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ORIGINAL ARTICLE

Architectural design concept and guidelines for floating structures for tackling sea level rise impacts on Abu-Qir

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Abstract Previous studies indicate that floating structures developed through the last decades concluding that it's the most sustainable solution against sea level rise (SLR), preferring it to land reclamation approaches regarding sustainability, lifespan, and cost-effectiveness, that Egyptian researches seem to disregard. This paper guides architects and urban planners when designing floating structures by introducing new approach of floating community model and architectural design guidelines for floating structures for tackling SLR impacts on Abu-Qir. To illustrate such approach, this paper initially conducts analysis on Abu-Qir and coastal management solutions practiced as their properties provide the required knowledge for selecting the best mitigation solution for such area. Second, it conducts exploratory analysis to investigate floating structures as a more sustainable and long-term solution. Third, applying conclusions from previous sections of site analysis, mitigation solutions, and floating structures to define a floating community concept model for Abu-Qir. Findings support key arguments that traditional mitigation methods aren't sustainable or long-term solutions. Analysis demonstrate Abu-Qir Bay as the most vulnerable area to SLR. Although floating structures have demonstrated not to be the optimum solution in every case regarding cost-effectiveness and/or site suitability, however upon site analysis, it presents itself as the ideal solution for Abu-Qir bay.

1. Introduction

The primary purpose of this paper is to introduce new approach of floating community model and architectural design guidelines for floating structures for tackling SLR impacts on Abu-Qir. Research and speculation on SLR impacts on coastal areas, small islands and low-lying areas in the world have been growing at a rapid rate. In recent years,

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the study of mitigation solutions regarding tackling the rising seas challenges has dramatically increased. Over the past few years, studies on very large floating structures (VLFS) has been attracting architects, urban and city planners, and civil engineers as it has emerged as an effective solution for tackling the rising seas challenges.

This study is designed to assess two hypotheses: the Nile Delta's coastline will eventually be submerged as design strategies and coastal management practiced only offer unsustainable short-term solutions; and that floating structures may offer the optimum solution for safeguarding Egypt's coastal sovereignty when addressing land subsidence problems. This paper is set out to explore SLR impacts on Abu-Qir, furthermore, this paper highlights probable architectural design strategies and guidelines when designing floating structures for tackling the SLR challenges, to emphasize the absence of global an authorised context regarding their implementation and usage. The objectives of this paper research have been:

- To identify coastal planning strategies and mitigation solutions practiced in most vulnerable sites to SLR and their evaluation in Abu-Qir as Egypt's most vulnerable area.
- To study and analyze different coastal management and adaptation approaches executed around the world for undertaking the SLR impacts in respect to Abu-Qir Bay.
- To introduce a new approach of floating community concept model to function as a future reference for architects and urban planners when designing and planning coastal developments.
- To set architectural design guidelines for developing floating houses for Egypt and the Nile Delta coastline to asses the hypothesis made on floating structures.

This paper well deserves careful analysis on SLR impacts, adaptation approaches, and sustaining the coastal developments of Abu-Qir as it highlights the most vulnerable locations and mitigation approaches practiced. The findings of this paper introduce floating community model and architectural design guidelines for floating structures to demonstrate the benefits of VLFS as the optimum mitigation solution for tackling SLR impacts in some of the most vulnerable areas in the Nile Delta coastline and to offer a future floating structures design reference for Egypt. The more the SLR, the greater the risk on vulnerable and low-lying coastal areas around the world. Therefore, old fashioned and traditional land reclamation solutions practiced by the Egyptian Shore Protection Authority (ESPA) should be abolished and replaced by floating structures wherever possible. The distinct sustainable and flexibility features of floating buildings in settings and environments makes them preferred for their various applications and advantages. If the government applies the recommended method derived from the outcomes of this paper, it will safeguard Egypt's coastal sovereignty for the long-term wherever implementation is possible. Herein this paper, authorities are guided on what should be done to efficiently design and sustain costal urbanizations in the Nile Delta's most vulnerable locations. The study uncovers critical impacts of SLR on costal urbanizations of Abu-Qir and offers VLFS as a sustainable long-term adaptation solution that Egyptian researches seem to disregard. Therefore, a new approach on adapting to SLR concerning Egypt's Nile Delta is explored.

2. Literature review

Recent studies conducted by the Intergovernmental Panel on Climate Change [10,11] concerning mega-deltas have shown that the Nile Delta in Egypt is one of the three most vulnerable mega-deltas around the world due to their low-lying coastlines besides the Ganges-Brahmaputra Delta in Bangladesh and India, and the Mekong Delta in Vietnam. The probable one-meter SLR is anticipated to impact around 6.1 million inhabitants of the Nile Delta, while 1.5 m SLR may submerge an area around 22,000 km^2 in the Ganges-Brahmaputra Delta, impacting up to 17 million residents [6].

The Arab Environment Climate Change Report by Tolba & Saab [20] state that about 94% of Egypt's area (over one million km^2) is desert. With a population approaching a hundred million, most Egyptians only inhabit the Nile valley and the delta which make less than 6% of Egypt's area. The delta is currently withdrawing because of the accelerating erosion lengthways its shoreline. The construction of the High Dam between 1960 and 1970 has blocked great quantity of sediments in Lake Nasser which accounts as the greatest issue for erosion in the Delta.

Submerged coastlines are vital, specially to islands and low-lying areas like the Abu Qir in the Nile Delta's region [7], as it may lead to real sovereignty losses, because of the of sea borders movements. Also, as for risky areas, these losses in land areas may lead into some countries disappearances in case of island countries. The stages of SLR and Consequences [21]:

- Stage 1: SLR.
- Stage 2: Land loss.
- Stage 3: Maritime boundaries movement.
- Stage 4: Potential economic and/or sovereignty loss.

Countries will have to spend a lot of money to tackle this problem, to guarantee minimizing the possible economic and land loss. As that no country could obstruct any of the first two stages, they will have to delay the process form reaching the third stage [21]. Therefore, urban planning and development for any new and existing coastal settlements in any country, specially in Egypt's Mediterranean coastline, cannot be designed for or carried out without incorporating climate change and SLR studies and analysis.

Tolba & Saab [20] suggest that Egypt rely heavily on traditional land reclamation solutions especially in the Nile Delta's region where low-lying lands are being submerged gradually by SLR impacts. Architects, urban and city planners shift to land reclamation solutions to decrease the pressure on the current heavily busy zones and underground areas. Wang & Tay [25] state that by implementing fill materials from the seabed, mountains, as well as deep subsurface excavations, and construction wreckages, architects and urban planners are capable to make rather an enormous and respected area from the sea. Wang et al. [26] state that although land reclamation solutions can offer an unexpansive one, however, they only serve as temporary solutions, as they are unsustainable to coral reefs, and not cost-effective in areas with large depth.

Distinguished researchers [2,3,13,18] propose that future SLR impacts must be undertaken over an official adaptation. As stated by Suzuki et al. [19], the demand on different architectural and urban planning floating applications like floating