

Environmental Evaluation of the Master Plan for Al-Subiya New City, Kuwait

Ahmed M. Al-Hasem^{*}

Abstract: The master plan for Al-Subiya new city is based on socio-economic perspectives with very limited consideration of the area's physical and biological environment. From the preliminary evaluation, undesirable environmental impacts are expected in the future if the current master plan is chosen. In general, these impacts will result from changes to the hydrodynamic regime, the intertidal flats, the effect of future sea level rises as a result of global warming and the non-environmental location of the industrial area.

Key words: Al-Subiya new city, Tidal channel, Intertidal flat, Hydrodynamic regime, Future sea level rises.

Introduction

The State of Kuwait is a marine state bordered by the Arabian Gulf to the east with about 290 km. of coastline. Almost all urban, commercial, industrial and recreational activities are centered on or near the coast. Its population has grown rapidly within a few decades, increasing about fifteen times from 206,473 in 1957 to about 3 million in 2006. The high rate of growth is mainly a result of immigration into Kuwait to meet labour force demands. Additionally, the growing Kuwaiti population of young people suggests there will be a major demand for housing and jobs in the future.

The urban area of Kuwait, most of which lies within 20 km. of the coast, has also increased markedly over recent decades (Fig. 1). Hence, there is extensive pressure on the coast as it is now the site of residential and business uses, port facilities, oil support industries and recreational

^{*} Geography Department, College of Social Sciences, Kuwait University, Kuwait.

facilities. Because of this pressure and the country's rapid population growth, the Kuwaiti government is planning to develop new cities on the northern and southern coasts.

The purpose of this paper is to evaluate the main physical environmental impact of the proposed Al-Subiya City, which the Kuwaiti government plans to establish on the northern coast, in order to identify potential planning deficiencies and environmental impact.

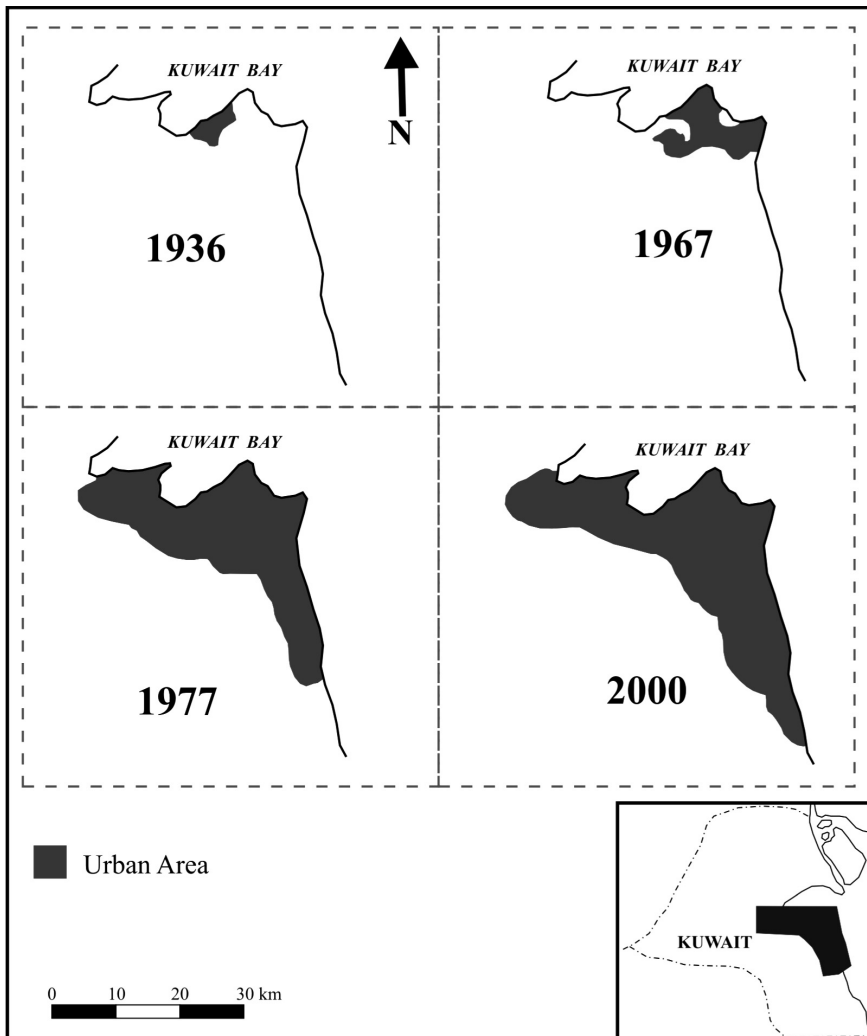


Figure 1: Urbanization of Kuwait from 1936 to 2000 (after Al-Sdirawi, 1994)

Al-Subiya New City

The Kuwaiti government plans to establish several huge projects along the northern coast, such as Madinat Al-Hareer, Al-Subiya New City, Boubyan Port and the South Coast Development Zone. Al-Subiya New City was first proposed by the Kuwait Master Plan in 1971. This new city will be built adjacent to Al-Subiya tidal channel. The Master Plan suggests that it will cover an area of 25,755 hectares and accommodate a population of approximately 382,100 residents, of which 48% will be Kuwaiti, and 52% non-Kuwaiti. The implementation will take about 25 years, in 4 phases (Kuwait Municipality, 2006).

The government plan is to build a complementary city in this area. Thus, the new city will include most major land uses (Table 1). This will create opportunities for new jobs in order to achieve self-sufficiency, in addition to the development of Boubyan Island and expansion of the Northern oil fields. To minimise traffic congestion on the proposed Subiya bridge, Jaber Al-Ahmad bridge will connect Al-Subiya headland with Kuwait City (Fig. 2).

**Table 1: General Land Use Summary for Al-Subiya New City
(Kuwait Municipality, 2006)**

Land Use	Area (ha)	Percentage
Total Residential	3,710	14.4
Total Commercial Facilities	946	3.7
Total Commercial	215	0.8
Total Employment Lands	1,754	6.8
Total Support Facilities	386	1.5
Total Utilities	5,027	19.5
Total Parks	967	3.8
Total Open Space	10,713	41.6
Rail Yard	2,037	7.6
Total	25,755	100

The major part of the new city will occupy the western coast of Al-Subiya tidal channel, while a small strip of the eastern coast facing the new city will be developed for recreational use (Fig. 3). The master plan for the new city is based on a socio-economic perspective, with limited consideration of the area's physical and biological environment. However, such a large project, with only limited consideration of environmental issues, may result in harmful impacts on both the regional environment in general and on coastal processes in particular. The plan has a great socio-economic assessment that meets the objectives of this city for attracting people to this area and achieving self-sufficiency, with its own economic base and all urban services. However, ignoring the physical environment of coastal zone management, particularly in sensitive area such Al-Subiya tidal channel, could result in significant environmental and coastal structure damages. For example, apart from the area of Lake Boubyan, development is located on existing high and medium visual quality (KISR Task Committee, 2005), and the master plan does not take into account this recommendation.

It is essential to establish a coastal management plan with minimum environmental impact and high socio-economic achievements. In this context, slowing down the implementation phases of Al-Subiya new city and making appropriate modifications to the master plan will minimise environmental degradation and consequent socio-economic impact.

Expected Environmental Impact

Because the management plan of Al-Subiya tidal channel has already been proposed, this section highlights the expected environmental impact that could occur based on the physical characteristics of the channel. The effects of this environmental impact on human activities and land use are discussed in the event that the current master plan is applied. Emphasis is placed on impact resulting from changes to the hydrodynamic regime, the intertidal flats and future rises in sea levels.

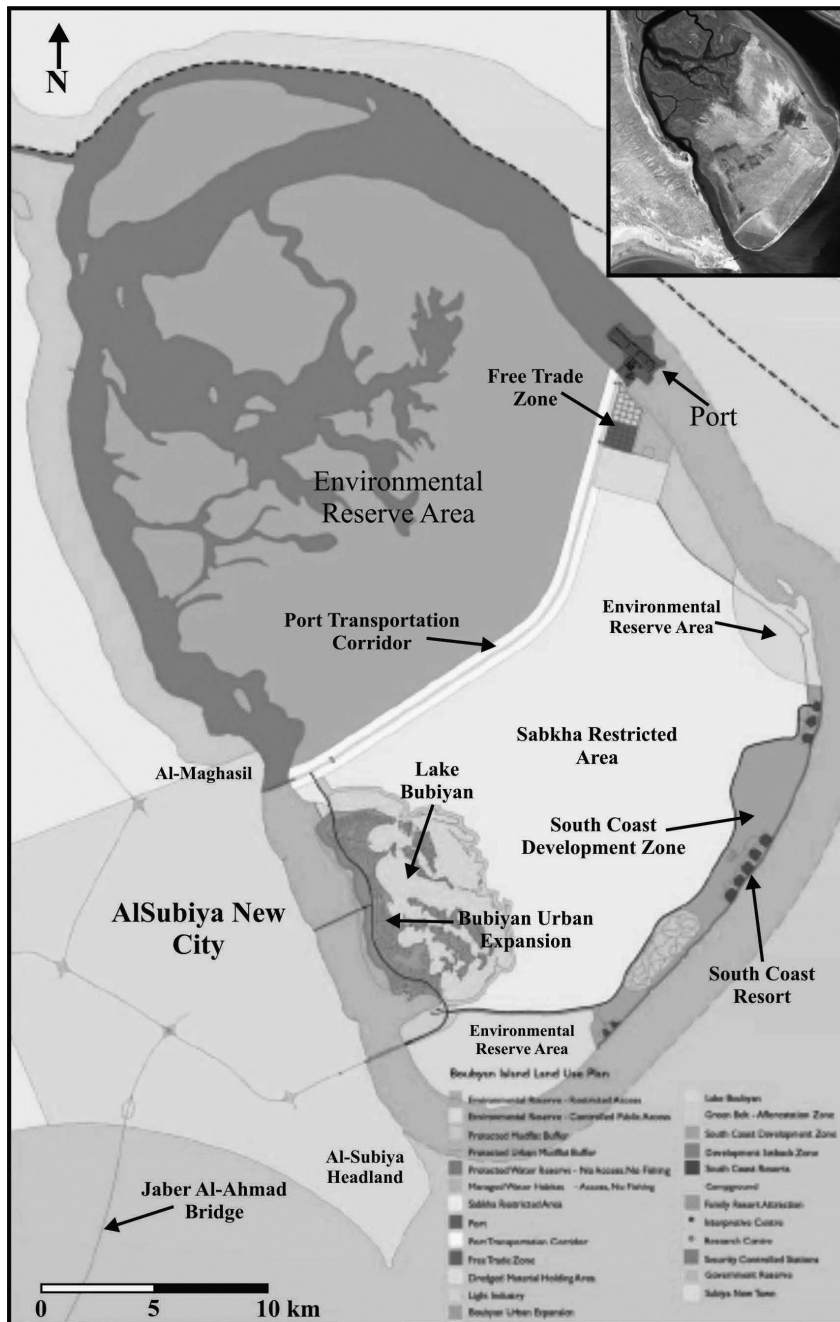


Figure 2: Land use activities for the northern coast of Kuwait

(KISR Task Committee, 2005; Ministry of Public Works - Mega Projects Agency, 2006)



Figure (3): Land use structure plan of Al-Subiya new city
(Kuwait Municipality, 2006)

Hydrodynamic Regime

There are several factors that influence the hydrodynamics and sediment dynamics along Al-Subiya tidal channel, such as the lateral and longitudinal characteristics of the channel's cross-section (Fig. 4), its shape and orientation, depth and bathymetric features, and the intertidal flat (Fig. 5). The channel's hydrodynamics are controlled by a combination of astronomical tide and channel morphology. Velocities vary from one station to another at the same cross-section, which is related to variations in geometry within the cross-section. This variation can be explained by the gradual slope and shallowness of the western bank of the channel. Modifications of intertidal areas and the sub-tidal channel will affect the relationship between the convergent and frictional effects which control the hydro and sediment dynamic behaviour along the channel (Al-Hasem, 2002).

It is clear from the map of the proposed city (Fig. 3) that both channel shorelines, from the channel entrance to Al-Maghasil area, will be modified by either dredging or reclamation or both. The master plan proposes two possibilities for shoreline development (Kuwait Municipality, 1990 and 2006), either by bringing the development area closer to the sea (reclamation) or bringing the sea further into the development area (dredging). Both possibilities will affect the channel's hydrodynamics and sedimentation.

In the first possibility, a great part of the intertidal zone will be reclaimed to be used as building sites and the remaining area will be dredged to form marinas, bays, artificial channels and lagoons. In this case, the cross-sectional area of the middle part of the channel (divergent area) will be reduced, thereby increasing the convergent effect. Moreover, the effect of the intertidal zone will be decreased and the demand of water spilling over the intertidal flat during the flood tide will be reduced. Both effects will lead to an increase in tidal range up-channel, causing the average depth of the channel to increase and diminishing the frictional effect.

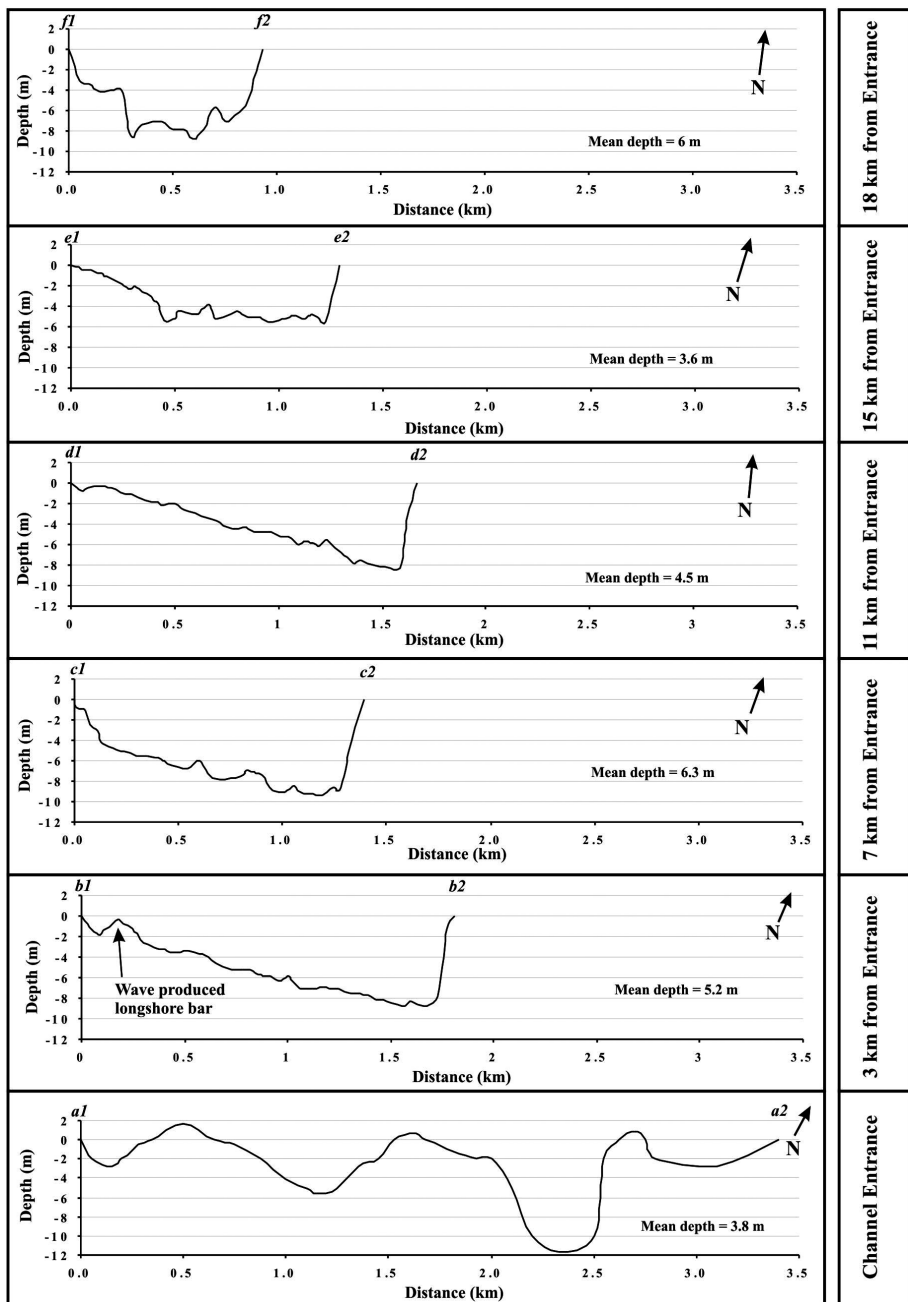


Figure 4: Channel cross-section profiles - depth refers to ACD
(Al-Hasem, 2002)

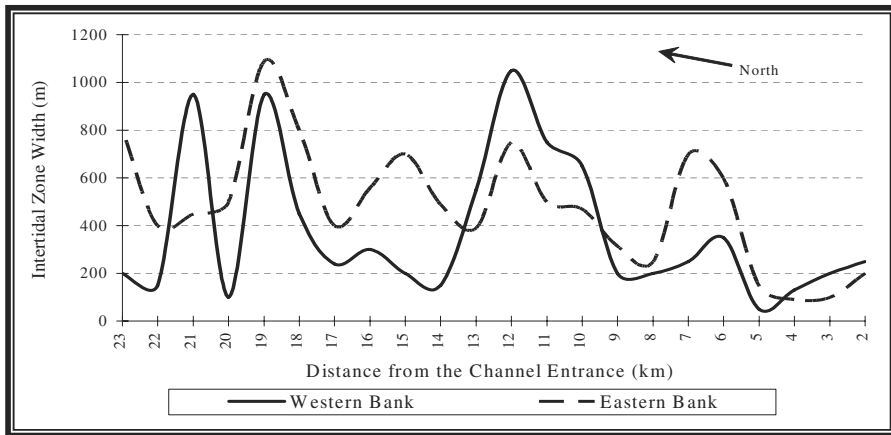


Figure 5: The intertidal zone width along the southern of Al-Subiya Tidal Channel (Al-Hasem, 2002).

Due to the increasing convergent effect and reduction of the frictional effect, the velocity of flood currents will increase and the meeting point of opposing flood currents will shift northward. This will change the flood-ebb relationship and the channel may switch from an ebb-dominant channel to a flood-dominant channel. This in turn will affect sediment transport and the sediment budget. Sufficient modification of the flood/ebb ratio may lead to the channel becoming an area of net deposition, particularly in the upper part north of Al-Maghasil area. Continued deposition in this area will result in a shallow area leading to this part of the channel being blocked by long-term sediment accumulation. This prediction is based on linear assumptions; however coastal morphodynamics are nonlinear and long-term behaviour is difficult to predict.

The second method to develop the shoreline is to dredge the intertidal flat to bring the sea further into the development area. This has the opposite effect of the first method. In this case, a significant area of intertidal flat will be dredged and a small part of the high intertidal flat will be reclaimed. Thus, the divergent area in the middle section of the study area and the demand for water needed to inundate the intertidal flat during flood tide will increase. This leads to an increase in the ebb-dominance in the channel, thereby increasing the amount of sediment exiting the channel into the open sea. Consequently, the depositional rate

will be increased in the outer part of the channel entrance. Because navigation through the channel's entrance will increase after development, routine dredging operations are required in the channel's entrance to sustain its accessibility to shipping.

Finally, the numerous artificial bays and lagoons created using either development method (such as Lake Boubyan Development and City Centre Waterfront "*the longitudinal artificial channel parallel to Al-Subiya tidal channel*") are likely to undergo rapid sediment accumulation, due to high suspended sediment concentration (SSC) in the channel. Again, this rapid accumulation will increase the cost of maintenance dredging activities and create the problem of dumping the dredged sediment. Long-term maintenance dredging will be required to maintain the quality of these bays and lagoons as recreational and leisure areas.

A similar situation of rapid sediment accumulation occurs in the existing Subiya Power Station and Desalinisation Plan which is located on Al-Subiya headland. In spite of the detailed Environmental Impact Assessment (EIA) for Al-Subiya Power Station contract that has been performed by the Ministry of Electricity and Water (Abou-Seida, 1988), the intake structure was built in the southern part of Al-Subiya tidal channel. This decision has recently resulted in the rapid accumulation of mud within the intake structure, leading to frequent maintenance dredging and extra cost. Moreover, because the channel is an ebb-dominant tidal channel, rapid mud accumulation has occurred along the outer northern structure of the intake.

Intertidal Zone

The intertidal zone is expected to be the area most affected by channel development. In both methods of shoreline development, the intertidal zone will be significantly altered. This will result in both short-term and long-term environmental impact. For example, changing the intertidal profile will affect the channel's hydrodynamics and sedimentation, as described in the previous section. As the intertidal flat in the study area is considered to be a depositional area, sediment that used to be deposited on the intertidal flat before reclamation will remain in suspension (also because of the increasing tidal current velocities due to reclamation). This will lead to increasing SSC, thereby increasing the

sedimentation rate in the upper channel and the outer part of the channel's entrance (Al-Hasem, 2002).

The soft, muddy intertidal flat in the northern coast of Kuwait is characterised by high biological productivity, being a significant nursing ground for many species of fish and shrimps and an important nesting and breeding ground for resident and migrating birds (Clayton, 1982; Al-Sarawi *et al.*, 1988; Abou-Seida and Al-Sarawi, 1990; Al-Bakri, 1996; KISR Task Committee, 2005; Ministry of Public Works - Mega Projects Agency, 2006). Consequently, this intertidal flat is very sensitive to alteration and pollution. It is ranked as one of the most vulnerable areas in terms of oil pollution and other environmental hazards (Al-Sarawi *et al.*, 1985; Al-Sarawi *et al.*, 1988; Al-Bakri, 1996). Regarding the master plan, the change of intertidal flat in the study area, either by dredging or reclamation, will have a direct impact on the developed shoreline, whose natural intertidal ecosystem will be completely destroyed by dredging or reclamation.

An indirect impact can result from urban pollution, such as domestic sewage, increasing navigation and stormwater outfalls. This pollution occurs as dissolved or observed chemicals into the water or suspended sediment (Marmoush, 1998). Based on the movement of water and suspended sediment in the channel due to tidal current behaviour, the suspended sediment and associated pollutants will be deposited on the intertidal flats at the outer channel entrance and its upper part. In the long-term, the intertidal ecosystem will be adversely affected by the deposition of the polluting suspended sediment.

As a final point, one of the guiding principles that has been adopted in establishing the master plan to underpin all development on Boubyan Island (Ministry of Public Works - Mega Projects Agency, 2006) states that there must be no development or construction activities in the intertidal zone (other than for Boubyan sea port, for which this is unavoidable). In addition, most of the issues for Boubyan Island EIA concluded recommendations in their mitigation requirements for design, such as no hard construction should occur within the intertidal zone (floating docks will facilitate water activity) and building 100 m. from the high tide mark will be enforced. However, the master plan for Al-Subiya New City neglects these recommendations.

Future Rise in Sea Level

Numerous studies have concluded that sea levels in the world's oceans will rise in the future. A rise in sea levels is caused by a combination of the worldwide eustatic rises in sea levels and any local subsidence at a given site (ASCE, 1992). The eustatic rise in sea levels, which is constant in all the world's coasts, is due in part to atmospheric global warming, due to the increase of CO₂ in the atmosphere (otherwise known as "The Greenhouse Effect"). The increase of CO₂ and other anthropogenic greenhouse gases is expected to lead to a rise in atmospheric temperature of between 2 and 5°C. As a result of global warming, the eustatic rise in sea levels will occur because of the combined effects of oceanic thermal expansion and melting of land-based ice (ASCE, 1992; Gornitz, 1995; Neil, 1998).

Future rises in sea levels may also result from vertical land movements because of geological or human effects. Sudden geological effects may occur because of tectonic movements. Slow geological effects result from either heavy sediment loads carried by major rivers or the withdrawal of subsurface fluids (oil and water) by pumping (Gornitz, 1995). Human effects can be explained by ground subsidence associated with human activities, such as large cities (Belperio, 1993; Zanchettin *et al.*, 2007). In general, the current rate of eustatic rises in sea levels is between 1 and 2 mm./yr., and increases on coasts which have experienced land subsidence to between 5 and 10 mm./yr.. For example, the rate of rises in sea levels is 10 mm./yr. in the Mississippi Delta, 5 mm./yr. in the Nile Delta (Day *et al.*, 1995), varies from 1.8 to 10 mm./yr. over different parts of the Port Adelaide estuary (Belperio, 1993) and from 5.8 to 8.5 mm./yr. along the Maldives' coast (Singh *et al.*, 2001).

Apart from eustatic rises in sea levels, subsidence effects on sea level in the study area could result from two factors. First, the study area is located close to the Tigris-Euphrates delta; however it is unclear whether this area is stable or subsiding. Colter (unpublished oil company report; cited in Kassler, 1973) estimated that Kuwait's part of the delta has subsided by as much as 37 m. during the last 5,000 years. Kassler (1973) rejects Colter's estimation, stating that Kuwait's part of the delta is

relatively stable. Aside from this disagreement, subsidence of Kuwait's part may be a result of sedimentary loads carried by the Tigris/Euphrates delta and deposited in the northern Arabian Gulf. Second, the study area is located near three oil fields (Al-Raudhatain, Sabriya, and Bahra) and two groundwater fields (Al-Raudhatain and Amm Al-Aish). Some land subsidence is likely due to oil and groundwater withdrawals since the middle of the last century, although no data are available. Furthermore, the foundation of Al-Subiya City is expected to increase the rate of local subsidence, thereby increasing rises in sea levels.

The northern coast of Kuwait in general and Boubyan Island in particular are principally vulnerable to global warming and rises in sea levels. Boubyan Island is low-lying at between 1 and 4 m. above sea level. Consequently, it has little natural protection against tidal flooding, storm surges and rises in global sea levels.

The master plan for Al-Subiya City has ignored the potential impact of a future rise in sea levels on such a sensitive environment. There are three major probable effects of a rise in sea levels. **First**, it would increase the total tidal prism and current velocities (Chappell and Woodroffe, 1994), thereby increasing SSC, erosion and deposition. Based on development possibilities, a rise in sea levels will accelerate the rate of deposition either in the upper part of the channel (reclamation scenario) or in the outer part of the channel entrance (dredging scenario). Moreover, wave influence will increase up-channel because of increasing water depth. **Second**, the area of supratidal flats and sabkhas, particularly on Boubyan Island, will increase because of increasing tidal height and seepage. Third, the groundwater level will rise as a result of the rise in sea levels. This will increase the salinity and moisture of the upper soil, which will negatively affect botanical gardens and building foundations.

Overall, the current master plan of Al-Subiya New City will change the channel's morphodynamics, cause serious environmental degradation, increase the future cost of maintenance, and negatively affect socio-economic consequences. General recommendations and strategies in response to the potential impact are discussed in the next section, with a view to minimising the environmental impact and achieving high socio-economic benefits.

General Comments and Recommendations:

Based on the physical results of this study and the predicted findings of the environmental impact expected from the current development plan, there is an urgent need for a political decision to review the current master plan of Al-Subiya New City. Such a review should reconsider the plan in the context of the physical and biological characteristics of the natural system. In the event that a political decision is made to review the original master plan, the following comments and strategies should be considered:

- 1 - A council for reviewing the current master plan for Al-Subiya City should be constituted by the General Environmental Authority. The proposed council should consist of members from concerned ministries, organisations and authorities. The General Environmental Authority will elect the council's members based on their high technical background in coastal studies or their representation of ministries, organisations or authorities whose activities are linked to the coast. The task of this council is to evaluate the current master plan from different perspectives, determine the additional studies needed for the city, and set up modifications of the original master plan and alternative plans.
- 2 - It is judicious to learn from the mistakes and experience of others in the future development and modification of Al-Subiya City. Hence, external consultation with scholars and expert institutions, whose activities are linked to similar environments, could be involved, in order to achieve a level of sustainable development and the maximisation of economic benefits.
- 3 - The city should be relocated westward, leaving about half a kilometre to an undeveloped strip between the western coast of Al-Subiya tidal channel and the eastern part of the proposed new city. Its westward relocation would yield two benefits: more stable land for the city's foundations (quaternary gravel deposits) and less destruction of the intertidal zone. Both benefits would lead to a reduction of the cost of construction and shoreline development. Moreover, relocating the city will minimise the effects of future rises in sea levels and increasing tidal range on the city's structures and foundations.

- 4 - The eastern coast of the channel and a large area of Boubyan Island (except for the southern coast) are considered to be areas that are vulnerable to rises in sea levels. It is recommended that the island could be developed as a national park for nature-orientated recreational and educational uses.
- 5 - Waterfront development for leisure and touristic uses is one of the most important factors in socio-economic assessment. However, achieving such an objective must also ensure minimal environmental impact. The waterfront could be divided into two main areas with different categories of use. First, Al-Subiya waterfront might be developed along Al-Shumaymah shoreline for about 4 km., north of Boubyan Bridge. Firstly, this is because this part of the western channel's coast has already been affected by human-induced development (Al-Shumaymah artificial headland). Secondly, this area is characterised by high waves and a narrow intertidal zone. Al-Subiya waterfront could be developed for mixed public uses, such as cultural and leisure facilities.

The second waterfront is the southern Boubyan one. The southern coast of Boubyan Island is characterised by relatively high parallel ridges of shells and sand (Al-Asfour, 1982). It is a wave-dominant coast and less vulnerable to rises in sea-levels. It might be developed as a waterfront residential area, containing hotels and resorts, with water activities, marinas, public beaches, holiday villages and rented residences.

- 6 - Afforestation of the undeveloped intertidal flats with mangrove plants is needed in terms of providing coastal protection, conservation of biological diversity and provision of habitats, spawning ground and sand nutrients for a variety of fish and shellfish. Such a plan for planting mangroves has been carried out in two sites in the intertidal zone around Sulabikhat Bay and in general the results have showed a suitable level for the successful establishment of mangroves (Abo El-Nil, 2001).
- 7 - The location of the industrial area should be moved about 3 km. southwest of the western limit of the new city and separated from the city by a green belt. The recent proposed industrial area is located downwind (the area has prevailing north-westerly winds) from the new city. Thus, the new city will not be affected by air

pollution and unpleasant smells emitted from the industrial area. The northern area of the new city should be developed as a green belt. Its main purpose is to reduce the effect of aeolian sediment transported as bedload from Al-Quashaniay sand belt. The green belt could also be developed in such a way to allow for campsites for winter and spring camping activities. Finally, the major streets in the city should be designed parallel to the prevailing north-westerly winds to avoid air pollution.

In conclusion, the current master plan of Al-Subiya New City does not take physical and biological factors into serious consideration. Steps towards construction of the city will therefore lead to irreversible and serious damage to the environment. It is highly recommended that the current master plan is evaluated and revised, with great attention paid to physical and biological assessments.

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التقييم البيئي للمخطط الهيكلي لمدينة الصبية الجديدة في دولة الكويت

أحمد مبارك الحصم*

ملخص: يلاحظ تركيز المخطط الهيكلي لمدينة الصبية الجديدة بدولة الكويت على المنظور والمكاسب الاقتصادية والاجتماعية لهذا المشروع، مع إهمال واضح لاعتبارات البيئة الطبيعية والبيولوجية. وانطلاقاً من تقييم مبدئي للمخطط الهيكلي يتضح أن كثيراً من الآثار والأضرار البيئية السلبية متوقع بروزها في المستقبل في حال تطبيقها، وبشكل عام فإن هذه الآثار والأضرار سوف تنتج بسبب التغيرات المتوقعة حدوثها بالنظام الهيدروديناميكي وبيئة نطاق المسطحات المائية والتأثير المستقبلي لتغير منسوب سطح البحر المتوقع نتيجة مشكلة الاحتباس الحراري العالمي، أخيراً الموقع غير البيئي للمنطقة الصناعية.

المصطلحات الأساسية: مدينة الصبية الجديدة، قناة مدية، المسطحات المائية، النظام الهيدروديناميكي، مستقبل إرتفاع مستوى سطح البحر.

* قسم الجغرافيا، كلية العلوم الاجتماعية، جامعة الكويت، دولة الكويت.

