form the main source of food for many commercial fish species which will result in a reduction of fish catch.
4. Increased turbidity locally irritating or clogging fish gills, interfering with visual feeding and inhibiting photosynthesis.
5. Affect the genral current pattern, water movement and water quality in the area.
6. Increase in siltation due to the outslip of fine sediment, both at the cutter-head of the dredger and at the outfall end of the discharge pipe. Moreover, thick silt layers make problems for fishermen to get out to their fish traps, which cause them to lose their source of income.
7. The discharge of the fine material during dredging operations possibly resulting in the release of toxic compounds previously buried in the sediments.
8. Damage to barrier traps, long lines, pots and other types of nets.
9. Increase the salinity of groundwater.
10. Disconnection of the natural drainage of irrigation water causing damage to vegetation.

These points mentioned above could be used as a checklists in EIA processes employed to identify possible and likely impacts of dredging and reclamation acitivities, and then intergrate them into socio-economic analysis discussed in the following section.

3.2. Socio-Economic Impacts

The main benefit from dredging and land reclamation is to increase land available for housing, industrial, recreational and other purposes. This is gained at a very low monetary cost. The cost of dredging and reclamation is approximately US $0.80 per ft^2 the selling price now of reclamied land ranges from $8.00 to 8.50 per ft^2, which indicates large financial reward (4).

However, no doubt that dredging and reclamation in Bahrain have caused damage of the marine habitats, which has led to the reduction of fish and shrimp catch. Such reduction has been already noticed by local fishermen and many complaints have been sent to concerned governemtnal institutions for the adverse impacts of such operations. The annual statistics report of 1987 (16) shows that the landing of barrier traps, line and hooks have registered a decline of 29.2% and 34.0%, respectively in

1987 compared to 1986. The report also states that this decline in landing of barrier traps is due partially to the reclamation and excavation operations.

The implication of such reduction in fish and shrimp catch is the reduction in the net annual income of fishermen and increase in the number of citizens unemployed. Such a reduction could happen as a result of silting of hadrah and mooring areas of fishing crafts. The implication is made more clear by the fact that the greater part of Bahrain's catch is taken by the thousands of small inshore artisanal boats operating over the shallow reefs, sand flats and sea-grass beds which surround the islands of Bahrain. The landing of this artisanal sector in 1987 showed a decline of 6.5% in comparison to 1986 landing. The total revenue of this sector also showed a decline of 0.8% during the same period.

The government has to find alternative sites to the affected fishermen, or provide suitable compensation for the lost income. Although it is difficult to quantify this lost income at this stage of the research, yet we think the government departments concerned has to formulate appropriate plans to alleviate problems of fishermen. On the other-hand, it is important to mention that although reclamation has caused unemployment for a certain sector of people, it has simultaneously created employment and generated better and easier income for others. Thus, to take appropriate decisions regarding reclamation projects, jobs and income lost due to reclamation must be weighed against employment and income gained (4).

Nevertheless, the problem is not only that is related to income but also the fishing industry itself and an indigenous source of protein may decline. This has serious implications because of the role of the fishing industry in the Bahraini economy. It has been estimated that the industry provide employment for about 4.35 percent of the total working population or 10.5 percent of the indigenous Bahraini working population (4). Another implication of the decline in the fishing industry and reduction in fish catch, is the increase in imported fish in order to meet the rising demand for fish. Fish imports in 1983 made up to 39% of total fish consumption by weight, and it made up to 24.6% of total fish landing in 1987 (16). This has negative implications for the balance of payments of the state. In fact the available statistics does not only show that fish imports are rising, but also that Bahrain is a net looser in this respect. Table 4 shows fish imports and exports for the period 1979-1987. The table clearly indicates that Bahrain is importing more fish than exporting and that this gap is rising, ultimately leading to worse balance of payments.

Year	Imports		Exports		Net Balance	
	Q	V	Q	V	Q	V
1979	940.4	1.00	26.8	0.02	- 913.6	-0.98
1981	1786.3	1.60	232.5	0.13	-1553.8	-1.60
1983	3153.9	2.80	7.4	0.03	-3146.5	-2.77
1986	2931.6	2.30	365.7	0.40	-2565.9	-1.90
1987	3567.6	2.63	787.2	0.85	-2780.4	-1.78

* 1 Bahraini Dinar = US $2.64

Table 4. Fish imports and exports (Q) in metric tons, and their value (V) in Million Bahraini Dinars* for the period 1979-1987

Reclamation and dredging has seriously affected the groundwater resources of the island, these have blocked the natural agricultural drains leading to rising water-tables, intrusion of sea water and increasing salinity of agricultural soils and the ground water itself. In many areas groundwater is no longer suitable for domestic or agricultural use. This will not only affect the population and its distribution, but also the agricultural activities and its output. In fact it is common to observe an increasing number of dead palm-date trees along the coastline. The effect on agriculture will not only reduce the income of farmers but may also influence the agricultural activities, which will affect large sectors of the population. Additionally, this may lower and reduce indigenous food production leading to increased food imports with serious implications for the balance of payments and the national food security.

Another effect of reclamation and dredging is its impacts on the tourism industry. These activities affect the recreational beaches rendering them unfit for that purpose. At the state level tourism is becoming an important source of income and it is putting more efforts to enchance it. On the other-hand, reclamation in some areas has created attractive beaches for recreational purposes.

Although the selling price of reclaimed land is very high compared to the financial cost of dredging and reclamation, yet we beleive that not all economic, social and environmental costs have been taken into consideration. If account of these was made, the situation would have been much different, and probably less reclamation activities would have taken place. Figure (2) summarizes socio-economic effects of dredging and reclamation activities in Bahrain.

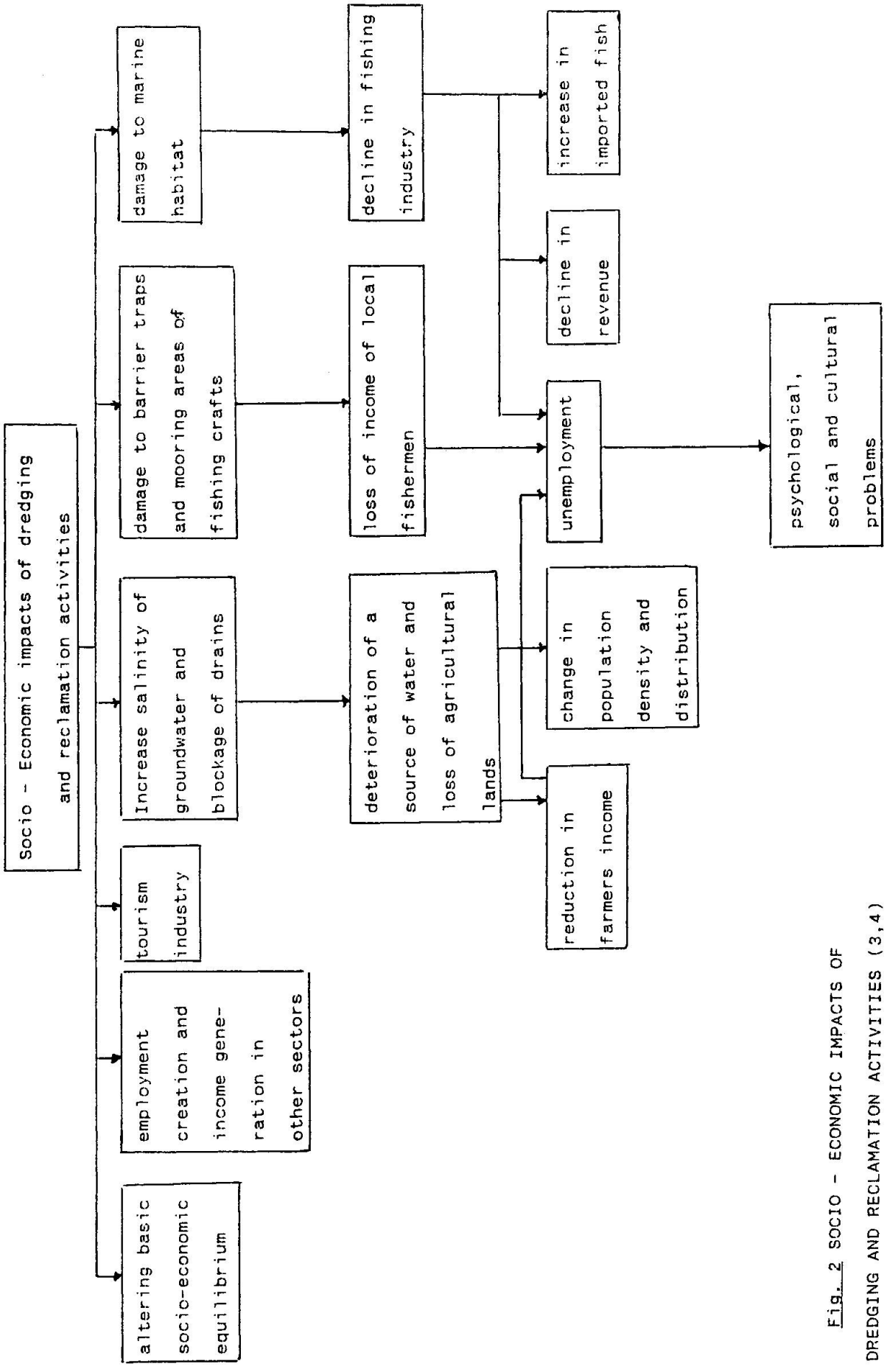

Fig. 2 SOCIO - ECONOMIC IMPACTS OF DREDGING AND RECLAMATION ACTIVITIES (3,4)

4. TOWARDS INTEGRATED ENVIRONMENTAL PLANNING

Our analysis has indicated that environmental impacts should be taken into consideration among other factors when assessing dredging and reclamation projects. To achieve such integration, it is important to integrate environmental impacts of the proposed activities at initial or conceptual stages of project planning. Figure (3) presents projects planning stages in an integrated model (4). The model is self-explanatory and it has been proposed here to facilitate integration of various aspects of the environment, ecological systems, resource management as well as negative and positive environmental impacts Also, it suggests the inclusion of public attitudes in the planning stages, since this is usually neglected.

However, there are problems and difficulties in quantification of certain type of environmental impacts and assigning monetary values to them. This indicates the difficulty in applying traditional cost-benefit analysis in the case of environmental impacts, and usefulness of other EIA techniques.

Once the project has passed the planning stages it will go for the implementation stage. This is followed by monitoring, auditing and evaluation. In doing so environmental impacts, and public opinion are taken into consideration at the initial stages of project planning and its duration. To achieve such an integration it is essential to formulate policies, legislations and create appropriate institutions.

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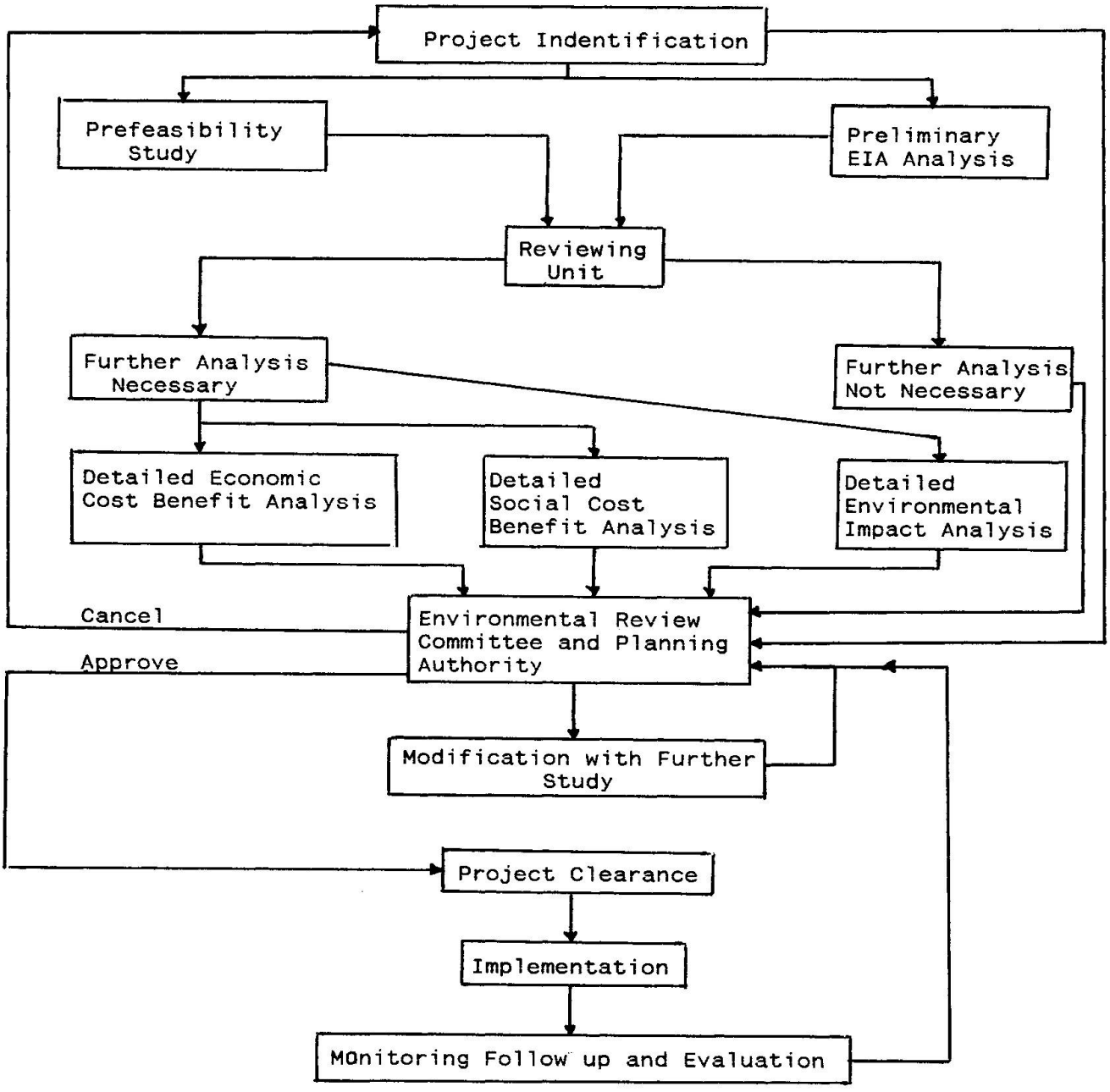

Fig. 3 Project planning stages (4)
(An intergrated model)

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