RECLAIMING THE COAST FOR SUSTAINABLE DEVELOPMENT LESSONS FROM ARABIA

Timothy W. Kana, PhD, President
Coastal Science & Engineering LLC
PO Box 8056 Columbia South Carolina 29202 USA
e-mail: tkana@coastalscience.com

Abstract

This paper presents historical trends in waterfront alterations and reclamations in the Arabian Gulf region. It describes a cycle linked to the exploitation of oil that can be characterized by three periods: first, *uncontrolled growth* (1950s & 1960s in some countries), then *redesign* (1970s and 1980s), followed by the present period of *unplanned problems*. Examples from Kuwait illustrate how some nations have attempted to reclaim the coast for sustainable development – that is, alter the shoreline further and restore habitat or the natural character and functioning of the area. Issues of concern discussed herein include management of stormwater, marina design, beach design, shore protection, preservation of habitat, estuarine flushing, water quality, and dredging. Lessons learned from these cases and others abroad suggest that six steps are required for sustainable coastal development: (1) Maintain accurate inventories of the coastal zone, (2) perform a critical examination of site-specific problems, (3) determine critical linkages among various water-dependent uses, (4) identify and prioritize water-dependent uses important to the nation, (5) establish laws and regulations that prevent uncontrolled growth and enforce them, and 6) communicate the plan for sustainable development to all citizens.

Introduction

The countries of the Middle East have a longstanding connection to the sea. It is a source for sustenance, commerce, transportation and recreation. Extraordinary development followed the discovery and exploitation of oil in the 20th century. Within one generation, small fishing villages were turned into major ports. Beaches and nearshore reefs, on which earlier ways of life revolved, were lost to development. Pollution increased with industry and growing populations.

Yet, the source of wealth for much of Arabia is also becoming a means to reclaim the coast. Remarkable projects have been completed along the waterfronts of Kuwait, the Emirates, Saudi Arabia and Qatar, to name a few countries. These projects have revitalized shorelines, provided waterfront parks that attract people back to the sea, and built artificial beaches where natural ones were lost to earlier development. The emphasis has been on water-dependent recreation (including marinas, beaches and parks) and fish markets where people can once again select their dinner right off the boat.

While projects like the 20-km Kuwait Waterfront Project have received praise from around the world, truly sustainable coastal development should strive to balance the artificial and commercial with the natural. The character of many nations derives from its coastal setting, its geology and geomorphology, and its peoples' interactions with the sea. Truly sustainable development cannot be wholly dependent on artificial manipulations of shorelines, nor on total preservation of natural areas.

This paper discusses trends in shoreline reclamation and draws on several case examples to show the range of issues that must be considered for truly sustainable development. It is by no means an exhaustive review of land reclamation practice. Further, it is admittedly biased by the author's personal experience which has been focused on Kuwait projects during the past three decades. Nevertheless, lessons learned from these examples are applicable in countries throughout the Middle East. The issues of concern – declining water quality, fisheries depletion, coastal erosion, oil spills, nutrient loading, etc. – are common to all nations bordering the sea because the tide exports them without regard to political boundaries.

Historical Trends

During the first half of the 20th century, Arabia's connections with the sea were not unlike those of the prior centuries. The harsh climate of the area (and lack of air conditioning) had limited growth of development and population. Trading, fishing, recreation, and waste disposal all made use of the sea. A view of the coastal zone in the 1920s shows scattered seaport towns separated by long reaches of undeveloped shoreline. Ports were small and catered to trading dhows and the periodic coastal freighter. With much of the coast undisturbed, it was possible to have small ports without any organized sanitation, yet avoid many of the chronic water quality problems associated with modern-day pollution.

To rephrase Professor Donald Pritchard of The Johns Hopkins University (1967) the solution to pollution *used to be* dilution. Tides in the Arabian Gulf or the open sea were sufficient to exchange the water frequently and disperse pollution so that it did not overload the system. Compare that with today. The Arabian Gulf has had to absorb numerous oil spills (Hayes et al 1993). Recent fish kills have left millions of tonnes stranded on the shoreline (Glibert et al 2001, in review). And in some places, coastal development extends for 100 kilometers without a break, eliminating most of the natural character of the land.

By the 1950s, oil discoveries that predated World War II were exploited. This drove demand for bigger port facilities. The port of Al Ahmadi in Kuwait illustrates the need. Serving the world's largest single oil field – *Burgan*, Al Ahmadi became a transhipment center. Small tankers in the early days moored at the end of long piers built into the Arabian Gulf. Oil flowed downhill under the enormous pressure of the field directly into cargo holds. Later, as the size of tankers increased, deeper navigation depths were required. At Ahmadi (rather than deepening the port), submerged pipelines were extended offshore to deeper water. Mooring buoys and platforms were installed to accommodate super tankers.

The story of coastal reclamation in Arabia began with the development of oil production facilities. Oil drove the need. It provided the wealth. And it made possible all that has happened since for many countries around the Gulf.

Cycle of Redevelopment

From the perspective of the last fifty years or so, it seems countries that prospered from the oil boom experienced a cycle of redevelopment that contained both good and bad aspects. Kuwait can be used to illustrate this. While the time periods will vary from country to

country in relation to the date of oil production, Kuwait's experience has parallels elsewhere.

Money from oil fueled an initial development boom. Coastal cities drew an immigrant population of oil workers that required housing and infrastructure. The old walled cities such as Kuwait's capital were expanded outward from the core. Old buildings and the compounds of longtime residents were razed to make way for apartments, office buildings, and boulevards. The improvements often involved land reclamation along the coast. Rubble from historical sites was bulldozed into the sea, obliterating the natural character of the shoreline. Beaches were buried. The outcroppings of limestone in the intertidal zone were excavated and used for building materials or shore protection. In Kuwait, this first part of the cycle occurred in the 1950s and 1960s. The first period could be characterized as one of *uncontrolled growth.*

By the 1970s in Kuwait, there was demand for renewal of existing development and a desire for more sophisticated design. Many buildings that had gone up quickly in the 1950s were, themselves, deteriorating. As it turned out, materials and designs recommended by foreign architects, and workmanship by contractors from the early days were often not as durable (physically as well as aesthetically) as the people of Kuwait desired. The oil pricing structure became more equitable for Middle East producers in the 1970s. This provided the financing for more ambitious redevelopment projects.

With the national wealth increasing several-fold in just a couple of years, Kuwait and its counterparts in the Gulf region had the means to rebuild again. This time, the lessons of the 1950s were applied in better design and construction. Emphasis was still on development and there was a lot of experimentation with design. In hindsight, the quality improved, some of the most innovative waterfront designs evolved and certain features of original shorelines were reclaimed. During this second period of *redesign* in the cycle, the emphasis in waterfront improvements was on recreation and access. Waterfront parks, such as Kuwait City's, reclaimed the edge of the sea and attracted people back to areas that were dumps of rubble just a few years before.

Waterfront master plans of the 1970s and 1980s established blueprints for redevelopment that continue to be implemented around the Gulf. They have successfully integrated multiple uses ranging from fish markets to fisheries research centers, from recreation to restaurants, from marinas to museums. Perhaps most importantly, they have brought people of Arabia back to the seacoast.

The most successful waterfronts are considered to be those that involved planning for extended reaches. This allows integration of multiple uses while not favoring the biggest and best use (which invariably involves industry or high density development at the expense of passive recreation areas and nature preserves).

A problem today is that extended sections of some coasts are not readily available for integrated planning or modification of existing land use. Private ownership (or occupancy) of some areas such as Kuwait's entire south coast has eliminated nearly all undisturbed areas. Chalets hug the shoreline and have reduced access, just as the earlier oil facilities have done. Where development setbacks from the sea are inadequate, individuals have built shore protection structures without a coordinated plan with their neighbors. In some ways the present period, which could be termed one of *unplanned problems,* mirrors the

experience in western countries. Increased affluence of the citizens of many Gulf countries is driving demand for vacation homes, marinas, and other waterfront amenities. As in America, this unplanned growth has introduced a new set of problems.

Defining the Problem

The title of this paper suggests two fundamental questions. What needs to be reclaimed? And, What constitutes sustainable development? There are no simple answers to these questions because there are so many variables. Yet, every nation needs a systematic way to evaluate the problem of unplanned growth and develop a vision for the future. Let's look at the second question first. What is sustainable development? Clark (1996, p. 659) defines it as follows:

> ***Sustainable development*** *- Development that ensures the continuance of natural resource productivity and a high level of environmental quality, thereby providing for economic growth to meet the needs of the present without compromising the needs of future generations.*

In the 1960s, the technique of *carrying capacity analysis* was introduced as a means of quantifying how much of a particular land use could be sustained in a given area. Oftentimes, there wasn't enough information to make accurate judgements, particularly in the coastal zone. Shepherds have long had a sense for how many sheep the desert can support. But what of fisheries, or chronic spills of oil? We generally lack experience in these areas that can be extrapolated into the future or used to define acceptable levels of impact. Just as often, we assume that the ocean in its vastness can absorb the occasional oil spill, or continue replacing the fish stocks depleted by coastal fisherman.

Only in recent decades have we begun to realize that sustainable development requires preservation of breeding habitat – e.g., coral reefs for many fish species of the Gulf (Carpenter et al 1997), intertidal flats for the amphibian mud skipper (Family *Gobidae*), or stable beaches for nesting sea turtles.

Sustainable development depends on maintenance of water quality within parameter ranges that do not create system overloads. Excessive release of nutrients associated with coastal development can trigger algal blooms which, in turn, increase BOD. In worst cases, dissolved oxygen levels plunge below levels required to sustain life in the marine environment. Dying organisms further increase the BOD producing a downward spiral of local ecosystems. Fortunately, nature is quite resilient and has a marvelous capacity to correct mistakes (Easterbrook 1995). In the meantime, though, fisheries have to be closed, markets shut down, and people have to live with the consequences. Kuwait's experience last summer with it's largest fish kill in history is a clear message that some part of the system exceeded its carrying capacity (Glibert et al 2001).

Although the question of what constitutes sustainable development has no firm answers, it can be evaluated rationally. Parameters can be established and monitoring put in place to track their range. We know from experience that water quality monitoring can identify periods when problems are more likely to occur - for example during hot summer months, low tide-range conditions, or periods of low wind and wave conditions. In short, times when water circulation diminishes. We know that concentration of organisms in small

areas (fish in pens, or people in apartments) increases the potential for excess nutrient loading.

The question of what needs to be reclaimed is more difficult. This is as much a political question as a technical question. Any answer must necessarily reflect the special conditions of the area. The climate and geology of Arabia cannot be converted to that of northwestern Canada anymore than Sweden can create a Caribbean reef environment along its shores. But each site has unique features and habitats on which their local ecosystems are based. These site specific features and habitats constitute the essence of what should be preserved and conserved, *or reclaimed,* if they've been lost.

Coastal development does not necessarily preclude preservation of natural systems. But clearly there will be conflicts between the two. How then, do the people of a nation go about resolving these conflicts and establishing a vision for their coastal zone? Several case examples from Kuwait illustrate how this has been considered.

Kuwait Waterfront Project

A large team of local and international designers have been involved in the masterplan for the 20 km Kuwait Waterfront Project (KWF). Consisting of six phases, four of which are complete, the KWF encompasses, marinas, fish market, commercial centers, artificial beaches, an artificial island and extensive parks along Kuwait City's original waterfront (Figure 1). Under lead architect, Sasaki Associates (Boston), the KWF was an integrated plan to restore some of the original character of the waterfront while accommodating the growing urban population. By the time planning began in the mid 1970s, most of the waterfront had been degraded as a result of earlier land reclamation and debris disposal. While some remnants of original beach and dunes remained, most of the edge consisted of rubble and debris, beach-rock revetments quarried from the adjacent tidal flats, or boat basins for trading dhows, fishing dhows or recreational boating.

The Sasaki (1979) masterplan sought to replace derelict areas with public parks, stable beaches, seaside restaurants, fishing piers and related amenities. It's scope was ambitious, innovative and costly. Yet by nearly any standard, it has already accomplished its primary goal of reclaiming the coast for the people of Kuwait. Access is extraordinary. Landscaping, while artificial, has strived to incorporate native plants and water conservation measures. On the whole, it has softened the interface between the land and the sea, not to its original condition, but to one that creates a blend of rocky habitat, sandy beaches and long vistas unbroken by large buildings.

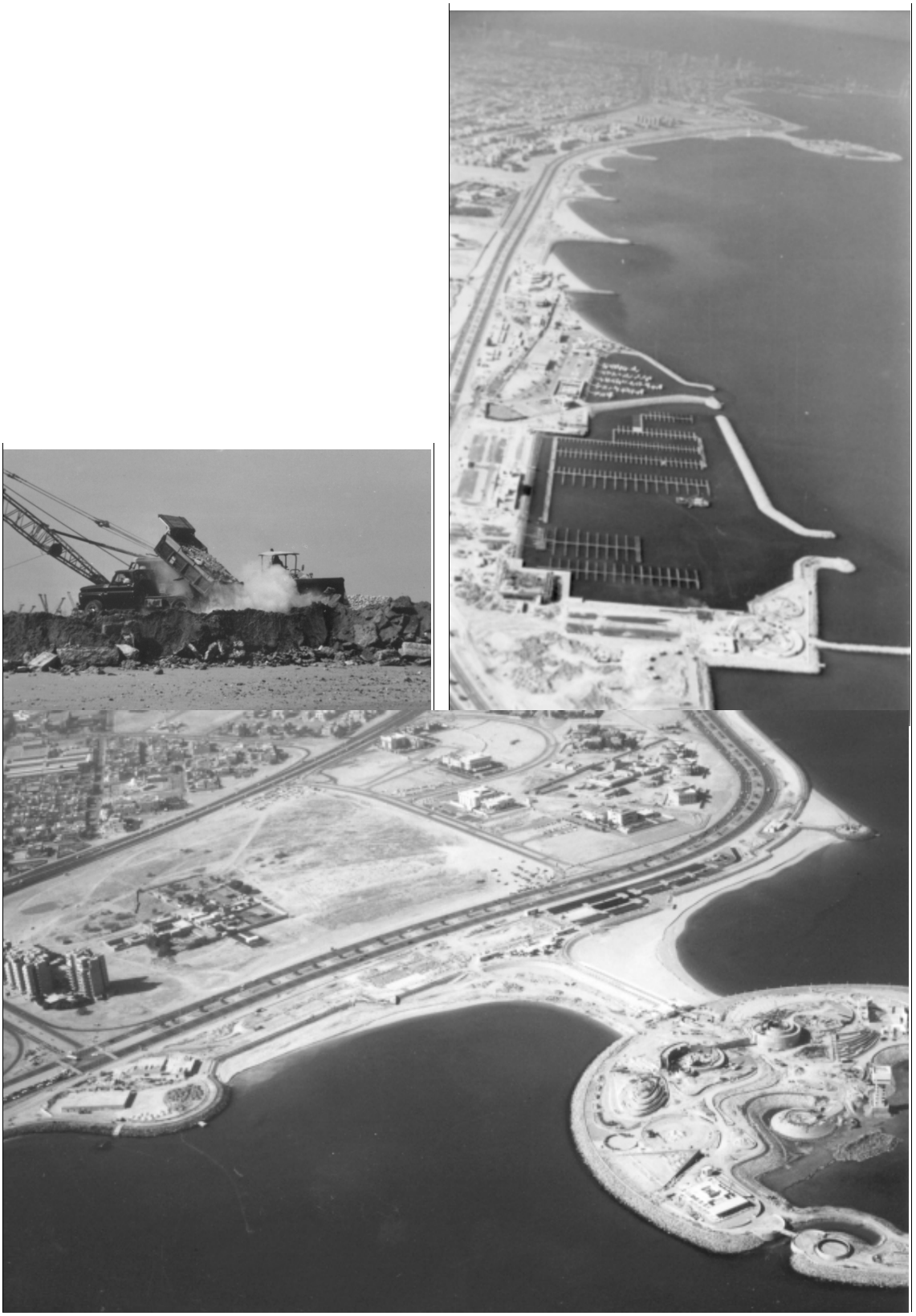

FIGURE 1. The Kuwait Waterfront Project involved restoration of beaches, construction of marinas, a "tombolo" island, and other park features along a 20-kilometer shoreline fronting Kuwait Bay. Early reclamation practice had degraded the shoreline by dumping debris. Photos by the author.

Following are some of the important environmental and quality of life issues addressed in the KWF (Al Sarawi et al 1987).

Stormwater and Runoff - The plan consolidated hundreds of small drain pipes into a network of more widely spaced outfalls and extended discharges further into the sea for more rapid dilution. The outfalls doubled as sand retaining structures for artificial beaches. Combined with improvements in the sewer collection and treatment systems, the problem of pollution from urban runoff, including erosion of debris and garbage previously dumped along the edge has been minimized. Coliform bacteria counts remain a problem in Kuwait Bay, but are believed to be independent of construction activities and changes associated with the KWF. There is anecdotal evidence of fewer algal blooms in the nearshore zone of the KWF.

Marina Design - Two large marinas and a basin for local fishing craft have been constructed along the waterfront. Unlike earlier marinas dating from the 1960s which were designed with single narrow entrances, the KWF yacht basins and fishing harbors generally incorporate dual entrances modeled after traditional harbors, or include a 2nd flushing channel to promote water circulation. This has mitigated to a large extent problems of stagnation in the far reaches of the marinas. The KWF has always had an advantage for flushing because of the 3-4 meter tide range in Kuwait Bay. Nevertheless, good management practices have been incorporated into the design to reduce adverse impacts normally associated with marinas.

Beach Design - The KWF so far has restored about 10 artificial beaches upwards of 500 meters long seaward of rubble edges. Beaches have been feasible where nearshore slopes were gentle and depths relatively shallow. Because of so many interruptions in longshore transport by existing structures, the restored beaches were designed as oriented planforms, bounded by outfall jetties, promenades and harbor breakwaters (RPI 979; Hayes et al 1986). Beach quality sand was imported from inland sites by truck to provide a more stable profile than dune sands and reduce turbidity and resuspension in the surf zone (Figure 2). The beaches were oriented into the predominant wave direction to minimize sand losses. None have required renourishment since completion.

FIGURE 2. Oriented beaches were designed to be retained by "groins," outfalls that doubled as promenades. Beach-quality sand was imported from inland sites and spread to the design shape.

Artificial Island - One of the more unusual design elements of the KWF was a 400 meter diameter artificial island. Its purpose was to create a focal point along the 10-km eastern half of the KWF (Sasaki 1979). Called Green Island after its plan to create a lush

landscape in the sea, the island concept was abandoned after it was demonstrated that littoral sands would accumulate in the lee of the feature and ultimately choke off flow between the island and the mainland. Instead, the redesign took this natural process into account and built beaches to the island modeled after natural "tombolos." In this way, the design provided more recreational beach area while mimicking a geologic coastal feature. Unfortunately, such depositional features in nature accumulate drifting debris. In an urban setting like the KWF, the debris in Kuwait Bay has not always been desirable.

Shore Protection - Much of the KWF was built on land reclaimed in the previous few decades. The first reclamation had extended the land into deeper water and created the situation where chronic erosion occurred in the fill. Waves and tidal currents continually shifted the material, exposing jagged steel reinforcing, bricks and garbage. High waves overtopped the fill and left standing water on the adjacent highway. These problems were corrected by building wave absorbing revetments in places where depths precluded restoration of beaches, and installing filter cloth and other barriers to prevent leaching of solids through the structures. Much of the armorstone for the KWF was imported by barge from Oman. Artificial armor units were also produced on site and used where wave energy was greatest and the cost of natural stone prohibitive.

Kuwait Pearls Concept Plans

During the past decade, even more ambitious waterfront alterations have been proposed for sites along Kuwait's shoreline. Fortunately for the environment they have not moved very far from the drawing boards. One scheme, for example, called for a huge barrier breakwater to encircle most of the KWF and create a lagoon between the shore and the outer barrier. Islands for development would be built in what is presently the open water of Kuwait Bay. Tides would be controlled at entrances to reduce the changes in water levels inside the lagoon. Aside from the cost, schemes like this work against the natural setting. They create conditions where runoff and nutrients are trapped, BOD levels increase, DO fluctuates more and infrastructure maintenance is exorbitantly expensive.

One of the concepts that has moved further along in planning is Al-Khiran Pearl City (Figure 3). The La'ala' Al Kuwait Real Estate Company (1987), in responding to local demand for chalets at the coast, proposed a number of plans involving excavation of lagoons into the dessert. This has been done in other Gulf countries, including Saudi Arabia. Rather than building into the sea, the basic idea is to bring the sea into the land. Converting land to lagoons is generally less costly because excavations (usually the single biggest expense) can be performed by land-based equipment. Further, the excavations can be used as fill for nearby development sites.

The scale of proposed Pearl City dwarfs most developments of this type. At nearly 7 square kilometers, it would create about 1500 hectares of canals and 15,000 residential lots. The proposed site is situated close to the border with Saudi Arabia in the Al Khiran estuary. Al Khiran presently consists of two small tidal estuaries – Khor Al-Ama and Khor Al-Mufatteh – that are unique environments in Kuwait. They are hypersaline tributaries bounded by fringing salt marsh and sabkha, a transition zone of supratidal flats. The sabkha is commonly a calcareous deposit with lesser amounts of quartz and evaporitic minerals such as gypsum. Situated at elevations above the marsh near the highest

astronomic tides, they flood infrequently but leave standing water. Deposits form as water evaporates leaving a surface of salts that inhibit vegetative growth.

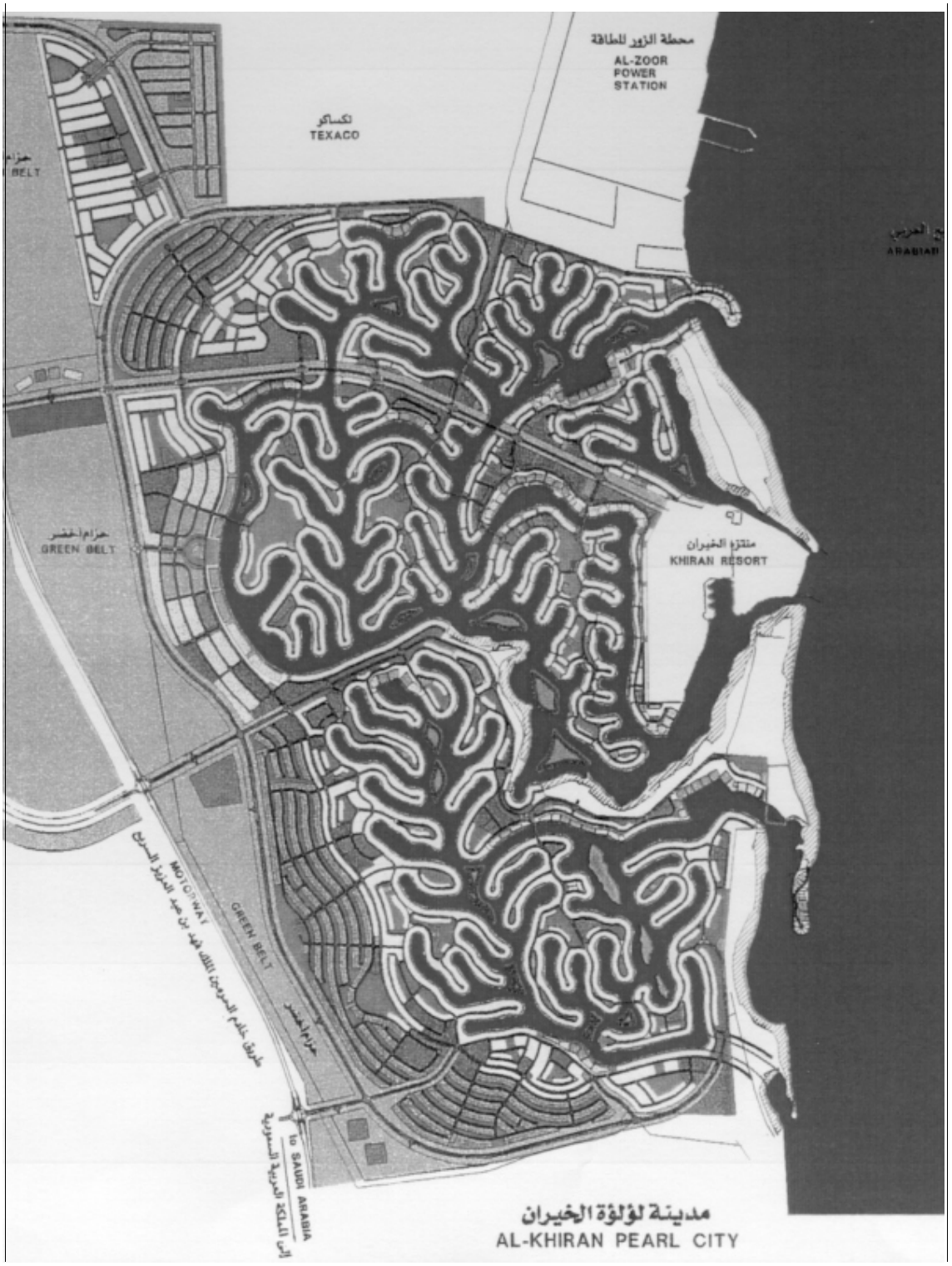

FIGURE 3. Concept plan for Al-Khiran Pearl City along the southern coast of Kuwait. The proposed development encompasses about 7 square kilometers. [Courtesy of Kuwait Real Estate Co]

Al Khiran estuary is an unique environment in Kuwait and home to shorebirds and mammals adapted to the area. The natural drainage is a simple dendritic pattern with channels increasing in width and depth toward the sea. While the estuarine basin exceeds 500 hectares, the normal area of open water is a tiny fraction of that value. The two entrance channels are less than 50 meters wide, 1 meter deep at low tide and handle tidal prisms of the order 100,000 cubic meters (Kana et al 1986). The issues of concern for development in areas such as Al Khiran include the following.

Preservation of Unique Habitat - Natural features that are rare within a nation's borders automatically command attention by virtue of their uniqueness. If such features also provide habitat that enhances biological diversity for the area, they should be preserved. Contrary to conventional wisdom, preservation need not imply no alteration, particularly if the unique habitat is disappearing rapidly as a result of natural processes such as sedimentation. There are demonstrated ways to increase desirable habitat by artificial means.

Providing Adequate Flushing and Water Circulation - Stagnant flows result when the rate of tidal exchange diminishes. Dead-end canals, multiple channels, and basins deeper than entrance channels have a greater chance of producing low velocity zones. Slower water exchange increases flushing time in estuaries. This leads to buildup of pollutants, higher temperature, salinity and DO ranges, and increased tendency for anaerobic conditions. Flushing and water circulation are enhanced by maintaining positive gradients in channel size and depth from the headwaters to the sea, or by providing large expanses of open water over which wind-driven circulation can increase mixing.

Erosion Control and Channel Stability - Artificial lagoons built into the land produce tidal flows through channels and inlets. Velocities are highest at the entrance channel and anywhere constrictions occur upstream. Bank stabilization is often required in high velocity areas. At entrance channels, littoral flows will be interrupted and the pattern and rate of erosion and deposition along adjacent beaches must be anticipated in the design. A common problem with artificial lagoons is their basin areas tend to be small and the tidal prism is likewise small, providing insufficient flows to maintain a stable entrance channel. Littoral transport tends to infill the entrance and inhibit navigation. Multiple inlets exacerbate these problems.

The concept plan shown in Figure 3 fails to adequately address the above issues. It would eliminate the sabhka, and increase the area of the waterway by more than 25 times. It would add two new inlets and produce a complex maze of canals. While designed to maximize the length of shoreline along which chalets may be placed, the plan violates certain basic rules of estuarine circulation and flushing:

1) It creates many low velocity points where tidal exchange would likely be insufficient for circulation. This becomes more critical in hypersaline environments like the Gulf where stagnant conditions lead to overheating of the water column.

2) It does not produce a dendritic pattern of tributaries having naturally increasing cross sections from the head of each tributary to the mouth of the waterway.

3) It does not create broad waterways over which wind driven circulation can enhance flushing or wave action can help maintain desirable DO ranges.

4) There is not likely to be sufficient tidal prism to maintain four separate inlets without frequent maintenance dredging in one or more of them.

5) The plan would result in elimination of the only salt marsh along the southern half of Kuwait.

With major modifications to Pearl City, it may be possible to accomplish a viable lagoon development in Kuwait's desert. As attractive as waterfront living can be, however, such plans must be suited to the local climate, and hydrographic regime. If not, stagnant water and anaerobic conditions will produce an environment that discourages people from settling permanently.

Sulaibikhat Bay

Sulaibikhat Bay is a broad embayment east of Kuwait City with little development around its 12 km margin. It is semi-enclosed by Doha spit along its north shoreline. Situated near the head of Kuwait Bay, tide range reaches 4 meters creating a broad intertidal zone extending several kilometers offshore. Mud flats that dominate along the shoreline, make this area less attractive for beach recreation but highly attractive to birds and other wildlife that forage on the tidal flats. The western shoreline is adjacent to one of Kuwait's premier bird sanctuaries. The bay is also home to the bou jalambo, local name for the unusual amphibian mud skipper.

For a number of years the Municipality of Kuwait City has been considering proposals for revitalization of the Sulaibikhat Bay shoreline. The south shoreline, in particular has been degraded by construction debris dumped along the edge. The Gulf Highway that bounds the south edge separates an existing residential neighborhood from the site. The hope has been that a commercial development can provide the impetus for the revitalization and subsidize enhancement of the wildlife preserve. Issues of concern are similar to those of the KWF as well as several others including the following.

Development Around A Wildlife Sanctuary - The existing bird sanctuary along the west margin of the site is a national treasure that should be preserved. Such preserves generally require broad buffers around their margins. The transition zone between sanctuary and development can be used for passive recreation (nature trails, wildlife viewing areas and boardwalks), or research facilities related to the studies and management of the particular habitat. Certain development activities should be discouraged adjacent to wildlife sanctuaries, including industrial plants that maintain disposal lagoons, or discharge chemicals (even in low concentrations) directly in adjacent waterways. Commercial development that generates excessive noise (e.g. shooting ranges, motor sports, etc.) should be kept some distance away from these areas.

Tides and Dredging - The high tide range of the setting provides only short periods of time during which the water's edge is close to high ground. High-tide beaches tend to be narrow and unsuitable for bathing. In this setting, portions of the site encompass broad expanses of fringing marsh near the high tide line. Tide range and the dominance of mud flats and fringing marsh constrain any development plan for the area. For example, excavation of channels along the margin of the bay to accommodate boats or provide full tidal cycle swimming are not feasible. High suspended sediment loads originating from

resuspension of muds in the bay, and wave action along the shoreline would quickly shoal such channels.

The Sulaibikhat Bay example suggests that some sites have so many natural constraints that it is unlikely a commercial developer will have the resources or incentive to make improvements that do not provide a reasonable return on the investment. Of the 12 km of shoreline being considered, perhaps only 15 -25% are suitable for commercial development. If the goal, however, is to restore nearly half the shoreline to a more natural configuration by the removal of debris and reshaping of the edge, it may be preferable for the government to assume the lead and control the outcome.

Lessons Learned

The few case examples given above illustrate a range of coastal zone planning issues that are typical for the region. They do not list all the problems that need to be considered, by any means. However, they provide lessons that can be applied in other places.

It should be apparent from Kuwait's experience that early manipulations of the coast during the 1950s and 1960s especially, have generated a need for more alterations. Future alterations as the KWF project implies are tending to moving toward restoration. In some cases, artificial beaches are "reclaiming the coast". In others, habitats are being protected from development and increased artificially. Just how much of the natural character can be reclaimed and sustained into the future is uncertain. And despite some demonstrated successes, there are still schemes proposed that violate basic rules for development in the coastal zone.

Worldwide experience with coastal zone management suggests each nation should follow a series of steps that help determine what is needed to sustain development along the coast. The overriding goal should be to strike a balance between necessary exploitation and preservation of the natural features that define the character of the setting.

1) **Maintain accurate inventories of the coastal zone**. Natural features, geology and habitats should be documented. Resource atlases, similar to those prepared for oil spill response (e.g., Al Sarawi et al 1985), are a useful starting point. Inventories should identify land use and related activities, and include lists of national needs (strategic, commercial, recreational, etc.). Systematic monitoring of coastal development, coastal erosion, water quality and related parameters should be performed regularly so that trends can be tracked and analyzed.

2) **Perform a critical examination of site-specific problems.** The list of potential problems in the coastal zone is long. However, the severity of each problem is highly site specific, and often focused around a select group of users (stakeholders). Some problems tend to demand attention, whereas others are less consequential. It is important to quantify the extent of each problem. For example, what is the rate of erosion? What are the levels of coliform bacteria or heavy metals in the water column? How much has the annual catch of fish declined? How long is the wait for berths in the port each year?

3) **Determine critical linkages among various water-dependent uses** - The coastal zone is a linked system whereby an action of one sort has the potential to impact another part of the coastal zone. Discharge of nutrients by industry or a treatment plant may adversely impact nearshore reefs. Elimination of reef habitat may adversely impact local fisheries. On the other hand, construction of breakwaters for a port may provide additional rocky habitat and attract more fish to the area. Not all development impacts in the coastal zone are bad. By the same token, artificial reclamations are sometimes not as ecologically successful as the natural features on which they were based.

4) **Identify and prioritize water-dependent uses important to the nation.** Every coastal nation has opportunities to use the coastal zone for the benefit of its people. The vision of each nation first depends on clear identification of the uses that are necessary, achievable and desirable, and of the natural features that should be protected. This requires input from all stakeholders, whether they are government officials, scientists, property owners, environmentalists, fisherman or concerned citizens. This is perhaps the most difficult step to take because it requires consensus. Preservationist must compromise with developers, port officials must share space and resources with fisherman. Some balance appropriate to the nation must be struck among disparate parties.

5) **Establish laws and regulations that prevent uncontrolled growth and enforce them.** Because the coastal zone is a communal resource, it cannot be owned or controlled by single individuals. Instead the collective wisdom of a nation must be applied to the formulation of laws and regulations that foster good management and penalize bad practices. Two common sense questions should be asked of any proposal for development in the coastal zone. Is the proposed activity water dependent? Will the activity deplete coastal resources? Once CZM laws are established, they need to be enforced.

6) **Communicate the plan for sustainable coastal development**. CZM plans are never perfect and, from time to time, they need to be updated. But no plan is worse than some plan. The more successful plans are continually used by government officials as a blueprint for coastal development and protection. They are shared with the citizens, often enlisting support from individual property owners for further communication of the plan. The plan in one sense is a vision of what a nation's coast can be in the future. In another sense, it is a practical guide for safeguarding the coastal assets of the state. It is updated periodically by repeating the first five steps, reevaluating the needs of a country, and adopting new technologies that render older methods of protection obsolete.

In short, reclaiming the coast for sustainable development starts with six steps.

Inventory Conditions – Identify Problems – Determine Linkages –
Set Priorities – Establish CZM Laws – Communicate Plans.

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References Cited

Al-Sarawi, M., E.R. Gundlach, and B.J. Baca. 1985. *Kuwait: An Atlas of Shoreline Types and Resources*. Kuwait Foundation for the Advancement of Science, 49 pp + 11 maps.

Al-Sarawi, M., A.H. Bu-Olayan, M. Ghannoum, T.W. Kana, B.J. Baca, and S.J. Siah. 1987. Assessment of coastal dynamics and water quality changes associated with the Kuwait waterfront project. Final Rept. for Environment Protection Council; Faculty of Science, Kuwait Univ., with assistance by Coastal Science & Engineering, Inc. (CSE), Columbia, SC, 197 pp. + appendices.

Carpenter, K.E., et al. 1997. *The Corals and Coral Reef Fishes of Kuwait*. Kuwait Inst for Scientific Research, Safat, Kuwait, 166 pp.

Clark, J.R. 1996. *Coastal Zone Management Handbook*. CRC Press Inc., Lewis Publishers, Boca Raton, FL, 694 pp.

Easterbrook, G. 1995. *A Moment on Earth*. Viking Press, New York, 745 pp.

Glibert, P, J Evans, and J Landsberg. 2001. The 2001 fish kill in Kuwait Bay: questions, causes, commentary. Report prepared for Environment Public Authority, Kuwait. Univ. Maryland Center for Environmental Science, Cambridge, MD, 69 pp.

Hayes, M.O., et al. 1993. Distribution and weathering of shoreline oil one year after the Gulf War oil spill. Marine Pollution Bulletin, Vol 27, pp 135-142.

Kana, T.W., B.J. Baca, and S.J. Siah. 1986. Chalets at Dubaiyeh, environmental impact and coastal engineering studies. Final Rept. to Kuwaiti Engineers Office; CSE, Columbia, SC, 102 pp. + appendices.

Kuwait Real Estate Company. 1997. Al-Khiran Pearl City. Technical Report, prepared by Al Shaheen Consultants and Buro Happold Consulting Engineers, Ltd., Kuwait, 99 pp.

Pritchard, D.W. 1967. Observations of circulation in coastal plain estuaries. In Lauff (ed), *Estuaries*, Amer. Assoc. for Advancement of Science (AAAS), pp 37-45.

RPI. 1979. *Kuwait Waterfront Project, Final Report on Coastal Studies*. Prepared for Sasaki Associates Inc., Watertown, MA. Research Planning Institute, Inc., Columbia, SC, 105 pp + appendices.

Sasaki. 1979. Master plan, final report Kuwait Waterfront Project. Prepared for Municipality of Kuwait. Sasaki Associates, Inc., Boston, MA, 85 pp + appendices.

[**REFERENCE:** Kana, TW. 2002. Reclaiming the coast for sustainable development: lessons from Arabia. In Proc Intl Conf on Coastal Zone Management & Development (Al-Sarawi and Al-Obaid, eds), 18-20 March 2002, Environment Public Authority, State of Kuwait, pp III-1 to III-14.]