

Open Access



Waterfront developments and engineered canals in the UAE

Mohamed El Amrousi^{1*} , Mohamed Elhakeem² and Evan Paleologos³

Abstract

Engineered canals and waterfront developments as a means to revitalize aging riverfront and coastal areas, dominated until the mid-thirties by industrial buildings and warehouses, have been at the forefront of many American and European cities. Urban revitalization is accomplished after prolonged public participation and has succeeded to transform abandoned areas to healthy public spaces, renovating old warehouses and industrial buildings to apartments with water views, and keeping alive the historical memory of a city. In contrast, in the United Arab Emirates (UAE), most of these waterfront developments, such as Al-Qana, a recent project in Abu Dhabi promote forms of modern, spectacular architecture that project a sense of departure from tradition, local culture and architecture. This is also visible in the area around the Dubai canal, which has opted for a modern development on its banks, replacing parts of an existing open park. A project that diverges from such an approach is the two-decades old waterfront project in the city of Sharjah, UAE. Al-Qasba in Sharjah aimed for a more balanced approach, intertwining new architectural forms with hybridized Islamic ornaments. The current article analyzes these three UAE waterfront development projects, focusing on the one in Abu Dhabi. In order to assess the water quality in these engineered canals on the long term we created simulation waterflow models using 2D Finite Element Surface Water Modelling System (FESWMS). Our hydrodynamic modeling results indicate that water velocities in some canals was better than others. Furthermore, on the long-term Al-Qana may require mechanical means in order to maintain healthy waterflow conditions.

Keywords Waterfront developments, Engineered canals, Al-Qana Abu Dhabi, Dubai canal, Al-Qasba Sharjah

Introduction

In the past decades waterfront projects accompanied by engineered canals that extend inland have been developed in several cities of the United Arab Emirates (UAE) in an effort to regenerate industrial port areas or bare land intrusions. Waterfront developments worldwide

have aimed to transform underutilized areas with parks, walkways by the water, cultural and entertainment centers, while attempting to preserve historical industrial buildings by converting them to mixed use buildings (Hristić et al. 2021). In U.S.A., urban regeneration projects, in cities such as Minneapolis and Pittsburg, have altered riverfront areas, dominated until the early 1930s by industrial buildings and warehouses, to be subsequently abandoned and fallen into decline (RiverLife Task Force 2021; Minnesota Historical Society 2023). The economic and social benefits of these projects have not been limited strictly to the riverfront areas, but have extended to the city as a whole by invigorating its economy, with new real estate, retail, cultural, and food business

*Correspondence:

Mohamed El Amrousi

mohamed.amrousi@adu.ac.ae

¹Department of Architecture and Design College of Engineering, Abu Dhabi University, Zayed 59911, UAE

²Department of Civil Engineering, College of Engineering, Abu Dhabi University, Zayed 59911, UAE

³College of Engineering, Abu Dhabi University, Zayed 59911, UAE



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.



Fig. 1 Urban riverfront regeneration, Minneapolis, MN, USA (photos by the authors)

opportunities, and a sense of pride and belonging to the city's citizens.

An important component of these U.S. cities riverfront projects' masterplan was that the vision and aims, as well as the design and planning were developed via public participation of all the stakeholders, which included the city's administration, the various chambers, museums and cultural foundations, architectural and other technical associations and firms that are active in the city, representatives of various economic sectors, and the public in general (see for example, RiverLife Task Force 2021). Active participation of all stakeholders is critical in urban waterfront regeneration projects because by changing the character of the area where these projects are done they offer new forms of public space, which needs to be embraced by the community if a project is to succeed (Sairinen and Kumpulainen 2006). Figure 1 illustrates the active public utilization (Xiao et al. 2020) and engagement with the developments at the Mississippi riverfront in Minneapolis, MN.

Redevelopment of ports, coast and riverfronts has also taken place in European cities in order to rejuvenate areas whose economic activities had become obsolete. Examples include Genoa in Italy, Hamburg in Germany, Lisbon in Portugal, Valencia in Spain, Marseilles in France, Rotterdam in the Netherlands, Antwerp in Belgium (see for example, Fekete et al. 2021; Notteboom et al. 2022). A recent example includes the \$8 billion Ellinikon project in Athens, Greece, the largest urban regeneration project in Europe in an area of the no longer used, first Athens airport. In this 6.2 million-square meters area, a smart and sustainable city with a projected 50,000 population is being developed, under a masterplan (Foster+Partners 2024) that includes marinas, residences, hotels, offices, and entertainment and retail centers and a third of the total area earmarked for a metropolitan park (Ellinikon 2023).

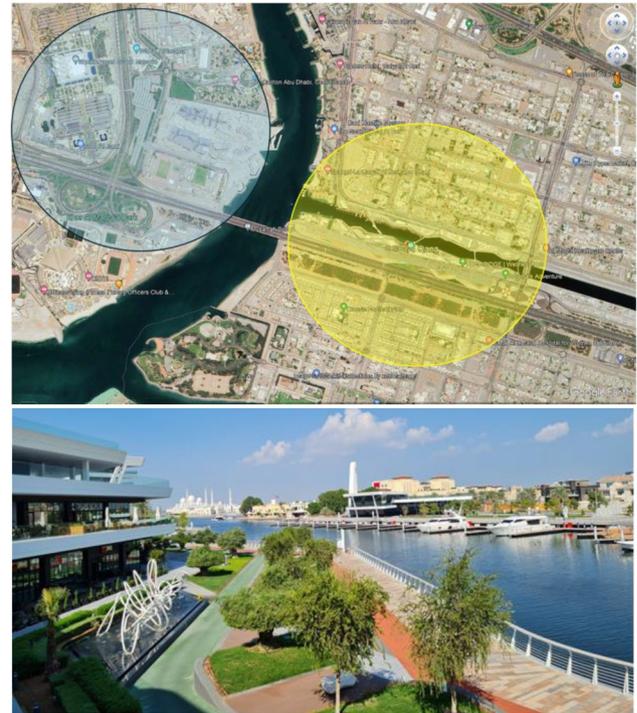


Fig. 2 Qana facing Sheikh Zayed Grand Mosque site context (top). View of the Qana project with the Sheikh Zayed Grand Mosque in the distance (bottom). (source: Google Earth, photo by the authors)

Waterfront developments in Abu Dhabi, UAE

Waterfront developments have reshaped much of the urban fabric of Abu Dhabi in the past decade. These range from mixed use developments in Reem and Maryah Islands which are designed to resonate a Manhattan style skyline, to leisure activities in Yas Island and mega-museums/cultural institutions in Saadiyat Island. In some cases, waterfront projects are made public in the form of displaying physical models of the projects and a masterplan as in the case of the cultural projects of Saadiyat. Other projects are announced through road signs next to the project or via the internet, with public participation in the outcome or project aesthetics to be scarce and decision-making made by developers in conjunction with government authorities (Ponzini 2011).

Engineered waterfronts in Abu Dhabi differ from other waterfront projects in other Emirates of UAE, like Sharjah and Ajman, which have taken a humbler approach, not diverging too much from existing architectural forms. This is highlighted by the new Qana project (Fig. 2) in Abu Dhabi that extends 2.4 km along an engineered canal in the vicinity of a major landmark, that of Sheikh Zayed Grand Mosque (Construction Week 2020). The waterfront development is located in the Maqta district and introduces modern building typologies dedicated to indoor and outdoor sports, such as running and cycling tracks, and a national aquarium, which is one of Middle East's largest aquariums measuring 7,000sqm

(Knaggs 2019). The Qana project is one of several man-made waterfront promenades in the UAE with earlier precedents being, among others, the Qasba Canal, Sharjah, UAE (BCG 2023) and the Dubai Canal in Dubai, UAE (RTA 2022).

Abu Dhabi's waterfront projects are part of a broader vision for a gentrification plan of the existing building stock in the downtown area and redevelopment of existing waterfronts. The industrial/fishing port of the city is undergoing a major transformation, where old warehouses are renovated to be transformed to cultural centers and a new fish market supported by renovated restaurants offer facilities aiming to improve the urban quality of the city. Major investments in infrastructure and cultural projects actively pursue investments and publicity to survive in the increasing inter-urban competition, and to alter the perception of the oil-rich Gulf states' cities from transit ones, where migrant workers temporarily resided, to cities with more sustainable communities. Waterfront developments and iconic cultural projects are part of Abu Dhabi's continuous effort to re-brand itself from a transit city to one that aims at continuity and stability in an attempt to retain its primarily expatriate population. Changes in the image of a city are significant in terms of the identity, the sense of well-being, and inclusion that a city may project. This is accompanied by recently introduced UAE policies regarding long-term visas for selected professionals, entrepreneurs, and small business owners in an attempt to retain vital human capital in the UAE.

Developers in Gulf States and especially in the UAE have embraced the approach of utilizing waterfronts as alternatives to large public gardens/parks that are common in Europe and the U.S.A., as these are more suitable for desert cities where maintaining large public parks is challenging because of the water scarcity. As the capital of the UAE, the Abu Dhabi metro area has a population of 1.57 million, roughly half of the 2020 population of the Emirate, which is composed by 19% UAE citizens with the remaining 81% being expatriates (SCAD 2020). The objective of promoting long-term living in Abu Dhabi is reflected in the housing typologies emerging on the waterfronts, which demonstrate a strategy to mitigate the perception of desert living in order to increase the appeal of the UAE cities.

Waterfront projects in Abu Dhabi aim for high-end residential and commercial redevelopment with these reconstructed districts being articulations of ways nature and urbanity are mobilized to shape community expectations (Hagerman 2007). The significant growth of Dubai and Abu Dhabi in the UAE in the past decade is coupled by significant urban sprawl, and the introduction of new planning policies and practices. To regulate Abu Dhabi's urban expansion, the Urban Planning Council (UPC) was

established in 2007 to review and align urban development proposals with the values of a modern Arab city. This encouraged collaborations and cross-national transfer of planning forms between Abu Dhabi and Vancouver based architects and planners (Khirfan and Jaffer 2014). In Abu Dhabi, rapid urban sprawl, scarcity of significant cohesive historical urban stock, and international collaborations allowed designers and urban planners to construct an urban fabric based on western ideals with scarce attempts to create hybrid or eclectic Arabian/Islamic styled buildings. Emerging waterfront developments in both Dubai and Abu Dhabi are similar in context in the forms of mega museums and iconic cultural institutions, as they are commonly designed by the same star architects.

The growing popularity of waterfronts signifies a new visualization of a city in the UAE where the desert is pushed backstage and water comes to the forefront. Due to the harsh climate, few outdoor spaces for social interaction existed and these are now supplied by waterfront projects representing an open-air experience in contrast to a car-based, shopping mall, sedentary lifestyle. Public spaces, walkways, and cycling paths incorporate urban greenery offering the benefits of a mild climate for several months of the year, and of social adaptation (Afrin et al. 2021). In that respect, the current article aims to study the effects of new architectural assemblages along engineered waterfronts in the UAE and the way these projects modify urban landscape. In doing so, it expounds on the similarities and differences of the Qana project in Abu Dhabi with previous waterfront projects in the cities of Dubai and Sharjah, UAE. Finally, a two-dimensional (2D)-hydrodynamic surface water model has been developed to investigate the flow pattern in the new Qana canal in Abu Dhabi versus the waterflow patterns in the Dubai canal and Qasba canal in Sharjah.

Methodological approach

The methodological approach of the article relies on an extensive interdisciplinary literature review of contemporary waterfront developments and their impacts on the urban fabric of a city. With reference to the Qana project in Abu Dhabi, the study provides comparisons with other cities in the UAE, such as Dubai and Sharjah, by contrasting attempts to integrate new waterfront developments, and others, which stand apart from the existing urban landscape. The characteristics of the Qana canal are analyzed through a survey of Abu Dhabi residents of the age between 19 and 35 years old, who had visited the Qana waterfront development, in order to extract the essential elements of user satisfaction. The survey method utilized one-on-one interviews and questionnaires that covered various aspects from attitudes towards the suitability of

the canal to questions related to its urban context, accessibility, and facilities.

The environmental performance of an engineered canal is determined by the quantity and quality of waterflow in it. Insufficient waterflow may result in stagnation, changes in water quality and unpleasant odors, especially as is the case of the Qana project where the canal terminates in a dead end and waterflow may be affected during drought periods and subsequent drops in water levels. An important aspect of canal engineering is to retain a flow regime that will not favor sediment deposition, or pollutant accumulation at the bottom and the banks of the canal. To investigate this aspect, the 2D Finite Element Surface Water Modelling System (FESWMS) was chosen for modeling the flow of the water in the canal. FESWMS is part of the commercially available Surface water Modelling System (SMS) software package (version 12.1) developed by the Federal Highway Administration (Froehlich 2002). 2D-hydrodynamic models have



Fig. 3 Simulation of the circulation flow pattern in the Dubai canal (top), emerging high-end apartments that took the place of certain green areas of the Safa Park (middle & bottom) (photos by the authors)

been deemed appropriate for simulating flow conditions and solve the depth-averaged continuity equation using finite-difference, finite-element, or finite-volume schemes (e.g., Spasojevic and Holly 1990; Papanicolaou et al. 2011). Thus, although the main contribution of the first part of this article is of theoretical nature, the quantitative part of the water flow modeling, provides original results on the water velocities in the Qana canal and contrasts them to the situation in two other canals in the UAE. Circulation patterns (highlighted through colour coding patterns) are important because they predict if these canals will remain healthy, attractive open air spaces or if sediment deposition, aquatic growth, and sulphide formation will affect them.

Engineered canals and public space—the Dubai canal

Plans to develop waterfronts have gained momentum in many Gulf cities, such as Dubai and Abu Dhabi in the UAE, and Doha in Qatar. These modern Gulf State cities have evolved to become significant economic centers between Asia and Europe with large-scale port, logistics, and banking facilities. They are expected to solidify their role globally after the completion of the Etihad Railway project, which will connect the Gulf countries of Bahrain, Kuwait, Qatar, UAE, Saudi Arabia, and Oman.

The UAE has a long history of urban interactions with waterfronts as manifested by the traditional waterfront houses along the Dubai Creek (Mohamed et al. 2020). Traditional water taxi's "abra's" still remain a favorable transportation method and these are contrasted to modern yachts passing through the Creek. In 2016 an extension of the Dubai Creek known as the Dubai Canal project (Fig. 3) was opened. As a natural waterfront the Dubai Creek and its new extension create a waterfront journey where visitors to the city can witness the transitional shift from local heritage to modernity in the city. For travelers traversing the Creek, traditional Emirati houses dating to the pre-petroleum era to different 1980–1990 s buildings stocks of the city to contemporary buildings emerge along the side of the new Dubai Canal. The manmade canal is 3.2 km long and 80 m wide at its narrowest section with 12 marine ferry/stations and a number of bridges that cross it (RTA 2022).

The top part of Fig. 3 shows with a red outline the Safa Park that existed before the developments along the canal. Parts of this park have been removed to allow for real estate development, with older buildings that once faced the park having their views blocked by the new generation of upscale buildings built along the banks of the new canal. The Dubai Canal is an example of urbanism promoted by developers that does not consider waterfront as public property and as a space of public social interaction (Hochhalter 2013).

Commercial and recreation functions create public areas whereas residential ones create private spaces (Awwal and Borsi 2020). The perceived decline of public space assumes that effective public life is linked to a public realm where public affairs are discussed in a set up that allows relaxation and social contact (Banerjee 2001). Open spaces in an urban landscape are important for social cohesion by supporting physical, psychological, and social health, and by providing a complete set of ecosystem services to a city. Public spaces especially waterfronts need to offer continuous, uninterrupted access to people giving them options for different ways of use of the space (Pittaluga 2020). In contrast, waterfront real-estate developments diminish waterfront accessibility and public use by aiming solely to profitability (Awwal and Borsi 2020). The interface of a city's urban fabric and its waterfronts is of a complex nature with new constructions either integrated within the existing urban fabric or contrasted to it (Health 2009). In addition, it is crucial to understand the role of urban waterfronts in the integration of different social groups within the existing city structure because waterfronts foster social interaction and offer venues of interaction with nature.

UAE investments in waterfront projects are not limited to the country but transgress on a transnational level as exemplified by the \$35 billion Waterfront Development

Project of Ras al-Hikma peninsula west of Alexandria, Egypt (Tabikha 2024) and the \$3.5 billion Belgrade Waterfront development project. While details of the Ras al-Hikma waterfront project have not been revealed, the Belgrade Waterfront project represents another example of UAE-style development that aims to exploit waterfronts in order to create high-end, high intensity, luxury spaces that undermine the role of public space (Perić 2020). The Belgrade project, which has been promoted by the UAE developer of Burj Khalifa and the Dubai Mall, has received mixed reviews with criticism focusing on the relation of the developed area's urban context and identity and its relationship with the hinterland.

Waterfront developments promoted by developers represent a stark contrast to the provision of publicly accessible space (Nemeth and Schmidt 2011; El Amrousi and Elhakeem 2019). The generation of waterfront developments in a city needs to create transitional or interfacing spatial zones between the dense built-up space of the living city and its hinterland (Valentino and Lutzoni 2020; Gospodini 2006). Creating projects for exclusive residential, office, and commercial buildings widens the gap between the city and its hinterland, especially if existing historic monuments or building stocks of certain identity exist (Jung et al. 2021). High-end waterfront urban landscapes as those in the UAE, which replace public space, create new skylines in a city by dissociating new buildings from an existing urban context (Hristić et al. 2021).

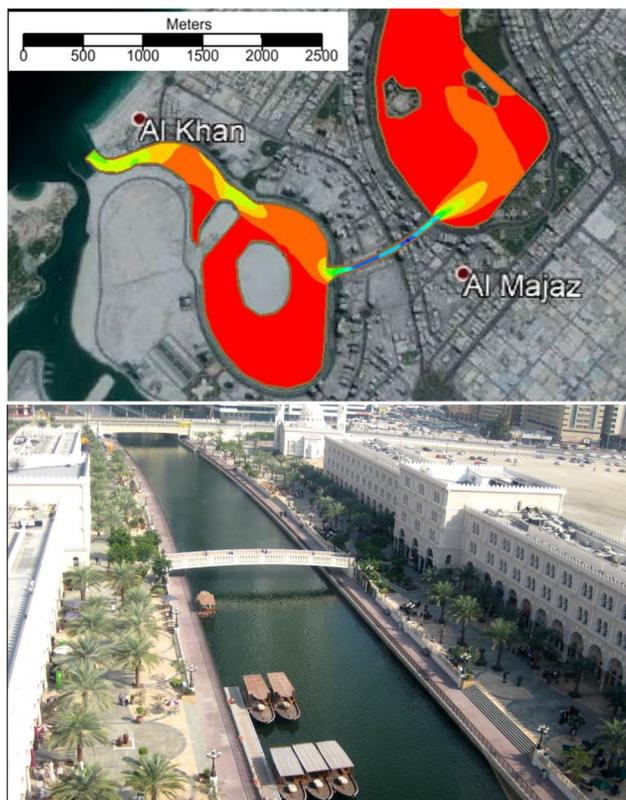


Fig. 4 Simulation of the velocities and view of the Qasba canal, Sharjah, UAE (modeling and photo by the authors)

The Qasba Canal in Sharjah, UAE

The positioning of architecture in relation to water has changed in the last decade with collaged forms and fragments from a broader vocabulary of Islamic architectural motifs representing a narrative where the notion of authenticity and reference to the past is sometimes coupled by post-modern architectural manifestations (Young 2006). This is represented by the Qasba Canal in Sharjah (one of the seven emirates in the UAE), which adopts an Arabian/Islamic style as a manifestation of its cultural identity, and striking a juxtaposed identity to its neighboring emirate of Dubai (BCG 2023). Sharjah's developments along the lagoons and the Qasba Canal manifest the belief that through urban regeneration the city has the ability to focus on more inclusive public spaces that are accessible to multi-ethnic socio-cultural groups. Sharjah's waterfront developments in Al-Majaz area (Fig. 4) along Lake Khaled have established a semiotic urban context that is based on classical institutions of Islamic architecture, such as the bazaar, the coffee-house, and the Noor congregational mosque, which traditionally make up spaces of gathering in Arab cities. Example of these forms include the neo-Ottoman-styled mosque, the gold and textile bazaar with a modern vaulting system,

and the coffee house that revives local wind towers, the barjeel.

Sharjah's waterfront development represents an attempt to interpret and develop expressions of cultural heritage, and blur the boundaries between tradition and modernity in order to regenerate traditional forms interwoven with green areas and public spaces. Taken together this group of new monuments along Sharjah's waterfronts forms a complex urban whole that serves to reflect and deepen an emerging sense of identity that is built upon a similarly complex mix of multicultural ethnicities that make up the population of Sharjah. Waterfront developments in Sharjah in the form of public gardens along lake Khaled and the Qasba Canal revitalize public space in Sharjah with a more inclusive identity than privately developed waterfront areas and high-end malls in Dubai (Fernández Águeda 2009). The Qasba Canal via its Moorish-Hispanic arcaded buildings provide shaded public space, path connectivity, and improved water circulation between the Sharjah lagoons. Here public spaces by waterfront projects represent spaces of gathering that manifest pluralistic cultural understanding the living city. Bridges, pedestrian paths, and an 'Eye of the Emirates Wheel' where visitors can view the city from above, reinforce the diverse cultural identities of expatriate communities in Sharjah, while building a sense of support for cultural and social activity (Al-Asad 2002; Dastgerdi and De Luca 2019). Such forms of urban landscapes have been championed by cities looking for new ways to foster new economic growth (Broudehoux 2010). Waterfront developments need to revive a city's cultural values and blend within their surrounding urban context. Thus, the Qasba, in contrast to the Qana project in Abu Dhabi and the Dubai canal in Dubai, is an alternative waterfront development model built around architectural forms that reflect the ideals of Sharjah as an emirate that fosters local culture and tradition.

The Qana project in Abu Dhabi

Iconic international museums in Al-Saadiyat island and mega cultural projects lean toward an architecture of the spectacle that borrows from a wide spectrum of architectural precedents and fragments, resulting in an eclectic urban fabric that is gradually transforming the Al-Saadiyat island into an open air architectural museum (Frampton 2003). Hence it can be argued that locational trends of the flourishing oil-based economy, along with the development of new urban strategies tend to rearrange the landscapes in the UAE cities (El Amrousi et al. 2019). The site of the Qana project is challenging architecturally because it faces the Sheikh Zayed Grand mosque and the newly

emerging traditional style Souq (market) in addition to several neo-Arab/Islamic buildings and resorts in the Bain al-Jessrain area along the Maqta canal. Thus, the Qana new waterfront development redefines public space with an identity that is more high-end and stylistically different from the pre-existing urban context. This new, ultra-modern project offers new urban landscape elements, pedestrian and cycling paths, waterfront restaurants and cafés and indoor adventure parks, pedestrian bridges across the canal, and a marina (Fig. 2). Even though the project creates a kind of shared communal space that connects communities via a highly eclectic architectural assemblies, it stands in stark contrast to iconic building, such as the Sheikh Zayed Grand mosque with its Indo-Arabian Islamic style. (Fig. 5)

The canal site before project construction, had on one side an undeveloped bank bordering a highway, and on the other side residential villas that were serviced by a low-traffic road, and which had uninterrupted views of the canal and access to the canal bank and the water. The Qana's ultra-modern buildings create a striking contrast between its reflections of neo-expressionism/deconstructivism styled buildings and the existing postmodern Arabian styled architectural manifestations. Although the project clearly demonstrates an understanding of the need to create an appealing environment in order to allow for an expansion of economic activities this is done at the expense of the local character of the area, and, in the same manner as the Dubai canal, by downgrading existing buildings, their views and water access, and by intensifying traffic in the area (Ellin 2010; Huang et al. 2016). Thus, the absence of a public dialogue on the vision and design of the project and its top-down approach are apparent and are in contrast to the extensive stakeholder involvement in similar projects conducted in the U.S.A., where neighborhood associations would not have accepted the construction of massive buildings blocking views of the water by residential houses. An additional point lies in that riverfront developments, such as that in Minneapolis, MN (Fig. 1), upgraded not only old industrial buildings, thus retaining the memory of the city, but also gave life to downgraded areas, and created large open spaces (Yıldız et al. 2020). In contrast, the Qana project, has narrowed open spaces and has introduced intense economic activities in a previous residential area (Gehl 2010). While this new, high-end waterfront project is stylistically homogenized, it exhibits signs of sanitation and stands apart from the location it is built in (Carmona 2015; Rausell-Köster et al. 2022). Thus, this waterfront project manifests an example of internationally assembled architectural elements with reference to no

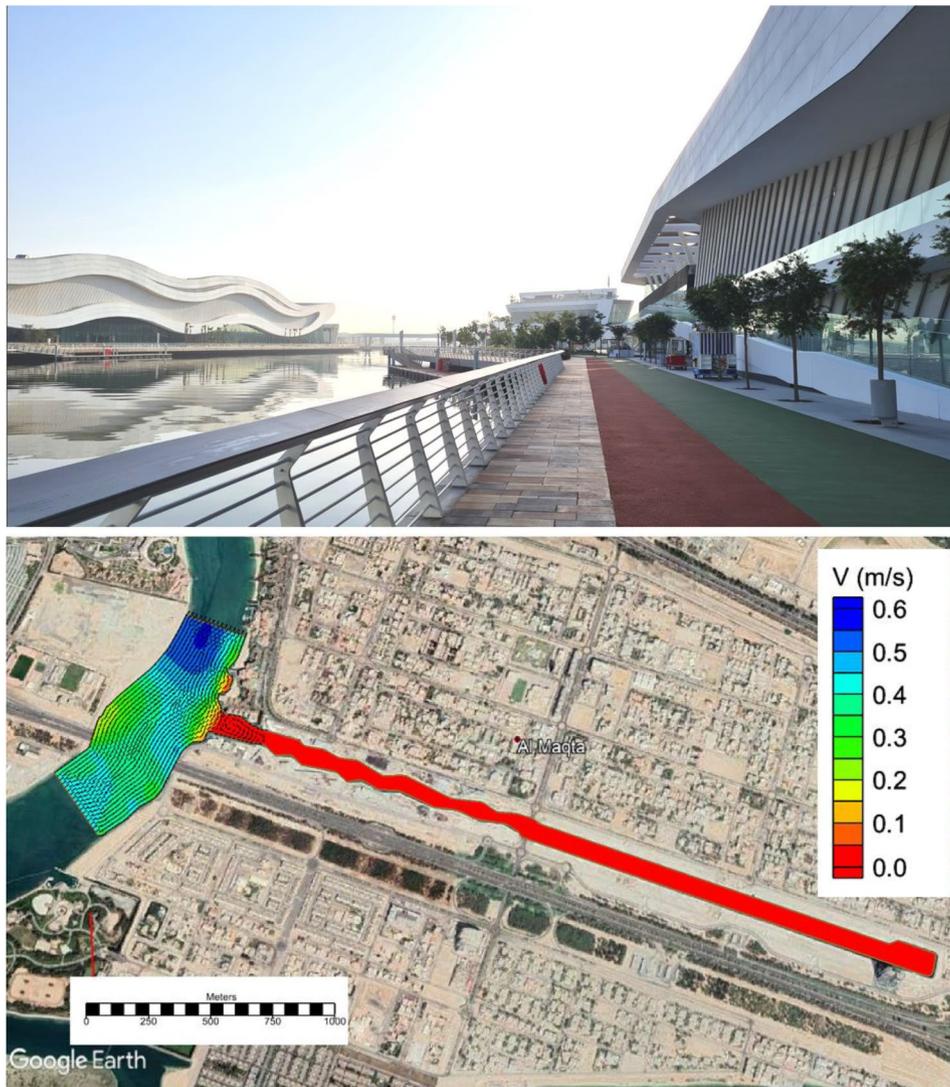


Fig. 5 Al-Qana (top). simulation of the velocities in the Qana canal (bottom)

specific culture and not linked to the existing urban fabric or history of the place (Zukin 1991; Olroyd-Robinson 2006; Cugurullo and Ponzini 2018).

Discussion and findings

To assess the Qana project from a user feedback perspective we conducted a survey. The survey included questions that aimed to assess: (1) accessibility, (2) convenience of parking/traffic management, (3) suitability of architectural style to urban context, (4) Whether the project will result in gentrification, and (5) level of satisfaction with the facilities. One-on-one interviews were conducted, and a Questionnaire was distributed to 40 working professionals living in Abu Dhabi. The respondents were between the ages of 19–35 years old. The percentage of female respondents was 37%, male respondents were 63%, 25% were UAE nationals and 75% expatriates.

Based on the feedback of the respondents the results in Fig. 6 show that accessibility to the Qana project was deemed to be satisfactory because of its location at the outskirts of the city and along a main highway. Accessibility to the waterfront is limited by metal handrails with steps leading to the waterfront, and controlled access points for families to take boat rides. Traffic and parking received the second lowest percentage of project satisfaction in the survey with almost half of the respondents finding that traffic to reach the site and parking availability not being satisfactory. This reflects the situation that during peak times traffic is congested and parking spaces are insufficient. Most respondents found that there was no visual connectivity to the surrounding urban context, especially with the Sheikh Zayed Grand mosque. However, some users highlighted that the white of the marbled Sheikh Zayed Grand mosque and the exterior color of the Qana buildings created a kind of visual connectivity. Respondents commented positively

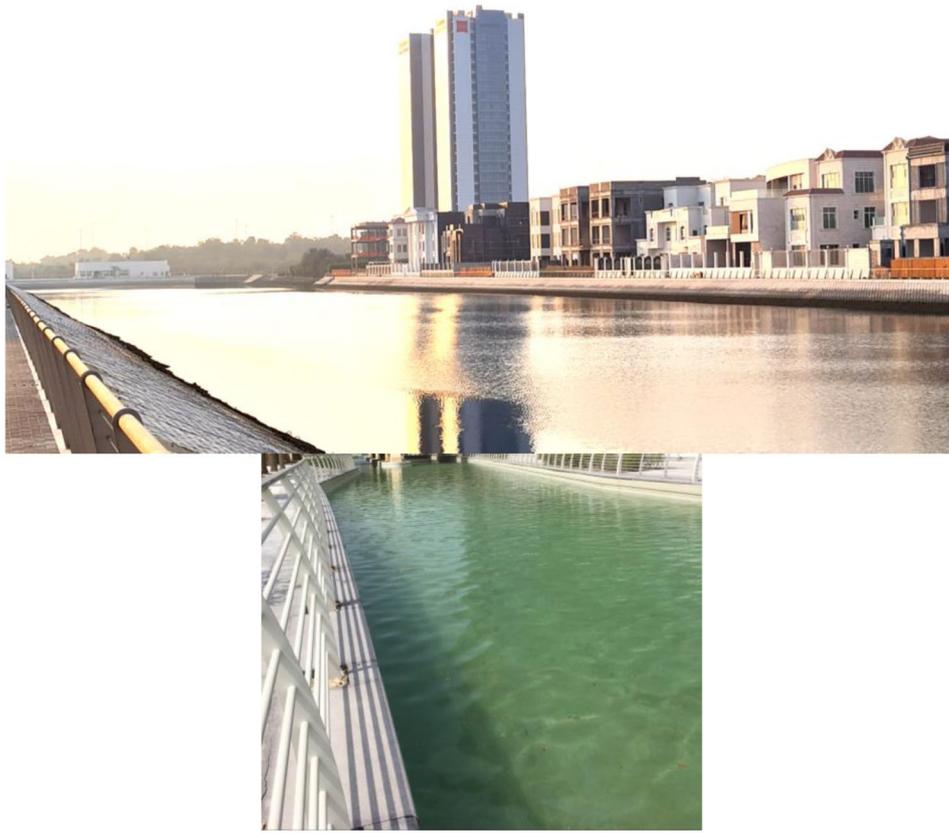


Fig. 6 Emerging high-end villas towards the end of the Al-Qana (top). Eutrophication of engineered canals in Abu Dhabi (bottom: photo by the authors)

on the separation of pedestrian and cyclist tracks and the nature-friendly landscape between cafes/facilities and waterfront. Most participants agreed that Qana would lead to gentrification of the area and that the new, modern villas that are being constructed in the vicinity of the canal are set apart from the older villas of the area. Several participants commented positively on the presence of the complex of the National Aquarium, the adjacent gym, and the indoor adventure park, which together can offer venues to all ages for family gatherings.

To measure the environmental impact of engineered canals our hydrodynamic simulations indicated when comparing the three canals; Dubai, Al Qasba and Al-Qana from hydrodynamic viewpoint, Al-Qana had the least preferable design because it is very long and terminates in an end point from one side. Hence, al-Qana from an environmental point of view is more vulnerable to contamination because our model indicated almost zero velocities especially towards its end versus water velocity of in the range of 0.3 to 0.6 m/s in Al-Qasba and Dubai canal. This means that apart from the days where wind-induced water circulation would take place, most of the days the water in the Al-Qana will remain stagnant. This is already apparent in many engineered canals that have been created on newly urbanized islands in Abu Dhabi in order to allow new towers to claim water views,

where there is absence of any marine life and the walking routes next to the canals have introduced litter in the water. Phenomena of eutrophication, i.e. of excessive algae growth, reduced oxygen content of the water, and eventual smells from the decomposition of algae, have already appeared in new canals (Fig. 7).

Conclusions

Engineered canals and waterfront developments have been used to revitalize aging parts of cities that had been dominated by industrial buildings and warehouses. Urban revitalization in U.S.A. and Europe is done after prolonged public participation in order to reach consensus on the vision, forms, and functions of the renovated areas. Aims of such interventions include transformation of abandoned areas to spaces of public use, renovation of old warehouses and industrial buildings, and retention of the historical memory and identity of a city. In contrast, in the United Arab Emirates (UAE), most waterfront developments promote forms of modern, spectacular architecture that diverge from the past, the local culture and architecture, and the city history. Revitalizing waterfront environments are important for UAE metropolitan areas to improve public health and social interactions, develop a healthy lifestyle outside air-conditioned spaces, satisfy aesthetic needs, and reduce

Questionnaire

Al-Qana Project in Abu Dhabi, on Al-Khaleej Al-Arabi Street in Al-Maqtaa area is a new addition to Maqtaa/Bayn Al-Jessrain area. We kindly request you to give your feedback about this project via this Questionnaire.



Is the Qana Project and its waterfront areas easily accessible to everyone?
Does the project provide easy approaches to the water for pedestrians and vehicles?
Do barriers—artificial or natural—block access to the water (fishing, boating, viewing)?
Does traffic and parking pose problems near the waterfront project?
What are the main strengths of Al-Qana waterfront project?
What are the social and environmental aspects of the project?
How important are visual messages, how does the project relate to Sheikh Zayed Grand Mosque and to the surrounding buildings?
Does the Qana project produce gentrification in the surrounding area, will more upscale buildings emerge?
Which parts of the project did you find most appealing? (the style of the buildings, landscape textures, Materials for flooring, the Aquarium, the Gym, indoor theme parks, the cafes)

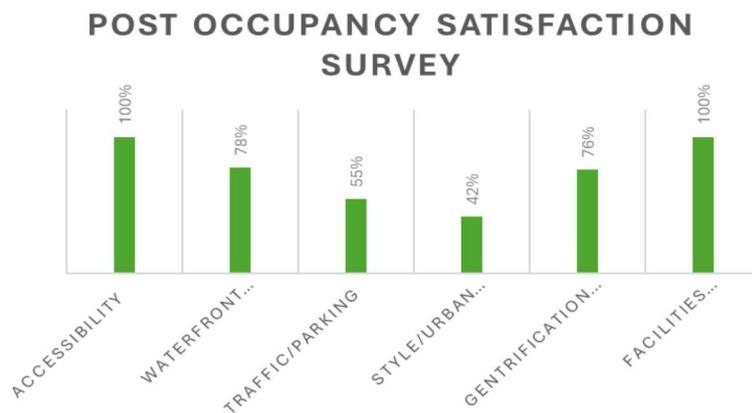


Fig. 7 Survey results of public perception of the Qana project

the effects of living in a desert region. Waterfront projects are important and need to be planned carefully to increase inclusion, diversity and liveability in modern Arab cities (Todes 2011). In addition to their social and urban impact artificial canals in urban areas have environmental impacts on their surroundings if their water quality deteriorates. Therefore, it is essential to monitor the water quality in these canals. During hot humid weather or drought, dense blooms of organisms, such as algae and cyanobacteria, and aquatic plants can form in these artificial canals. Therefore, an integral part of designing new urban areas along waterfronts or artificial canals is to access the water quality of these channels and their environmental impacts. The current success of such waterfront developments in the UAE is that they are still new and because they offer counter spaces and open-air alternatives to mega shopping malls, which were for a long time the primary public spaces for people to congregate, interact, and socialize (Oh and Gim 2021). Projects like the Qana in Abu Dhabi, the Dubai Canal, and the

Qasba in Sharjah repackage space through different design ideals creating new waterfront spaces of contrasting styles.

Acknowledgements

Not applicable.

Author contributions

All authors have original contributions to the manuscript, with approximate percentages as follows: 1st author 40%, 2nd author 30%, 3rd author 30% .

Funding

Not applicable.

Data availability

Not applicable.

Declarations

Competing interests

No competing interests.

Received: 12 November 2023 / Accepted: 27 March 2024

Published online: 12 April 2024

References

- Afrin S, Chowdhury FJ, Rahman MM (2021) COVID-19 pandemic: rethinking strategies for resilient urban design, perceptions, and planning. *Front Sustain Cities* 3:668263. <https://doi.org/10.3389/frsc.2021.668263>
- Al-Asad M (2002) Applications of geometry. In: Martin, Frishman, Hasan-Uddin K (eds) *The Mosque History, Architectural Development and Regional Diversity*. Thames and Hudson, London
- Awwal S, Borsi K (2020) Assessing the social impact of the public realm in waterfront regeneration. *Proc Int Conf Archit Civil Eng* 1(1):11–36. <https://doi.org/10.17501/26731029.2020.1102>
- Banerjee T (2001) Public space, beyond invented streets and reinvented places. *APA J Winter* 67(1)
- BCG (Boston Consulting Group) (2023) Al Qasba Canal. <https://www.bcg-uae.com/projects/al-qasba-canal/> (accessed November, 26, 2023)
- Broudehoux AM (2010) Images of power: architectures of the integrated spectacle at the Beijing Olympics. *J Architectural Educ* 63(2):52–62
- Carmona M (2015) Re-theorising contemporary public space: a new narrative and a new normative. *J Urbanism: Int Res Placemaking Urban Sustain* 8(4):373–405. <https://doi.org/10.1080/17549175.2014.909518>
- Construction Week (2020) Construction on Abu Dhabi's Al-Qana reaches 90% milestone. <https://www.constructionweekonline.com/projects-tenders/268896-construction-on-abu-dhabis-al-qana-reaches-90-milestone> (accessed September, 23 2023)
- Cugurullo F, Ponzini D (2018) The transnational smart city as urban eco-modernisation: the case of Masdar City in Abu Dhabi. In: Karvonen A, Cugurullo F, Caprotti F (eds) *Inside Smart cities: Place, Politics and Urban Innovation*. Routledge, London
- Dastgerdi AS, De Luca G (2019) Strengthening the city's reputation in the age of cities: an insight in the city branding theory. *City Territory Archit* 6(1):1–7. <https://doi.org/10.1186/s40410-019-0101-4>
- DOI 10.1007/s12132-011-9109-x
- El Amrousi M, Elhakeem M (2019) Walkability in modern Arab cities: An assessment of public space along Al-Qasba canal and lake Khaled in Sharjah. *International Conference on Human Systems Engineering and Design*, pp. 103–108. [https://doi.org/10.1007/978-3-030-27928-8_17](https://link.springer.com/chapter/https://doi.org/10.1007/978-3-030-27928-8_17)
- El Amrousi M, Elhakeem M, Paleologos EK, Misuri A (2019) Engineered landscapes: the new Dubai Canal and emerging public spaces. *Int Rev Spat Plann Sustainable Dev* 7 (3)
- Ellin N (2010) Canalscape: practicing integral urbanism in metropolitan Phoenix. *J Urban Des* 15(4):599–610
- Ellinikon (2023) The Ellinikon. <https://theellinikon.com.gr/en/> (accessed February, 26, 2024)
- Fekete A, Hodor K, Dai D (2021) Urban sustainability through innovative open space design. A novel approach to the regeneration of historic open spaces in some eastern European countries and China. *Earth* 2:405–423. <https://doi.org/10.3390/earth2030024>
- Fernández Águeda B (2009) Urban planning in industrial cities: The reversibility of decay, city futures in a globalizing world. An international conference on globalism and urban change 204–221
- Foster + Partners (2024) Projects/Ellinikon Masterplan. <https://www.fosterandpartners.com/projects/ellinikon-masterplan> (accessed February, 26, 2024)
- Frampton K (2003) The catalytic city: between strategy and intervention. In: van Oers R, Haraguchi S (eds) *Identification and documentation of Modern Heritage*. UNESCO World Heritage Centre, pp 72–78
- Froehlich D (2002) User's Manual for FESWMS Flo2DH: Two-Dimensional Depth-Averaged Flow and Sediment Transport Model. Release 3
- Gehl J (2010) *Cities for people*. Island, Washington DC
- Gospodini A (2006) Portraying, classifying and understanding the emerging landscapes in the post-industrial city. *Cities* 23(5):311–330
- Hagerman C (2007) Shaping neighborhoods and nature: urban political ecologies of urban waterfront transformations in Portland. *Or Cities* 24(4):285–297. <https://doi.org/10.1016/j.cities.2006.12.003>
- Health K (2009) *Vernacular Architecture and Regional Design: cultural process and environmental response*. Elsevier-Oxford
- Hochhalter A (2013) *Waterfront Spectacular*. Thesis –UIUC – 2013 –Landscape Architecture
- Hristić ND, Stefanović N, Milijić S (2021) Aspects of the public domain in regenerating waterfronts: a case study of Belgrade's waterfront, Serbia. *WIT Trans Ecol Environ* 253:173–181. <https://doi.org/10.2495/SC210151>
- Huang KH, Pai JT, Liu JH (2016) Study of performance assessment for urban renewal project in Taipei City. *Int Rev Spat Plann Sustainable Dev* 4(1):64–77
- Jung C, Awad J, Al Qassimi N (2021) Analyzing the users' satisfaction levels and perceptions of the Dubai Water Canal for future waterfront development in UAE. *Future Cities Environ* 7(1):14: 1–14. <https://doi.org/10.5334/fce.134>
- Khairfan L, Jaffer Z (2014) Sustainable urbanism in Abu Dhabi: transferring the Vancouver model. *J Urban Affairs* 36(3):482–502. <https://doi.org/10.1111/juaf.12050>
- Knaggs A (2019) National Aquarium in Abu Dhabi will anchor new Al-Qana complex by MZ Architects. <https://www.cladglobal.com/news.cfm?codeid=342437> (accessed December 17, 2023)
- Minnesota Historical Society (2023) Minneapolis Riverfront History. https://www.mnhs.org/sites/default/files/millcity/visit/area-attractions/mplsriverfrontwalkingtour_web.pdf (accessed January 20, 2024)
- Mohamed A–M, O, Paleologos EK, Howari F (eds) (2020) *Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering*. Elsevier Butterworth-Heinemann, ISBN: 978-0-12-809582-9, ISBN-13: 978-0128095829, 1170 pp
- Nemeth J, Schmidt S (2011) The privatization of public space: modeling and measuring publicness. *Environ Plan* 38:5–23
- Notteboom T, Pallis A, Rodrigue J-P (2022) *Port Economics, Management and Policy*. Routledge, New York, ISBN: 9780367331559, 690 pp
- Oh H-J, Gim T-HT (2021) The choice of urban spaces in the COVID-19 era. *Int Rev Spat Plann Sustainable Dev B: Plann Anal Simul* 9(4):50–66
- Olroyd-Robinson K (2006) *The Urban Architecture of Al-Bastakiyyah*. In: Damliji S (ed) *The Architecture of the UAE*. Garnet Publishing, Reading UK, pp 179–204
- Papanicolaou AN, Elhakeem M, Dermisis D, Young N (2011) Evaluation of the Missouri River shallow water habitat using a 2D-hydrodynamic model. *River Res Appl Wiley* 27(20):157–167
- Perić A (2020) Public engagement under authoritarian entrepreneurialism: the Belgrade Waterfront project. *Urban Res Pract* 13(2):213–227. <https://doi.org/10.1080/17535069.2019.1670469>
- Pittaluga P (2020) Pioneering urban practices in transition spaces. *City Territ Archit* 7(18). <https://doi.org/10.1186/s40410-020-00127-6>
- Ponzini D (2011) Large scale development projects and star architecture in the absence of democratic politics: the case of Abu Dhabi. *UAE Cities* 28(3):251–259. <https://doi.org/10.1016/j.cities.2011.02.002>
- Rausell-Köster P, Ghirardi S, Sanjuán J et al (2022) Cultural experiences in the framework of cultural cities: measuring the socioeconomic impact of culture in urban performance. *City Territ Archit* 9:40. <https://doi.org/10.1186/s40410-022-00189-8>
- RiverLife Task Force (2021) *A Vision Plan for Pittsburgh's Riverfronts*. RiverLife Task Force report to Mayor Tom Murphy and the Citizens of Pittsburgh, p. 78
- RTA (Road and Transport Authority Dubai) (2022) *The Dubai Water Canal: Case Study and Lessons Learned*, RTA report, pp. 33
- Sairinen R, Kumpulainen S (2006) Assessing social impacts in urban waterfront regeneration. *Environ Impact Assess Rev* 26:120–135. <https://doi.org/10.1016/j.eiar.2005.05.003>
- Spasojević M, Holly FM (1990) *MOBED2: Numerical simulation of two-dimensional mobile-bed processes*. Technical Report No. 344. Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa
- Statistics Center Abu Dhabi (SCAD) (2020) *Statistical yearbook of Abu Dhabi 2020*. SCAD Report, p 272
- Tabikha K (2024) <https://www.thenationalnews.com/business/economy/2024/02/27/uaes-35bn-investment-to-develop-ras-al-hikma-provides-lifeline-for-egypts-economy/>
- Todes A (2011) *Reinventing Planning: Critical Reflections*, Urban Forum (2011) 22:115–133
- Valentino M, Lutzoni L (2020) Among territorial project and architectural design. *City Territ Archit*. <https://doi.org/10.1186/s40410-020-00115-w> 7 7
- Xiao Y, Zhang Y, Sun Y, Tao P, Kuang X (2020) Does green space really matter for residents' obesity? A new perspective from Baidu street view. *Front Public Health* 8:332. <https://doi.org/10.3389/fpubh.2020.00332>
- Yıldız S, Kıvrak S, Gültekin AB, Arslan G (2020) Built environment design - social sustainability relation in urban renewal. *Sustainable Cities Soc* 60. <https://doi.org/10.1016/j.scs.2020.102173>
- Young L (2006) Villages that never were: the museum village as a heritage genre. *Int J Herit Stud* 12(4):321–338
- Zukin S (1991) *Landscapes of power from Detroit to Disney World*. University of California Press, Berkeley

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.