Urban Design Strategies for Intervention of Constructed Wetlands in Semi-Arid Zones:
An Application on the case of Abu Nakhla Wetlands in Doha, Qatar

By

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of
Master of Science in Urban Planning and Design

June 2014
Declarati

On

To the best of my knowledge, this thesis contains no material previously published or written by another person or institution, except where due reference is made in the text of the thesis. This thesis contains no material which has been accepted for the award of any other degree in any university or other institution.

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Abstract

With rapid economic growth and increasing population, Qatar is facing enormous challenges in protecting the environment while sustaining its natural resources (The Peninsula, 2012). Apart from pollution and natural resource shortages, limited fresh water supply and wastewater management are other challenges facing Qatar. Accelerated demographic changes and escalating industrialization due to the preparation of the upcoming mega event 2022 FIFA World Cup indicate that the country needs proper wastewater management in parallel with preservation of the native habitat. Today, many green initiatives and smart solutions can be merged together with advanced technology implemented around the world, to come up with better strategies for water management through Constructed Wetland Systems.

Abu Nakhla Constructed Wetlands marks the biggest Treated Sewage Effluent reservoir in the Gulf state of Qatar. The wetlands are considered as a good ecological and attractive habitat for various animals, as it is a refuge for the survival of these animals in the middle of the desert (Abdulfatih, et al., 2002). Recently, local authorities announced to drain Abu Nakhla Wetlands and the area rehabilitated, trusting that it is the best environmental solution (Gulf Times, 2014). This decision was made due to various reasons including residents’ complains about their health and safety concern (Raya News, 2014). In order to consider these concerns and maintain a healthier neighborhood for them, yet preserving the reservoir and its rich eco-diversity, the thesis sets guidelines and urban design strategies to support the positive demand of these parties. Its importance derives from the fact that it highlights the significance of constructed wetlands and preservation of its environmental biodiversity, especially in Semi-Arid Zones like Qatar’s where continuous draught causes threats to water and food security. The thesis studies and analyzes landscapes in the Semi-Arid zone of Qatar, emphasizing water challenges in the region. It
proposes a clearer understanding about Wetlands in general terms by identifying the different typologies and systems. The thesis applied the Case Studies Methodology for some wetlands with similar characteristics to Qatar’s climatic conditions and Abu Nakhla’s case to provide reference and guidelines for the case study. In addition, the thesis sheds light on Qatar’s perspective on Wetlands and the current use of Treated Sewage Effluent with reference to local environmental legislations. Finally, the study concludes with a comprehensive analysis for Abu Nakhla Wetlands. Accordingly, urban design guidelines and strategies are developed to sustain the environmental development, thus supporting national vision and local green initiatives. These aim for a positive contribution to the national levels in terms of economic, environmental, and social performances under four approaches of Environmental and Eco-Touristic, Food Production, Educational, and finally recreational and leisure.

*Keywords:* Constructed Wetlands; Water Security; Treated Sewage Effluent-TSE; Sustainability; Abu Nakhla; Qatar
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### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water-Quality</strong></td>
<td>The condition of the water including the chemical, physical and biological characteristics with respect to its suitability for particular purpose (Diersing, 2009)</td>
</tr>
<tr>
<td><strong>Water-Recycling</strong></td>
<td>Filtering and storing grey-water for irrigation, building, cooling, or groundwater replenishment (Bunster-Ossa I., 2001)</td>
</tr>
<tr>
<td><strong>Energy-Conservation</strong></td>
<td>Minimizing heat gain or loss through proper block layout and building orientation and through the planting of shade trees, vine structures, and vegetation that can screen or funnel prevailing winds (Bunster-Ossa I., 2001)</td>
</tr>
<tr>
<td><strong>Urban-Regeneration</strong></td>
<td>Comprehensive and integrated vision and action which leads to the resolution of urban problems and which seeks to bring about a lasting improvement in the economic, physical, social and environmental condition of an area that has been subject to change (Roberts, 2000)</td>
</tr>
<tr>
<td><strong>Bio-Remediation</strong></td>
<td>The use of organisms such as bacteria to remove environmental pollutants from soil, water or gases. It is used to clean up contaminated land and oil spills (Bateman, Curtis, &amp; McAdam, 2006)</td>
</tr>
<tr>
<td><strong>Urban-Revitalization</strong></td>
<td>A process that comprises a set of urban management strategies to facilitate economic, social, environmental, cultural and historical re-development of problematic deprived and derelict urban areas (Garcia, Spandou, Martínez, &amp; Macário)</td>
</tr>
<tr>
<td><strong>Landscape</strong></td>
<td>An element of urban infrastructure... in the context of contemporary urban development and public works, as opposed to an art historical...</td>
</tr>
</tbody>
</table>
genre, an environmental science, or an applied art (Bunster- Ossa I., 2001)

**Wetlands**
An area of land which is often covered by water or which is very marshy (Bateman, Curtis, & McAdam, 2006)

**Constructed-Wetlands**
A shallow basin filled with some sort of filter material (substrate), usually sand or gravel, and planted with vegetation tolerant of saturated conditions. Wastewater is introduced into the basin and flows over the surface or through the substrate, and is discharged out of the basin through a structure which controls the depth of the wastewater in the wetland (UN-HABITAT, 2008)

**TSE**
Treated Sewage Effluent

**Urbanism**
A lens that views and interprets a city by understanding how economic, political, social, ecological, and cultural characteristics of place affects urban form and social life (Németh, 2010)

**Urban Expansion**
Urban Sprawl, the spreading of urban development (as residential, commercial, or other use) on undeveloped land near the city

**Landscape-Urbanism**
A theory of Urban Planning arguing that the best way to organize cities is through the design of the city’s landscape, rather than the design of its buildings (Melbourne, 1995)

**Sustainability**
The ability of a process or human activity to meet present needs but maintain natural resources and leave the environment in good order for future generations (Bateman, Curtis, & McAdam, 2006)

**Biodiversity**
Creating and enhancing wildlife habitat by introducing complex,

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ecological coherent and self-sustaining landscapes wherever possible, especially along waterways, retention ponds, and wetlands through bioengineering techniques (Bunster-Ossa I., 2001)

**Urban-Agriculture**
The practice of cultivating, processing, and distributing food in or around a village, town, or city (Bailkey & Nasr, 2000)

**Infrastructure**
The system of public works with basic equipment and structures that are needed for a country, state, or a region to function properly (Merriam-Webster, n.d)

**Ecological-Footprint**
Measures human appropriation of ecosystems (National-Footprint, 2012)

**Waterfowl Habitat**
Birds ecologically dependent on wetlands (Matthews, 1993)

**Water-Security**
The availability of an acceptable quantity and quality of water for health, live hoods, ecosystems and production, couples with an acceptable level of water-related risks to people, environment, and economies (Grey & Sadoff, 2007)

**Sabkha**
An area of coastal flats subject to periodic flooding and evaporation, which result in the accumulation of Aeolian clays, evaporates, and salts, typically found in North Africa and Arabia (Oxford, 2014)

**Deep Well Injection**
Vertical pipe in the ground which water, other liquids, or gases are pumped or allowed to flow (Environmental Glossary, 1998).

**MENA**
Middle East and North Africa

**Water Aeration**
The process of increasing the Oxygen saturation of the water (Water-Aeration, 2014)
Acknowledgements

I am eternally grateful for those people who have supported me in making this thesis possible. I would like to express my deepest respect and appreciation to the department chair of Architecture and Urban Planning at Qatar University, Professor Ashraf Salamah, for his constructive comments toward the thesis.

I owe my profound gratitude to my thesis supervisors, Professor Yasser Mahgoub, and Professor Anna Grichting, who both have contributed greatly in this thesis. Their constructive comment and continuous reviews were very significant in developing a strong structure for this thesis. I would like to thank Professor Anna sincerely whom has been a true inspiration, and whose enthusiasm for Sustainable Urban Planning and Design made a significant impact and generated a great interest to me. She took keen interest in my thesis topic and guided me along, till the completion of the work. Her devotion and passion in teaching enlightened me and motivated me in every single way as it encouraged me to aspire for more knowledge. I am so thankful to her for engaging me to participate in various international conferences, workshops, and publications which has developed further skills and confidence in me.

Furthermore, I would also like to acknowledge with much appreciation the crucial role of the Faculty of the Department of Architecture and Urban Planning at Qatar University, whom provided the students with a strong foundation of good academic skills and supported me in providing permission to contact local authorities with regards to my thesis topic.

In addition, I would like to thank Ashghal Ministry of Public Works, UNESCO- Qatar, other local authorities and ministries; all were very enthusiastic and welcoming in providing me essential information and important statistics to be used.
I would like also to thank all my dear friends whom supported me, and incented me to strive towards my goal.

Finally, I especially thank my family, my father, mother, siblings, and my husband. My hard-working parents have scarified their lives for my siblings and me and provided unconditional love and care. My siblings have been my best friends all my life and I love them dearly and thank them for all their advice and support. Special appreciation goes to my beloved husband who always provided me with unfailing support and continuous encouragement. Words cannot express how grateful I am to my family and husband for all the sacrifices that they have made on my behalf.
Dedication

To my family and husband, for their unconditional support and love.
Chapter I- Introduction
1.1 Background

The topic of this thesis was triggered by a series of researches carried out by previous courses in Master of Urban Planning and Design. These include one core course and two other elective courses under the field of Urban Planning and Design. The course for “Urban Design and Regeneration” was an optional course that studied Abu Nakhla in an “Ecological Remediation” perspective. The term Urban Regeneration is a result of several factors of influences and challenges presented by urban degeneration in a particular place at a certain moment in time. It involved improving current conditions and challenges facing an urban space. Its aim was to make the best possible outcome from the current urban conditions, while tackling various aspects that include economic, physical, social, and environmental factors.

The study involved detailed analysis of the existing treated waste water pond; Abu Nakhla Wetland, Qatar. It developed a study related to social structure, physical features, and the quality of the present urban fabric. According to these analyses, Urban Design recommendations targeting the regeneration of the environmental urban areas were suggested. The study recommended a positive contribution towards long term national economic, environmental, and social performances as urban changes and designed landscapes occur gradually and over time (Mossop, 2006). In addition, regeneration scenarios and strategies for implementation were developed to be considered by the local authorities.

The second course named, “Sustainable Urban and Land Design” provided a theoretical base of understanding in sustainable urban and landscape design within the integration of both built and natural environments. It developed a positive reception towards evolving integration of design facets in urban, rural, and desert environments. The course focused on learning outcomes over working on existing case studies and projects that deploy urban-systems thinking approach. The
course highlighted urban food systems and design scenarios supporting food security, how food is vital to the organization of a city, and how it becomes a significant part of infrastructure that transforms the urban experience. Utilizing productive landscapes as tools for sustainable growth in an urban development, the study of Abu Nakhla proposed some systems focusing on maximum optimization of treated wastewater used for irrigation and landscaping purposes and recycling food waste, such as composting methods in order to sustain better and healthier environment. Furthermore, the study emphasized maximum optimization of water treatment for food production to serve local and gradually, international demands.

The third and final course, “Environmental Planning and Management” discussed major aspects of environmental analysis, planning, and management. It covered some principles related to site analysis, land use methods, and geological hazard planning. One of the vital topics drew attention to Risk and Disaster Management. Since one of the major issues threatening Abu Nakhla Wetlands is water seepage and leakage, it was interesting to investigate and conduct a study tackling Risk and Disaster Management of Water Seepage in constructed Wetlands - the case of Abu Nakhla. The study underscored the continuous increase of Treated Sewage Effluent-TSE discharge to Abu Nakhla wetlands, the consequent rise in flooding and seepage threats to the surrounding residential villages and neighboring farmlands. Additionally, the paper investigated the water seepage risk of constructive wetlands and the pollution caused by poor wastewater management in Qatar. By applying one of the Environmental Management Systems-EMS tools, the study proposed recommendations to assist local authorities with the seepage and the leakage challenges of the Abu Nakhla Wetlands.
1.2 Introduction- Overview

As the first early urban development in Qatar was recorded in 1940, the capital city of Doha was perceived to be acquiring very modest vernacular settlements. The urban fabric of the city was quite simple due to lack of significant economic income (Figure 1). This was also reflected on the infrastructure, including sewage and drainage networks. However, prior to the economic oil boom in the 1970s, Qatar witnessed a massive change within the urban expansion framework due to progressive economic status until present days. The country developed a strategy that supported urban expansion, including construction of infrastructural system and underground utilities. As Qatar was booming with construction activities and consequent rapid growth, the
demand for local infrastructure and utilities was equally rising. Shaped and driven by the
abundance of oil, sea water desalination was one of the main sources for domestic water supply.
Another factor that also contributed and encouraged further urban expansion is Qatar’s high
determination towards hosting the 2022 FIFA World cup. Qatar is seeking global recognition and
is aiming to become a leading nation in all aspects. Using sports as a catalyst for change, Qatar
was competing for a global stage in several international mega sport events. This motive of
creating a world-class image provided Qatar a great opportunity for its development in terms of
economic, education, social, and environmental aspects.

1.3 Problem Statement
In a growing metropolis, rapid economic growth provokes escalating population, and resulted in
hyper-dramatic acceleration of water consumption in Qatar within the last few decades. Currently, local authorities and mineral water companies highly depend on sea water
desalination as the main water source. In preparation for the 2022 FIFA World Cup, Qatar has
proposed to adapt various sustainable and smart solutions that would leave a green legacy. These
include adequate waste management stressing on water recycling. Such a concept can be applied
today as Qatar has limited fresh water resources due to its geo-location in a Semi-Arid Zone. On
the other hand, Qatar’s National Vision 2030 strives to diversify the economy and supports
environmental sustainability. These green initiatives and smart objectives can be merged together
along with advanced technology implemented around the world to come up with better strategies
for water management through Constructed Wetland Systems. One of the existing wetlands in
Qatar, Abu Nakhla, is rich with ecological biodiversity but also sadly threatened as it is not
wisely utilized and is confronted with various challenges. How important it is to preserve this
site and other related ones, and how we can fully utilize them in order to support the national vision, are questions which are tackled throughout this thesis.

In conclusion, the most suitable urban design strategies, recommendations, and scenarios are considered as the best practices for Qatar in reference to selected case studies and international environmental guidelines that are recommended.

1.4 Theoretical Framework- Landscape as a Living System

The terms “Urbanscape”, “Landscape Urbanism”, or the “Matrix of landscape” all refer to an urban type that is not focused on a dense middle but instead, a more fragmented matrix of discontinuous land usage. It is also increasingly perceived as a medium of city-making. However, one of Landscape Urbanism’s distinguished aspects is its crossing of disciplinary boundaries. The issue relies on the separation of human beings from nature and the consequent confusion it generates when discussing the urban landscape as “Landscape” is equated with nature. In fact, Landscape Urbanism has focused on infrastructure as one of the vitally effective public landscapes as they meet higher standards of technical efficiency. Such relationships between natural systems and public infrastructure are initiated to propose means of development of landscape infrastructure networks concerning ecological systems. The starting point here is that most permanent and enduring elements of cities are related to underlying landscapes that includes geology, topography, natural rivers, and climate. In such a case, there should be a relationship between the underlying structures of topography and hydrology and the major structuring elements of the urban form including new approaches to open systems of urban water management (Mossop, 2006). Looking at Qatar’s perspective, the country is situated in an Arid region that is categorized by crucial environmental conditions including high temperatures during summer, low rainfall measures, high evaporation rates, and low nutrition availability in
the soil. Natural and renewable fresh water resources including rainfall and ground water are scarce. These facts in addition to the continuous increase in population and economic growth raise water security concerns. Water security means having reliable access to safe drinking water at an affordable price for every individual to lead a healthy, dignified, and productive life.

The strategy of water consumption in Qatar is utilizing groundwater for agricultural purposes. Desalinated water is used to provide potable municipal water. The reclaimed treated wastewater is used for irrigation of animal fodder and landscaping. There are two main basins of groundwater in Qatar; the Northern Groundwater and the Southern Groundwater basins. Three secondary basins are referred to as Abu Samra, Doha, and the Aruma deep Groundwater basin situated in the southwest of Qatar (Figure 2).

![Figure 2 Ground Water Basins in Qatar](image)

*Source: (Darwish & Mohtar, 2012) modified by Author*
Agricultural areas are scattered where the groundwater of reasonable salinity is available for farming (Darwish & Mohtar, 2012). A local agricultural project, Roza Hassad is situated in Al Shahaniya, in the Northern Groundwater Basin (Figure 3). The project is distinguished by flower production, where irrigation systems completely rely on groundwater sources (Pierre, 2012). Statistics show the extraction of groundwater from the North Groundwater Basin and South Groundwater Basin in 2004/2005 was 220.2 mm³ (Darwish & Mohtar, 2012).

1.5 Landscapes in Arid and Semi-arid zones

There are many connotations that vary by culture and historical period for the term “arid”. For some, it implies barren wastelands, while to others it evokes landscapes of biological, cultural, and aesthetic richness. However, scientifically, aridity refers to a scarcity of moisture, in which precipitation is exceeded by potential evapo-transpiration. This indicates the amount of water that could be consumed by plants and through evaporation when unlimited water is available.
The terms aridity and drought were developed in order to analyze water scarcity (Wescoat, 1996).

Dry lands have less than 8% of the world’s renewable water resources and are challenged by extreme temperatures, frequent droughts, land degradation, and desertification (Figure 4). In addition, these lands are also characterized by poverty imbalances, high population growth, and high number of vulnerable children and pastoralists. These lands face limiting factors of water and desertification to foster economic, social, and environmental development (Pedrick, Devlin, & Timmermann, 2012).

Figure 4: Cracking phenomena of drying soil nearby a water pump station in Irkayya Farm, Qatar

Source: Author April 2012- site visit organized by Qatar University
Chapter 2- Investigating Wetlands
2.1 Overview

Wetlands are perceived as places to drain and convert to more obvious uses such as agriculture. The process has gone so far in the developed countries as the disappearance of wetlands was leading to undesirable consequences. These include loss of groundwater reserves and the consequent need for irrigation, flash floods, shoreline destruction, and many others. In addition, many useful plants and animals that are dependent on wetlands were also disappearing with them. The first article of the Convention on Wetlands clarifies the definition as “areas of marsh fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters” (UNESCO, 1994) Wetlands are extremely diverse in nature, depending on their method of formation, geographical location, and altitude. The flow of water into and out of the system is influenced by the climate and the configuration of the catchment area. The system’s capacity for storage is determined by landscape and geology (Matthews, 1993). Unfortunately, wetlands in the past were considered as sites of diseases or as obstacles to human progress. Later on, studies emphasized their importance and significant purposes such as providing wildlife habitat, serving as filters of groundwater, and assisting in flood control (Steiner, Butler, & APA, 2007)
2.2 Wetlands- Typology

There are many types of wetlands. These falls under categories related to climatic zones and typology whether they were natural or constructed/man-made. They include the following:

- Semi- Arid Wetlands
- Tropical and Sub-tropical Wetlands
- Constructed Wetlands
- Accidental Wetlands

2.2.1 Semi-Arid Wetlands

Arid Wetlands include swamps, salt pans, clay pans, lakes and springs. The water provides habitat for various types of animals and waterfowl. Arid wetlands are not associated with the
term “Wetlands” with the dry inland areas of the continent, yet a big variety of “Desert Wetlands” exist. These environments contribute to the overall ecological character as they support distinctive vegetation, and provide habitat for many wetland dependent animal species (AridWetlands, 2005)

2.2.1.1 Threats for Semi-Arid Wetlands

- Introduces grasses and other weed
- Unsustainable water extraction
- Grazing by domestic and introduced animals
- Unsustainable tourism

2.2.1.2 Impacts for Semi-Arid Wetlands

- Displaces native species and creates a greatly increased fuel load for wildfires
- Removes water available to sustain the specialized ecosystems
- Damages soil structure and vegetation and causes erosion
- Compacts soil and causes erosion (AridWetlands-Australia, n.d)

2.2.2. Tropical and Sub-Tropical Wetlands

Tropical Wetlands are referred to be among the most productive ecosystems on Earth as they contain unique aquatic and terrestrial communities high in biodiversity. Wetlands forests include organic soils of mangroves, and freshwater swamp forests that are allocated along coastlines and on coastal plains throughout the tropics. In fact, Tropical Wetlands have received little attention in scientific literature and are categorized among the lesser studied tropical ecosystems. Distinguished factors and importance for Tropical Wetlands include protection of inland areas from erosion and dissipating energy from storm surges and tsunamis. Moreover, the ecosystem
and carbon storage of Tropical Wetlands are extremely vulnerable to the negative effects of climate change. In addition, statistics record that they are among the highest reported ecosystem carbon pools on Earth with 49-98% of ecosystem carbon stored in their organic soils (Murdiyarso et al., 2011).

2.2.3 Constructed Wetlands

As defined by United Nations Habitats, a Constructed Wetland is a shallow basin filled with filtration material including sand or gravel, and planted with vegetation. Wastewater is channeled through the basin and flows over the surface or through the substrate depending on the system utilized, and is then discharged out of the basin through a structure which controls the depth of the wastewater in the wetland (UN-HABITAT, 2008). It is an engineered, marsh-like area where specially established organisms and plants feed on the organics and nutrients that are in the wastewater. Pollutants are transformed into basic elements, plant, biomass, and compost (Hairston, Stribling, & Beck, 2001). This technique provides further treatment for the water especially when recycling Treated Sewage Effluent- TSE.

2.2.3.1 Components for a Constructed Wetland

1. Basin
2. Substrate
3. Vegetation
4. Liner
5. Inlet/ Outlet Arrangement System

Constructed Wetlands have a shallow water depth ranging from 4 to 24 inches and can cover a large area. Permeable substrate (rock, gravel, sand and soil) is filled into the excavated basin where the water level is maintained to be below the top of the substrate in order to ensure that all
flow is supposed to be subsurface. The substrate is important as it supports the roots systems of the emergent vegetation, which are planted in the top surface of the substrate. The equal distribution and collection of wastewater is achieved by inlet and outlet arrangement systems. In case the protection of the groundwater is important, a liner is used (UN-HABITAT, 2008).

![Figure 6 Components of Constructed Wetlands](image)

**Figure 6 Components of Constructed Wetlands**

*Source (UN-HABITAT, 2008)*

### 2.2.3.2 Advantages of Constructed Wetlands

- Wetlands can be less expensive to build than treatment options
- Utilization of natural process
- Simple construction (can be constructed with local materials)
- Simple operation and maintenance
- Cost effectives (low construction and operation costs)
- Process stability (UN-HABITAT, 2008)
- Removal of Nitrogen compounds and Phosphorous are readily accomplished (Hairston, Stribling, & Beck, 2001)
2.2.3.3 Limitation of constructed wetlands

- Large area requirement
- Wetland treatment may be economically relative to other options only where land is available and affordable
- Delayed operational status (Hairston, Stribling, & Beck, 2001)
- Design criteria have yet to be developed for different types of wastewater and climates (UN-HABITAT, 2008)

2.2.4. Accidental Wetlands

Accidental Wetlands are considered as unintentional creation of wetlands. It is often a result of an increased storm water runoff and snowmelt collected in depressions on the surface-scape. Soil typologies mostly absorb large volumes of water prior to storm incidents. Accordingly, vegetation increases the surface area of the landscape for water retentions (PDEP, 2012). However, in other cases, manmade reservoirs tend to become accidental wetlands. They would attract variety of plant and animal species and would be accordingly rich in biodiversity. If such an accidental phenomenon was used wisely for various areas of interest such as research, recreation, and tourism, a lot of economic value would consequently generate to serve and support national economy (RAMSAR, 2011).

2.3 International wetlands alliances and preservation communities

There are many international wetlands organizations and alliances that mainly seek to preserve, maintain, and enhance some of the world’s most prominent and distinguished wetlands that are either in danger or significant. Some of them include Ramsar Convention on Wetlands, the Okanagan Wetlands Regeneration Alliance and Wetlands. The following text will provide further information about what each organization aims for and how it was established.
2.3.1 Ramsar Convention on Wetlands

In an Iranian town of Ramsar on the 3rd of February 1971, the representatives of 18 nations across the globe put their signature among the text of a remarkable treaty. Seeking to conserve natural resources on a global scale, the Ramsar Convention was the first modern initiative concerned with the most threatened group of habitats, the wetlands. International action was vital for various reasons. Many wetlands lay crossover national boundaries or their water is supplied from neighboring countries; therefore, the circulation of water in the atmosphere is international. In addition, water birds, migrating over thousands of kilometers twice a year, also ignore these boundaries and need the wetlands of many countries to rest, feed, and breed. Finally, for the developing countries to use their wetlands wisely, there must be international arrangements for the provision of technical and financial aid. The Ramsar Convention is based in Gland, Switzerland and is funded by the subscriptions of the conventions’ Parties (Matthews, 1993).

2.3.2 Wetlands International

Dedicated towards wetlands conservation and restoration, Wetlands International is a global non-profitable organization that is deeply concerned about the deterioration and loss of wetlands. The Vision of Wetlands International is a world where wetlands are treasured and nurtured for their beauty, the life they support, and the resources they provide. The organization is dedicated to maintaining and restoring wetlands as they are distinguished by their environmental values and the services they provide to people.

Most of the organization’s work is funded on a project basis by governmental and nongovernmental donors. The organization is supported by membership of government and Non-Governmental Organizations- NGOs (Wetlands International, 2012)
Activities of the organization range from field work to research and advocacy, and are a significant part of various international conferences and summits concerning the environment and wetlands preservation. The organization’s field work emphasizes sustainable development and land planning.

2.4.0 Wetlands Management

Maintenance of sources of water is required for successful wetland sites management. In order to maintain a wetland management plan, there are many functions that are involved within such processes (Figure 7). These processes include the following:

1. Identifying the objectives of site management:
   The first function is important as it frames the scope of work to be achieved in regards to the ecological character of the site, and other prominent features including cultural, and educational values.

2. Identifying the factors that affect or might affect the characteristics of the wetlands:
   Achieving wise use of wetlands is influenced by some factors; these include trends, constraints, and obligations. In this function, it is important to identify all factors that have impacts on the wetland site including the ecological character.
3. Resolving Conflicts:

Most sites confront various difficulties in identifying properties ownership and perhaps some conflicts of interest, therefore it is mandatory to resolve these conflicts throughout the planning process.

4. Defining monitoring requirements:

In order to measure the effectiveness of the management and acknowledge that objectives are achieved, a monitoring process is required as an essential aspect of the management plan.

5. Identifying and describing the management required to meet planned objectives:
Some cases where habitats require some action regarding safeguarding, a plan identifying the objectives of the management is necessary. It also describes and estimates the cost of the action to be taken.

6. Maintaining continuity of effective management:
   In this function, management processes shall be adapted to meet a wide range of varying factors. Continuity of monitoring is equally important to the continuity of management.

7. Obtaining resources:
   Identifying and quantifying the resources required is a must for management planning. This supports and justifies bids for resources.

8. Enabling communication within and between sites, organizations, and stakeholders:
   Presenting information in a structured and accessible format is vital for management plans and management planning process as it will inform others about the site, management aims, and management process.

9. Demonstrating that management is effective and efficient:
   Those who are in charge of developing the plan are required to demonstrate that they are making the best use of resources and that management is anticipated to be effective.

10. Ensuring compliance with local, national, and international policies:
    Policies, strategies, and legislations are to be met with the management plan. Some policies however may be contradictory and one of the functions could integrate the various policies as a consequence.
2.4.1 Islamic Water Management:

The Islamic law, Sharia, meant “the Law of Water”. The Arabic word ‘Ma’ which is water, is mentioned 63 times in the Quran and has specific religious significance for Muslims through the performance of various Islamic rituals including *Wudu*, ablution, and *Ghusul*, bathing (Figure 9). There are many international water law principles that are developed in accordance with Islamic values and principles as these laws are in parallel with universal values. In reference to Islamic understanding, water is perceived as a gift from God that all creatures have the right to drink. It should be apportioned equitably for other uses. In addition, relevant universal values are embodied in the emphasis of Islam on protecting and preserving water and its ecosystems by avoiding any harm (Wickström, 2010).
Islam has supported water conservation practices throughout the society by inducing saving water and using water more wisely. All humans are dependent on water for their survival; therefore it is very crucial to preserve it for sustaining a better future for the next generations (Ahmad, 2011). An Islamic approach to the environment reflects how water is perceived in Muslim society. In reference to Islamic laws and customs, human beings are the first priority for water supply, followed by animal watering and agricultural purposes; industrial uses come Fourth, and recreational fifth (Abderrahaman, 2000). One of the main issues over time is water conservation as it is linked to water scarcity. The rapid population growth throughout the world
raises concerns about water security. Countries across the globe regardless of their wealth are confronting rising concerns over the amount of safe drinking water available. In reference to Islamic principles, Prophet Mohammad (Peace Be Upon Him) warned against waste in various Hadiths\(^1\) and used a minimal amount of water for daily life use as most of the Islamic essential rituals depend on water for cleanliness and purity (Ahmad, 2011).

On the other hand, reuse of wastewater effluent for irrigation, has been perceived as possible and accepted. According to Islamic laws, effluents are considered pure after removal of impurities by proper technical treatment. As Islam is a dynamic religion that responds to changing conditions, reuse of wastewater for various purposes in order to conserve the limited water resources especially in Arid and Semi-Arid lands is a major concern of leading Islamic scholars, water scientists, and decision makers. Following intense research and investigation about the reuse of wastewater, the Fatwa\(^2\) declared that “impure wastewater can be considered as pure water and similar to the original pure water, if its treatment using advanced technical procedures is capable of removing its impurities with regard to taste, color, and smell, as witnessed by honest specialized and knowledgeable experts. Then this cleaned water can be used to remove body impurities and for purifying and drinking. If there are negative impacts on human health from its direct use, then it is better to avoid its use, not because it is impure but to avoid harming human beings. The CLIS\(^3\) prefers to avoid using it for drinking (as far as possible) to protect health and not to contradict human habits” (Abderrahaman, 2000).

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\(^1\) Hadiths- Collection of sayings and deeds of Prophet Mohammad (PBUH) that report the Sunnah (Practices) which Muslims aim to implement into their daily lives (Ahmad, 2011)

\(^2\) Fatwa: The consensus of opinion of the council of Ulamah, ‘Counsel of Leading Islamic Scholars [CLIS]’

\(^3\) CLIS: Counsel of Leading Islamic Scholars
2.4.1.1 Water in the Islamic Garden

In Islamic teaching, Water resembles purity which is a significant virtue in Islam. Fountains and bodies of water are conspicuous in many Islamic park areas. Also, water is used as a connection element between vegetation and architecture (Yu, 2010). It has a significant impact on architecture and landscape in Islamic civilizations as its presence is very common in various public buildings and private houses. Basins, fountains, and pools are of a decorative characteristic in mosques, traditional Arab houses or ancient palaces. Moreover, some buildings and palaces are rich with greenery and gardens which somehow recall the idea of the Islamic Paradise, a place with abundant water and rich vegetation, an image that is found in the Qura’an many times (Gilli, 2004). In fact, the constant flow of water not only provides a sense of movement but also cools down the temperature as most ancient Islamic societies were experiencing crucial climatic conditions (Bödeker, 1996). In addition, Islam supports planting and gardening as it generates various benefits for the people, and environment. Prophet Mohammad said: “If a Muslim farms the land or plants a tree, and then a bird, a beast, or a man eats something from it, he receives in return the reward of a charity” (Ahmad, 2011). Designed landscapes and gardens in various cultures have roots in the agricultural landscapes which were referred to as the initial expression of civilizations. For instance, Islamic Gardens evolved from dry fields that required irrigation (Yu, 2010).

2.4.2 Contemporary Water Management

Due to increasing uncertainties caused by climate and global change in addition to changing socio-economic boundary conditions, water management is facing major challenges. Moreover, sustainable water management has in fact become an issue including environmental, human, and technological factors. Water management is a purposeful activity with multiple and partly
conflicting goals in order to maintain and enhance the state of water resources. In many areas, the available water is polluted and therefore cannot be used for various purposes or requires expensive treatment. Factors including uncontrolled urbanization like the case of Doha, Qatar and fast industrialization in developing and threshold countries contribute to exacerbate the pressure on water resources. Water management techniques and systems have developed over time as more emphasis is being paid toward environmental preservation and broader awareness of the concept of sustainability is being implemented (Figure 10). For instance, the idea of Adaptive Water Management has been discussed since 1999. It refers to a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies. In other words, it is defined as “learning to manage by managing to learn”. On the other hand, some radical changes are believed to be required for water management. These include, shifting from technical management to a true integration of human dimension, and making management more adaptive and flexible to make it operational under fast changing socio-economic boundary conditions and climate change (Pahl-Wostl, 2007).
Governments recognize the vital economic and environmental role that wetlands play in supporting human life and biodiversity, according to a United Nations-backed report (UNEP, 2012), it emphasizes that the protection of wetlands is essential for countries to transition into resource-efficient and sustainable economies. Policies and decisions often do not take into account the many services that wetlands provide – thus leading to the rapid degradation and loss of wetlands. There is an urgent need to put wetlands and water-related ecosystem services at the heart of water management in order to meet the social, economic and environmental needs of a nation. According to United Nations Environmental Program- UNEP, half of the world’s wetlands were lost during the twentieth century –mainly due to factors such as intensive agricultural production, unsustainable water extraction for domestic and industrial use, urbanization, infrastructure development and pollution. The continuing degradation of wetlands

Figure 10 Segregation of water as a sustainable solution of water management

Source: (RAMSAR, 2010)
is resulting in significant economic burdens on communities, countries and businesses (UNEP, 2012).

Environmental Impact Assessment- EIA of projects affecting wetlands directly, or impacting their support systems such as groundwater, river flow, or migratory species, is essential to sound environmental management and the sustainable utilization of wetland resources. However, EIA will only be effective as part of a wider strategy for four reasons. First, the results of EIA often show adverse effects which, for some people, make it a "negative approach" impeding “development”. Second, EIA takes time and generates hostility through delays in project implementation. Third, where EIA is the only defense for wetland resources, EIA reports can be commissioned or "bought" by those seeking to change wetlands. Finally, EIA studies are normally concentrated on the largest and best known wetlands, but small wetlands should not be destroyed without an evaluation of the functions at risk.
Chapter 3 - Case Studies
3.0 Overview

Defined by researcher Yin, the case study research method is an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 2009). The key strength of the case study method involves using multiples sources and techniques in the data gathering process. Tools to collect data can include interviews, documentation review, observation, site visit, and even the collection of physical artifacts (Soy, 1997). The case study methodology is used to develop a better understanding of wetlands in particular areas of the world that are slightly similar to Qatar’s climatic conditions. They are used to emphasize detailed contextual analysis of various conditions and their relationships. The study of numerous urban design characteristics in each case is intended to establish a foundation where significant principles could be applied to Abu Nakhla.

The cases are divided into two categories, Semi-Arid Zones Wetlands and Subtropical Wetlands. The first category studies Wadi Hanifa Wetlands in Riyadh, Saudi Arabia, and Al Wathba Wetlands in Abu Dhabi, UAE. Whereas the second group, highlighting the subtropical wetlands studies, analyzes Putrajaya Wetlands in Putrajaya, Malaysia, and Hong Kong Wetlands Park in Tin Shui Wai, Hong Kong (Figure11). Data was gathered from various resources including journal articles, documentary short films, personal observation through site visit, and online websites. The structure of the study in each case focuses on three major aspects. These include general overview about the case, clarifying its geographical location, historical background, and significance. The second aspect highlights the context of the wetlands in terms of the Urban Design contextual features, and other amenities the project provides. The third part of the
analysis emphasizes the features of the case study which indicate distinguished elements and concepts that are adapted in the project giving the case more significance and value.

Following the case studies is the comparison table that provides better understanding between the relationships of these cases. As it evaluates each case through stressing on several aspects, it is intended to improve the analysis and accordingly, setup a framework for Abu Nakhla’s case. The final part of this chapter concludes the lessons learned from each case and signify the importance of some features and how can they be achieved in Abu Nakhla.
3.1 Semi-Arid Constructed Wetlands

The following Wetland case studies are situated in Arid and Semi-Arid zones; each of a similar zone like that of Qatar’s. The first zone is Wadi Hanifa Wetlands in Riyadh, and the second is Al Wathba Wetlands, Abu Dhabi.

3.1.1 Wadi Hanifa Wetlands

Wadi Hanifa is a natural water drainage course located in the middle of Najd Plateau in Riyadh, Saudi Arabia. Wadi Hanifa covers an area of 4,000 km² (Figure 12). As many parts of the valley have gone through several environmental harms, local development authority has deployed a development strategy aiming for ecological remediation. The project involves landscaping, public spaces of recreational areas, development of adjacent agricultural land, and wastewater treatment facilities that provide further water resources for the surrounding rural inhabitants (Aga-Khan, n.d).

The main concept is to reflect the name of a “living valley” or “living Wadi” and bring it back to health. The vision of the project seeks to transform problems of the Wadi into opportunities, and sees Wadi Hanifa as a clean, green, safe, and healthy environment. The project integrates architectural interventions, master planning, landscaping, architecture, signage, and urban furniture. Through an eco-driven strategy, the project also permeates the water through a bio-remediation facility.
3.1.1.1 Wadi Hanifa Wetlands Overview

Wadi Hanifa is perceived as the source of life in the middle of the desert. Its significance goes back to ancient centuries where monuments and historical ruins were found aged 3,500 B.C. It also has a wide range of agricultural activities and production (Whatmore, 2010).

By taking advantage of water, stone, and arable lands, the Saudi Kingdom strategically allocated its capital city at Addiriyyah on the West bank of Wadi Hanifa. Subsequently, the city of Riyadh was developed along the Eastern side of the Wadi, up until the rapid urban expansion started in the mid-1970s. The city and the Wadi were both in harmony as the Wadi was used as a sustainable resource for water and food. The Wadi was exploited to support the increasing demand of water arising from the rapid growth of the capital city. By the 1980s, the water resources in the Wadi could not cope with the increasing demand. In order to meet this new level
of demand, the water was being supplied from the desalination plants pumped from the eastern coast of the kingdom. However, this caused the problem of the rise in the groundwater level, which was necessary to control. Wadi Hanifa provided a solution for this necessary control by discharging the groundwater into the Wadi. While on the other hand, dry weather flows created attractive microclimates for various plants and wildlife communities; yet, it was perceived as a sewer because of its poor water quality conditions, smell in some areas, and was considered as a health hazard in others (Samhouri, 2010).

As stated by Eng. Al Sheikh, rapid urban expansion following the economic boom, which began 70 years ago in Saudi Arabia’s history, resulted in massive negative impacts upon the Wadi’s environmental conditions. The Wadi became a hazardous dump for construction, industrial,
hydrocarbon, and domestic waste. Industrial waste composing of chemical and solid forms also caused further pollution and contamination to the water of the Wadi. Thus, the Wadi was transformed to swamps filled with contaminants, and poisonous lakes which accordingly decreased the relevant agricultural activities and the overall vegetation cover. Also, the Wadi was full of public utilities serving the unplanned settlements along it. In addition, the condition of suburban and rural architecture and urban design declined, as the image of the Wadi was deteriorated. All these were challenges that local planning development authorities had to tackle in order to enhance and save the environment (Whatmore, 2010).

3.1.1.2 Wadi Hanifa Context

The Arriyadh Development Authority- ADA appointed British firm, Buro Happold, as consultants along with their Canadian Landscape Architect partners, Moriyama and Teshima, in 2001 to develop the Wadi Hanifa Comprehensive Development Plan- WHCDP. The plan framed a 10 year program of works that aimed to restore and develop Wadi Hanifa as an environmental, recreational, and tourist resource (Figure 13). The construction works implementing the master plan were divided into two parts: The Wadi Hanifa Restoration Project, and Wadi Hanifa Development Program. The Restoration Project involves construction works required to restore flood performance and water quality, and to complete the restoration of the Wadi bed. The Development Program is formulated around public infrastructure and public landscape capital construction works which along with private sector investment projects will build on the platform provided by the Wadi Hanifa restoration project to complete the implementation of the WHCDP (Samhouri, 2010).
A series of natural stone weirs were built in order to introduce oxygen into the water as it passes over and through them and helps to reduce the amount of pollution in the Wadi. 

Source: (Aga-Khan, n.d)

The Arriyadh Development Authority- ADA realized the environmental concerns and challenges threatening Wadi Hanifa and conducted various short and long-term plans (Figure 18). These include the following:

- The Wadi has been declared as a protected and preserved natural area in order to gain the ecological balance of the Wadi and its surroundings.
- Transporting the construction vehicles and stopping the debris dumping activities.
- Reducing construction of public utilities works along the Wadi and maintaining continuous monitoring work regarding the environmental aspects of it.
- New regulations were made supporting the Wadi in terms of spreading environmental public awareness and setting new laws to protect Wadi Hanifa.
• The Wadi was outlined with buffer zones and water flow paths were secured in order not to protect its contours.

• The projects tackled the deteriorated sections first and most damaged areas that required to be remediated.

• 500,000 m³ of contaminated construction, industrial, and domestic waste was removed from the Wadi to achieve the vision of the project.

• Adjustment of water levels and maintaining the water flow movement towards the South were the second steps in the project.

• Organization of water discharge and seasonal torrents including floods.

• Construction of 30 km long public utilities networks that serves the Wadi and its surrounding settlements directly, including transforming overhead telephone and electrical cables to underground ones combined with water pipelines.

• Construction of new roads intersecting with the Wadi.

• These involved bridges, water canals, and crossways serving neighboring farmlands and residential villages (Whatmore, 2010).

3.1.1.3 Wadi Hanifa Features

The city of Riyadh consumes approximately 1.3 million m³ of water, and this number is forecasted to reach 3 million m³ by the year 2021. Due to the city’s continuous increase in population and demand on water supply, alternatives shall be found to cope with such increasing demand. Arriyadh Development Authority- ADA seeks to recycle one million cubic meter of water per day by year 2021 in order to meet a third of the city’s total water demand. To achieve this, it is required to clean up the water entering the Wadi. By introducing oxygen into the water, various beneficial outcomes are generated (Figure 14). A Coliform bacterium present in the
water is increased accordingly, allowing organisms to grow, and adding to the natural cleaning of
the water (Figure 15). In fact, similar methods were used to support this concept such as
constructing new stone-lined channel which introduces Oxygen into the water as it passes over
and through them; this allows microorganisms to grow and thus act as a part of a food chain for
other various species (Samhouri, 2010).

By providing environmental enhancement, ecological habitat for the wildlife, and recreational
public space, wetlands provide many benefits other than wastewater treatment. Moreover,
constructed wetlands are credited with remarkable savings in terms of wastewater treatment
costs. They are intended to implement additional treatment polishing the secondary effluent

Figure 15 this project is already successful in providing water treatment while creating a one-of-a-kind natural facility and open-space public attraction

Source: (Aga-Khan, n.d)
treatment by the mechanical system. Thus, they are a proven technology for removal of waste water contaminants and pollutants. However, wetland effluent is then discharged to surface water to be utilized for landscaping and irrigation purposes; resulting in an effluent that meets AWT-advanced water treatments standards (Sheikh, 2011)

Analyzing Wadi Hanifa, the project involves constructed wetlands for waste water treatment as it receives sewage from treatment plants. The received water carries high concentration of harmful chemicals such as BOD-Biochemical Oxygen Demand, suspended solids, and others. These chemicals can be effectively removed by the constructed wetlands through processes of aggregation, sedimentation, and interception. Aggregation is defined by Merriam-Webster Dictionary as a group, body, and mass composed of many distinct parts, whereas Sedimentation is the action or the process of forming or depositing sediment otherwise known as settling. The last process Interception is the action of interrupting stopping, or seizing a progress (Sheikh, 2011).

**Wadi Parks**

Following the vision of the project, seven parks were constructed on site and two are anticipated to be completed in a while, one of them being a large water park. The parks are developed with supporting services, amenities, and an adequate parking space for visitors’ convenience (Figure 16). Preserving traditional and cultural values of outdoor picnicking, all parks were designed to accommodate hundreds of families. Instead of developing European themed parks, The Wadi Hanifa Master Plan recommended that Wadi be landscaped as naturalized desert parkland that is adaptable with the local environment and the ecology of the city of Riyadh. This resulted in a harmonious design that blends with the existing nature and surroundings. However, three of
these parks emphasized the water bio-remediation by implementing water treatment facilities (Whatmore, 2010).

Figure 16 Interpretative trails that wind their way throughout the Wadi allowing the public to access the area easily and to direct them to places of interest

Source: (Aga-Khan, n.d)

**Bioremediation facility**

As clean water generates potential for recreational outdoor attractions and public spaces; enhancing the water quality of Wadi Hanifa through bio-remediation facility forecasts better long term opportunities for the Wadi. The facility cleans the water naturally through various processes of biological functions.

**3.1.1.4 Impact of the project**

The rehabilitation of the Wadi has strengthened the cultural identity of the residents by re-linking them with the origins of their social fabric, to a time when people inhabited the area (The Hanifa
Tribe). As the very first human settlement in this dry region took place in the Wadi and continued to the rise of the modern city of Riyadh, a fact that gives the Wadi more significance rises and it is that the ruling family of Al Saud is originally from this area, which is the Hanifa Tribe (Samhouri, 2010).

On the other hand, the project was very popular among the residents across various social classes as the park allowed fair levels of privacy respecting the local culture and traditions (Figure 17). Semi-closed areas where families can utilize for the day, without being disturbed by adjacent families, were designed to meet local people’s convenience (Samhouri, 2010).

![Figure 17 Developing a major part of the Wadi Bed Naturalized Parkland and Recreational and Interpretative Trail, to get early public participation and use of the Wadi environment](image)

*Source:* (Aga-Khan, n.d)

The project has a significant impact tackling the educational aspect. Rich diversity of flora and fauna is found in various areas across the Wadi which proved to be an attraction to many school programs, educational institutes, and research centers. Moreover, the bio-remediation facility
with its distinguished large scale and its informative signage is considered as the most interesting and attractive scientific experimentation facility. It is visited by various groups of the environmentally aware of the contemporary generation (Samhouri, 2010).

Figure 18 Wadi Hanifa Project Illustrative Map

Source: (Wadi-Hanifa, 2010)
3.1.2 Al Wathba Wetlands Overview

Al Wathba Wetlands Reserve was created by an accidental discharge of over-capacity TSE from Al Mafraq Wastewater Treatment Plant. Gradually, it developed as a suitable habitat for migratory birds and a breeding area for the Greater Flamingo. It was officially declared protected by the late president of the United Arab of Emirates, Sheikh Zayed Bin Sultan Al Nahyan in 1998 to support his vision. The reserve covers a total area of 5 km² and is managed by Environmental Agency- Abu Dhabi- EAD. Al Wathba Wetlands are home to approximately 250 species of birds that rely on the wetlands for resting, feeding, or breeding. Moreover, it provides a safe refuge for various species of reptiles, small mammals, and insects. The wetlands gained international recognition when the Greater Flamingo successfully bred at Al Wathba in 1999 (Figure 20). Moreover, Al Wathba has been recently declared as an official RAMSAR site-wetlands of international importance designated under RAMSAR Convention on wetlands. EAD undertakes regular monitoring for the area, as protecting such area is very crucial in the preservation of Abu Dhabi’s biodiversity. In order to ensure better protection of this fragile area, Al Wathba Wetlands is currently closed to the public (EAAD, 2013).
3.1.2 Al Wathba Wetlands Context

Al Wathba Wetland Reserve is located approximately 40 km south-east of Abu Dhabi, the capital city of the United Arab Emirates-UAE. The reserve has an estimate area of 3.7km X 1.9km, resulting in a total of 450 hectors (Figure 19). The site is composed of water bodies that are engulfed by sand dunes and is managed by the Environment Agency- Abu Dhabi (EAD).

The lakes occupy an area of inland Sabkha. As a result, the lake shows salinity regimes that vary spatially and temporarily (Abdelfattah & AL Meharibi, 2005).

Currently, the area is outlined by a fence which excludes desert predators that would affect the birds’ life in the protected area. In reference to scientific and ongoing research, breeding season is continuous at Al Wathba Site where it reaches its peak period in April (Kosztolanyi, et al., 2009).
3.1.2.3 Al Wathba Wetlands Features

Al Wathba Wetland has two main roles which are to provide breeding habitats for the Greater Flamingo, and to conserve biodiversity in all its forms (Figure 21). The first recorded breeding of the Greater Flamingo in the Arabian Peninsula was recorded in 1999 at Al Wathba Wetland (FlamingoBreeding, 2004). Al Wathba Reserve is one of the most important inland wetlands in the UAE. Mixed vegetation communities dominate the lake, whereas reed beds are allocated along the margins of the less saline water bodies (Saji & Whittington, 2008).

As the Environment Agency- Abu Dhabi undertakes the supervision and monitoring of the protected area, Al Wathba Wetland Reserve is currently closed to the public to ensure better protection of the fragile area. However, the reserve receives a limited number of students and birdwatchers (EAAD, 2012).
Figure 21 Industrial complex and Mafraq Sewage Treatment plant viewed from Al Wathba Wetlands

Source: (Radan, 2013)
3.2.0 Tropical and Sub-Tropical Constructed Wetlands

3.2.1 Putrajaya Wetlands Overview

The case study of Putrajaya Wetlands was considered throughout a site visit that was organized by Qatar University through The Department of Architecture and Urban Planning in March 2013. As an educational field trip shedding the light on the architecture and urbanism of selected cities in Malaysia, the city of Putrajaya was visited to explore the New Urbanism strategies and Urban Design concepts that were implemented in the city. In fact, Putrajaya wetlands mark a distinguished element that adds a unique character, and beauty.

The city is developed to be Malaysia’s new Federal Government Administrative Center and referred to as an intelligent city in a garden. A 197 hectare man-made lake lies in the center of the city, which was created by damming the Sg. Chuau and Sg. Bisa. Putrajaya Wetlands is ranked as one of the largest constructed wetlands in the tropics. Storm water treatment of such
scale by using constructed wetlands has been rarely undertaken elsewhere. The lake gives the city a distinctive character and identity transforming an oil palm plantation site, into a wetland ecosystem (Figure 23). In order to ensure that the water entering the lake is clean and suitable for body contact or recreational use, a sustainable approach was adopted by constructing a series of wetlands to treat the catchment runoff before it enters the lake. The construction of these wetlands began in March 1997 and was finished by August 1998, targeting storm water pollution control in a tropical zone such as Malaysia (Huat, 2002).

Putrajaya Wetlands aim for many goals classified under three categories which are environmental, educational, and recreational. Under the environmental category, the design aims to create self-sustaining and balanced lake ecosystems, developing a natural habitat for the conservation of wetland flora and fauna. The educational aspect seeks establishing an

Figure 23 Putrajaya Wetlands viewed from Putrajaya International Convention Center
Source: Author March 2013
environment that is suitable for public education and scientific research on wetlands. On the other hand, the recreational aspect seeks developing a pleasant environment that enhances the quality of life and is referred to as a touristic destination; also improving the water quality to be suitable for body contact recreational activities (Figure 24).

Figure 24 Wawasan Bridge Putrajaya is one of the visually striking icons along Putrajaya wetlands  
Source: Author- March 2013

3.2.1.2 Putrajaya Wetlands Context

Putrajaya Wetlands is divided into two components which are the Taman Wetland Putrajaya and Lake Recreational Center; where the first serves as the public face and the gateway to Putrajaya Wetlands and the other is a water recreational spot (TamanWetlands, 2013).
Figure 25 Taman Wetlands Putrajaya is an educational, touristic, and recreational hub in Putrajaya

Source: Author March 2013

The constructed wetland system is composed of six arms with twenty-three cells, where all arms-excluding one, discharge the treated storm water to the main central wetland (Appendix A). Even though they are connected, they differ in depth, size, plant typology, and pollutant load. The design of the wetland involves a multi-cell, multi-stage system with flood retention capability in order to maximize the space available for colonization by water plants. The plants are vital for water treatment and filtration. In addition, the plants provide root zones where bacteria and microorganisms can flourish to assist in filtering (TamanWetlands, 2013).

In Malay, the native language spoken in Malaysia, the word “Taman” means “Park”. The Wetlands Park or Taman Wetlands is an attractive eco-touristic destination that was personally visited during the 2013 Qatar University educational field trip of the Department of Architecture and Urban Planning (Figure 26). The park is allocated at the highest peak of the wetlands and has
a Look-out Tower which enables visitors to overlook the wetlands, the forest, and the city of Putrajaya. The tower also allows bird watching and is very distinguished as it has various informative signs about the natural habitats and the native environment. The tower is approximately 25 m high (Figure 27).

As a person walks through the park, they can view the many native trees which were planted, protected, and labeled by their names, indicating interesting facts about them. The Park also involves a Nature Interpretive Center that is approached by a canopy bridge of wooden material, which is harmonious with the surroundings as it is embraced within clusters of tropical trees. The center is an interactive exhibition where visitors acquire interesting information and knowledge about the wetland system and learn more about the native habitat (Figure 28).
The wetlands park has a wide range of facilities which include the Water Recreational Center, Green House, Moroccan Pavilion Garden, Putrajaya Botanical Gardens, and waterfront restaurants. The water recreational Center hosts various water sport activities that would attract visitors to participate and attend. The green house and the Botanical gardens seek to educate the public and spread environmental awareness about native tropical and other plant typology. Finally, the Moroccan garden and pavilion is another interesting feature that showcases decorative ornamentation and design related to the Moorish architecture.

3.2.1.3 Putrajaya Wetlands Features

Prior to the design phase of the constructed wetlands was a comprehensive study for the catchment conditions involving terrain, drainage, soil, geology, topography, hydrology, and ecology associated with land use changes. Hydrologic and water quality modeling aimed to
quantify the hydraulic and pollution loading rates by forecasting the potential development conditions to maintain the desired water quality standards. The design of the wetlands aimed to achieve retention and disposal of various catchment pollutants that involve nutrients, and other contaminants. The shaping of wetlands morphology, sizing, wetlands contouring, hydrology design, selection of vegetation and plant layout were all crucial for the design and performance of the wetlands.

As wetlands design is generally composed of a combination of vegetated area and open water, a river inlet zone is constructed at Putrajaya Wetlands at the head of each wetlands system. This serves as controlling incoming flows and it is lined with rocks to generate energy, reduce flow velocity, and maintain distribution over the sedimentation basin (Figure 25). The vegetation
plays an essential role in promoting wetland’s performance as they take up nutrients directly, trap sediment, and support plantation growth. In order to ensure sustainability of the botanical design of the wetlands, the use of native wetlands’ species is adopted. The distribution of the plants in Putrajaya Wetlands involved around 70 species that were mapped while their growth was monitored. Factors such as native species, ease of propagation, availability, aesthetic value and the ability to transfer Oxygen to the roots were taken into consideration when selecting the plants. In addition, as wetlands construction may result with excessive mosquito breeding, stocking of special kind of fish was applied in order to control such phenomena.
3.2.2.0 Hong Kong Wetland Park

3.2.2.1 Hong Kong Wetland Park Overview

Located in the southern side of Deep Bay, northeast of Tin Shui Wai- originally meaning the “Sky” and the “Water” Village in Chinese, The Hong Wetland Park-HKWP is a manmade constructed wetland. The 64-hectare park has fresh water marshes, mangrove habitats, and is considered as a significant environmental hub where visitors are guided from the main visitor center to explore various outdoor nature related facilities.

HKWP arose as a result of series of coincidences coming along during the late 1990s as there was a high demand to develop new towns in the New Territories Islands of Hong Kong (Figure 29). The area of Tin Shui Wai was a rural area known with its farmlands, fishponds, and large natural wetland that is located in a delta area which discharges fish water into Deep Bay. In addition, the area is the route of migratory birds heading South in winter, therefore it is
distinguished by a large diversity of habitats which enrich these birds with nurturing feeding grounds. Recently, due to the urban expansion, the area was chosen as a location for large scale residential development (Lin & Chen, n.d). Therefore, this fact has encouraged the development of HKWP to compensate the loss of natural habitats arising from the urban development of the new town, in addition to creating tourism attractions for sustaining a long-term growth of the tourism industry (EnvironmentalConcepts, n.d).

![Figure 30 Hong Kong Wetland Park Map Guide showing all facilities and context of the park](image)

**Source:** (HKWP, 2014)

The project aims to foster public awareness, knowledge, and understanding of importance and values of wetlands in order to gain public conservation and support in preserving and appreciating wetlands. Its main objective is to gain international recognition as being a significant wetland site for eco-tourism to serve visitors, researchers, and people of such interest to the wild life (AFCD, 2004).
3.2.2.2 Hong Kong Wetland Park Context

The HKWP is implemented in two phases. Phase One was completed in 2000 where it included the development of the Exhibition Pavilion, and landscape forecourt. These served as an early venue for the park’s publicity and promotion in spreading environmental public awareness. However, Phase Two was under planning and development till late 2005. The second phase included the construction of indoor visitor centers with 3 main exhibition galleries, indoor and outdoor play areas, classrooms, a resource center, and other recreational and dining spaces (Figure 30) (AFCD, 2004). The park has some zones which are not accessible by the public. This was planned to preserve the wetlands, as it is vital for the upkeep of the wetland water system. For instance, reed beds and some other large storage ponds are developed to supplement the proper functioning of the water system (EnvironmentalConcepts, n.d). Moreover, the visitors’ facilities are divided into two main components; they include indoor visiting venues and outdoor exhibits areas (EnvironmentalConcepts, n.d).

The Main Visitor Center Building:

The visitor center is nearby the entrance of the site and the urbanized area of Tin Shui Wai. It follows a series of displayed gardens, exhibition ponds, and leads to the satellite building. It is hidden, as it is embraced within the natural landscape and vegetation to maintain the overall natural outlook of the project, giving the impression of a green hill rising above the entry plaza (Figure 31). In order to maximize the energy efficiency, the roof is landscaped and designed to be oriented to minimize solar gain and allows it to achieve low thermal transfer value. Moreover, it involves skylights that are utilized to maximize natural lighting, especially in the central atrium. Timber louvers are employed along the external surface of the curtain wall of the building, they aim to provide shading to the building’s interior, and act as a visual barrier to the
waterfowl species overlooked. It houses various exhibition galleries over two stories (EnvironmentalConcepts, n.d). It exhibits and displays wetland systems in various parts of the world (Appendix B). Through an interactive learning concept, the center integrates artificial streams and planted marshes with numerous wetland species (Lin & Chen, n.d).

Satellite Building Discovery Center:

This building is an educational center that is situated between the two large water marshes and connects to an outer zones area dedicated to bird-watching, in what they call, a Bird Hide. The Bird Hide is a 1 to 3 story high building that is located nearby a mud flat and tidal channel (Lin & Chen, n.d). The center is referred to as an outdoor classroom that encompasses a series of boardwalks to the bird hides allocated along the wetland and nearby the RAMSAR site. It is
considered as an outdoor classroom that is surrounded by interpretive zones that enable visitors to investigate and explore the life forms found in water bodies, and learn how the wetland park is managed and the how the water levels are manipulated by various mechanical devices. It is designed to collect rainwater for water recycling scenarios, and relies on natural ventilation where heat is minimized through the employment of timber louvers. (EnvironmentalConcepts, n.d). The park also features a boardwalk which is embraced within the mangroves and provides an exciting experience for visitors.

3.3.3.3 Hong Kong Wetland Park Features

HKWP has adapted many features in order to enhance the wetland environmental system and to also attract people around the world, to explore such unique environmental urban spaces. Some
features include the installation of artificial bird nests and bat boxes. The artificial nests and boxes are also included in the visitation area where various sizes were installed and the supervision of these boxes are conducted on a regular basis throughout the breeding seasons (AFCD, 2011).

Figure 33 Artificial Bat Box installed in Hong Kong Wetland Park

Source: (HKWildlife, 2007)
### 3.3.0 Case Studies Analysis

Table 1 Case Studies Analysis

<table>
<thead>
<tr>
<th>Wetlands Profile</th>
<th>Semi-Arid Wetlands</th>
<th>Tropical and Sub-Tropical Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Wadi Hanifa Wetlands</td>
<td>Al Wathba Wetland Reserve</td>
</tr>
<tr>
<td><strong>Typology</strong></td>
<td>Natural and Constructed</td>
<td>Accidental Constructed</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>In the middle of Najd Plateau in Riyadh, Saudi Arabia Wadi Hanifa</td>
<td>40 km south-East of Abu Dhabi</td>
</tr>
<tr>
<td><strong>City, country</strong></td>
<td>Riyadh, Saudi Arabia</td>
<td>Abu Dhabi, UAE</td>
</tr>
<tr>
<td><strong>Size/ Scale</strong></td>
<td>120 km stretch, covers an area of 4,000 km²</td>
<td>5.00km²</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Reflecting the name of a “living valley/Wadi” and bringing it back to health</td>
<td>Wild life preservation</td>
</tr>
</tbody>
</table>

**Ecological Components** **

<table>
<thead>
<tr>
<th>Geomorphic Setting</th>
<th>Semi-Arid Wetlands</th>
<th>Tropical and Sub-Tropical Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural drainage valley</strong></td>
<td>Located in 24.7</td>
<td>Situated in the desert, caused by an accidental</td>
</tr>
<tr>
<td><strong>Located in 24.7</strong></td>
<td>Located at a natural existing delta of Kam Tin River and</td>
<td>Located at catchment area of Sg. Chuau</td>
</tr>
</tbody>
</table>

---

4 Ecological Components are employed from (RAMSAR, Handbook 18- Managing Wetlands: Frameworks for managing Wetlands of International Importance and other wetlands sites, 2010)
<table>
<thead>
<tr>
<th>lat. and 46.6 long (Distance Calculator, 2013).</th>
<th>discharge of wastewater treatment plant located in 24.25 lat. and 54.6 long (Distance Calculator, 2013).</th>
<th>nearby a RAMSAR SITE Located in 22.4 lat. and 114.0 long (Distance Calculator, 2013).</th>
<th>and Sg. Bisa. Located in 2.9 lat. and 101.69 long (Distance Calculator, 2013).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate:</strong></td>
<td>Hot, arid, low rainfall</td>
<td>Hot, arid, low rainfall</td>
<td>Rainy, hot, and humid</td>
</tr>
<tr>
<td><strong>Flora/fauna</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Habitat Type</strong></td>
<td>Desert wild life</td>
<td>Desert wild life</td>
<td>Tropical</td>
</tr>
<tr>
<td><strong>Plant Communities, vegetation zones and structures</strong></td>
<td>Desert habitat</td>
<td>Desert habitat</td>
<td>Tropical rainforest</td>
</tr>
<tr>
<td><strong>Subtropical forest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Animal Communities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Main Species present</strong></td>
<td>Birds</td>
<td>Flamingos</td>
<td>Frogs, fish, and others</td>
</tr>
<tr>
<td><strong>Aquatic conditions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water regime</strong></td>
<td>Natural drainage course that utilizes bio-remediation facilities</td>
<td>Treated waste water</td>
<td>Natural and constructed wetlands</td>
</tr>
<tr>
<td><strong>Construct wetlands with storm water treatment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Connectivity of surface waters and of groundwater</strong></td>
<td>Connectivity of groundwater, as it feeds the ground water</td>
<td>No connectivity to surface water as it is located in the desert</td>
<td>Connected to a natural drainage channel that is connected to the sea</td>
</tr>
<tr>
<td><strong>No connectivity to sea water as it is located in an inland zone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water turbidity and color</strong></td>
<td>Continuous filtration and runoff character provides further treatment to the water. Color is clear</td>
<td>Water is not clear as further treatment to the water shall be provided</td>
<td>Green-ish as it is sweet water</td>
</tr>
<tr>
<td><strong>Brownish to red-ish depending on the shallowness of the water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water Salinity</strong></td>
<td>Semi-saline</td>
<td>Saline</td>
<td>Sweet</td>
</tr>
<tr>
<td><strong>Semi-sweet</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water quality</strong></td>
<td>Good</td>
<td>Bad as further treatment to be provided</td>
<td>Bio-remediation is provided through reed beds. No human contact with water</td>
</tr>
<tr>
<td><strong>Good for body contact as many treatment is provided for storm water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ecosystem Services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinking water for humans and/or livestock?</td>
<td>No, used for irrigation and farming</td>
<td>No</td>
<td>No, used for irrigation and farming</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------</td>
<td>----</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Water for irrigated agriculture</td>
<td>Yes</td>
<td>No, could have the potential</td>
<td>Yes</td>
</tr>
<tr>
<td>Water for industry?</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Water Purification/waste treatment or dilution</td>
<td>Yes, has a bio-remediation facility</td>
<td>Waste water discharged is previously treated</td>
<td>Yes, through reed beds</td>
</tr>
<tr>
<td>Usage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food for Humans</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Food for livestock</td>
<td>Yes</td>
<td>`No</td>
<td>Yes</td>
</tr>
<tr>
<td>Wood, reed, and fiber and peat</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Medical Products</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Biological Control agents for pests/diseases</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Flood control, flood storage</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water sports</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nature study pursuits</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other recreation and tourism</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Educational Values</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Cultural Heritage</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Contemporary Cultural Significance</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
</tr>
<tr>
<td>Importance for research</td>
<td>Bio-remediation facility</td>
<td>Birds breeding</td>
<td>Wetlands and habitat</td>
</tr>
</tbody>
</table>
3.4.0 Case Studies- Conclusion

Many lessons were learned from the previously examined case studies. Covering two different climatic conditions, yet having similar characteristics of hot climates, the case studies showcased many interesting strategies that could be implemented.

In the Wadi Hanifa Wetlands case, the main objective was to bring the valley back to life. Situated in a conservative society, the design of the park adapted many design strategies and principles to deal with social privacy restraints with various urban furnishing and landscape designs. Also, as the Wadi has a long history of being the savior for the habitats in the middle of the desert, treatment facilities and design strategies were implemented to sustain such vision. By constructing rocks, vegetation, and having the bio-remediation facility, the water gets circulated and goes through continuous filtration to ensure that it is useable for food production and human contact. Another interesting feature in the design is how it respects the local climatic condition and natural landscape by planting the park with native plants, and making it in harmony with the surrounding natural landscapes.

On the other hand, Al Wathba Wetland Reserve displayed the role of government and legislations in preserving such environmental haven that contributes to the overall ecosystem. Following the rulers vision, the wetland is an accidental discharge caused by an adjacent Wastewater treatment plant. Here, one can argue that the vision is excellent in terms of natural preservation, yet, not well developed in terms of having various amenities and services to the public to spread environmental awareness. It is believed that implementing a master plan that aims to preserve the wildlife, while educating and entertaining the public, would add further value to the space. Since it is referred to as one-of-a-kind in the Gulf, the legacy shall continue to educate the public and support research.
Moving away to the tropics, Putrajaya Wetlands are designed to serve a mixed use development of a New Urbanism. It mainly focuses on storm water pollution control, creating an environment that is suitable for native wetland flora and fauna, and providing an environmental public awareness while serving scientific research on wetlands. It is perceived that Putrajaya’s new development could emphasize touristic and aesthetic concerns; yet, the project is believed to be well planned and developed as it also includes various research centers and botanical gardens that serve food production. In such large-scale development, the vision could not be achieved immediately; instead it is a long term process that will be acquired within numerous years.

Finally, in a rapid urban development of Hong Kong, local initiatives toward promoting eco-tourism and the natural environment were clear when the HKWP project was developed. Various environmental sustainable measures, in terms of the park’s design was taken into consideration. Moreover water treatment was provided through adapting the reed-beds principles and the circulation of water. On an educational aspect, centers for research and interactive educational venues were developed to maintain educational awareness and learning experience to visitors. Such initiatives could be taken into consideration when planning and developing a wetland park of Abu Nakhla.
Chapter 4- Qatar’s Perspectives on Wetlands
4.1.0 Wetlands hydro-scape in Arid and Semi-Arid Zones

Most of Arid and Semi-Arid Zones evapo-transpiration rates are higher than actual rainfall (Figure 34). Therefore, very few of the wetlands in such zones are supported by locally generated water supplies as they are usually fed by runoff and/or groundwater flows from higher and moister parts of the basin. In Semi-Arid and Arid Zone wetlands, the outflow is usually less than the inflow; thus making the concentration of salinity very common. Since these wetlands are very limited in such areas, they are considered to be special places for humans and wildlife. They attract urban development as they tend to have a surfeit of the scarce Arid Zone, water (Hollis, 1990).

![Figure 34 Illustrative diagram explaining the Evapo-transpiration process](EvapoTranspiration)

4.2.0 Unlocking TSE potentials in Qatar

The principal objective of wastewater treatment is to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment (WastewaterTreatment, 1992). The most appropriate wastewater treatment to be applied before effluent use in agriculture is that which will produce an effluent, meeting the recommended
microbiological and chemical quality guidelines both at low cost and with minimal operational and maintenance requirements (Arar & Pescod, 1988). Adopting a low level of treatment is desirable especially in developing countries, not only from a cost aspect but also in acknowledging the difficulty of operating complex systems reliably.

Ashghal Public Works Authority is in charge of conducting infrastructure projects and related amenities following international standards and specifications in Qatar. Projects under Ashghal’s umbrella include Sewage Treatment Plants, Water Drainage Networks, Groundwater Network Management, and TSE Networks (Figure 35). Currently, there are three main Sewage Treatment Plants; Doha South Treatment Plant, Doha West Treatment Plant, and Doha North Treatment Plant which has been established recently (Table 2) and (Figure 36).
Table 2 Comparison between the usages of TSE discharged from plants in Qatar

*Source:* (Ashghal, 2010)

<table>
<thead>
<tr>
<th>Treatment Plant</th>
<th>Capacity</th>
<th>Current amount</th>
<th>landscaping</th>
<th>Agriculture</th>
<th>Sand Washing</th>
<th>Deep well injection</th>
<th>TSE Lagoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doha South Treatment Plant</td>
<td>106,000 m³</td>
<td>125,000 m³</td>
<td>20,000 m³</td>
<td>25,000 m³</td>
<td>-</td>
<td>40,000 m³</td>
<td>40,000 m³</td>
</tr>
<tr>
<td>Doha West Treatment Plant</td>
<td>135,000 m³</td>
<td>135,000 m³</td>
<td>40,000 m³</td>
<td>60,000 m³</td>
<td>4,000 m³</td>
<td>5,000 m³</td>
<td>-</td>
</tr>
<tr>
<td>Doha Industrial</td>
<td>12,000 m³</td>
<td>5,000 m³</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>64,000 m³</td>
</tr>
<tr>
<td>Doha North Treatment Plant (expected)</td>
<td>244,000 m³</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 36 Doha Sewage Treatment Plants location map

The Treated Sewage Effluent- TSE is recycled and used for various purposes according to local demand. These include irrigation and landscaping purposes involving beautification of roads’ intersections, and highways’ ornamentation (Appendix C). In addition, TSE is used for animal
fodder on local farmlands. It is also used for industrial and commercial use, including construction and sand washing, central cooling distracts and deep well injection (Ashghal, 2010).

In reference to the above table, the analyses indicate that there is a large percentage of unutilized TSE water (Figure 37). It is believed to be for various reasons which include the rapid increase in population growth as the number was almost doubled within the years 2004-2008. Also, the urban development expansion through a very short period of time including massive construction works and mega projects (Ashghal, 2010).

![Figure 37 Qatar's TSE usage](source: Ashghal, 2010)

Currently, sewage water disposal in Doha-Qatar is being recycled for beneficial objectives and as an environmental approach. This TSE treated sewage effluent is being re-used for various purposes. For instance, landscaping, animal fodder farmlands, sand washing plants, and cooling districts that consist of a central cooling unit which distributes cooled TSE in order to cool offices; whereas sufficient TSE is discharged to a significant reservoir known as Abu Nakhla Lagoon (Al-Hamar, 2012). The lagoon is distinguished with being a vibrant ecosystem as it is known for rich vegetation, occupancy by a variety of birds, and several animal species. On the other hand, it pumps treated water for adjacent farmlands that support animal fodder.
The State of Qatar has limited fresh water resources. The state’s Wetlands have so much potential, if they were well managed, they could serve the local irrigation water demand. One of Qatar’s Wetlands, Abu Nakhla, marks the biggest TSE reservoir in the state. Abu Nakhla Lagoon was constructed in 1979 to store tertiary treated wastewater for irrigation and landscaping use and to grow animal fodder (Osman & Babiker, 2012). It is located approximately 12 kilometers of the outskirts of the city of Doha, Qatar along the Southern borders of Abu Nakhla Village (Figure 38). Treated municipal water from Doha-West and Doha- South Waste Water Treatment Plants are discharged to the wetlands on a regular basis. The lagoon is elevated approximately 37 to 38 meters above sea level, while the water depth is found to range from one to two meters. The capacity of the wetlands is 5 million square meters, taking 2 km length by 2 km width. During rainy seasons, the water level emerges without changing the outer boundaries of the wetlands. Since 2006, the borders have been fixed so it does not flood and damage the surrounding areas (Osman & Babiker, 2012).
Statistics record that due to the Deep-Well Injections that were implemented in 2009, the wetlands had received 80,000 cubic meters of discharged tertiary and/or advanced treated wastewater daily in 2010, which was reduced to 23,000 cubic meters daily in 2012 (Ashghal, 2010). Treated Sewage Effluent- TSE was discharged directly to the roads’ landscaping irrigation network, while the superfluous TSE is pumped to the wetlands. However, as the demand has recently increased, the TSE amount has increased accordingly. According to (Ashghal, 2010) Irkayya, Hassad, and Al Rafa’a, farmlands are now assigned to cultivate animal fodder utilizing TSE for irrigation purposes, pumped from Abu Nakhla (Figure 39). Sand Washing processes in adjacent plants are also integrated to reduce the salinity of the sand for construction and agricultural purposes.
### Table 3 Abu Nakhla TSE discharge details
*Source:* (Ashghal, 2008)

<table>
<thead>
<tr>
<th>Abu Nakhla Wetlands Details- dated 29 Dec. 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Flow m³</strong></td>
</tr>
<tr>
<td><em>(Al Nuaija&amp; Al Saliyah STWs)</em></td>
</tr>
<tr>
<td><strong>Ground Injection (approx)</strong></td>
</tr>
<tr>
<td><strong>Lagoon Level in cm</strong></td>
</tr>
<tr>
<td><strong>PS 32 Levels in m</strong></td>
</tr>
</tbody>
</table>

**Figure 39 Irkayya Farm by Hassad Qatar Project**
*Source:* Author, April. 2012 - During a site visit organized by Qatar University

### 4.2.1 Challenges confronting Abu Nakhla Wetlands

The rapid population growth in Qatar is resulting in a massive flow of TSE to Abu Nakhla Wetlands and other relative reservoirs. Local authorities have given so little attention to the impact of the produced water quality of Abu Nakhla Wetlands towards the environment (Abdulfatih, et al., 2002). Recently, the amount of waste water discharged regularly to Treatment[^72]
Plants exceed the plant’s capacity. Scientists in the area question the quality of the TSE pumped out of the processing plant as they believe it is not well treated and has traces of organic matters, microorganisms, salts, and gases (Abdel-Wahab, 2012). Abu Nakhla wetlands which are a TSE reservoir were initially situated a few kilometers away from the city to protect residents from being housed within a semi-polluted environment (Appendix D). Due to the rapid urban expansion, the wetlands in addition to Sewage Treatment plants become more embraced within the boundaries of the residential neighborhoods, threatening public health. Additionally, there is a risk of water seepage to these surroundings.

In reference to local newspapers, Abu Nakhla Wetlands is accused of threatening the surrounding residential neighborhood. Surprisingly, the wetlands are perceived as an untreated waste water pond that generates illusions of the dreadful resulted consequences. As described by (Abdullatif, 2011), the wetlands are surrounded by earthen barriers that are intended to avoid water leakage. However, these walls fail to stop the water seepage and thus result in muddy polluted areas engulfing the residential quarters (Abdullatif, 2011). Others highlighted the fact that Abu Nakhla Wetlands is the biggest waste water storage in the state, which causes a great risk toward the surrounding areas. It stresses on the fact that urban expansion of the Industrial Area is problematic as it threatens the lives of the workers living in the area (Abu Nada, 2013). Moreover, the Wetlands are addressed as a habitat for those who had escaped from justice since the area is surrounded by high dense reeds (Al Kabbani & AL Mari, 2013).

Another challenge concerns the use of TSE versus the desalinated water supply. Qatar’s treated waste water is limited to some agricultural and landscaping uses. Statistics record that approximately 25% of municipal water supply is treated. Qatar is an Arid country that is categorized by crucial environmental conditions including high temperatures during the summer,
low rainfall measures, high evaporation rate, and low nutrients availability in the soil. Natural renewable fresh water resources including rainfall and ground water are scarce. Moreover, the continuous increase of population and economic growth raises concerns about water security. Water security indicates having reliable access to safe water at an affordable price for every person to lead a healthy, dignified, and productive life (Darwish & Mohtar, 2012).

Only one third of the municipal waste water is treated, recycled, and reused for the irrigation of crops and landscaping. However, the water sustainability in Qatar is believed to be at risk; as the consumed renewable water used including rainfall and ground water, is several times more than its replenishment rate. Records state that municipal water depends entirely on desalination of sea water which consumes energy, and utilizes unsustainable measures (Darwish & Mohtar, 2012). In fact, most of the supplied municipal water is of potable quality. This water is however being wasted away and misused in services that do not require much of high quality water such as garden irrigation, washing cars, flushing toilets, and other relevant activities.

4.3.0 Local initiatives towards sustainable Wastewater Management

There are various local green initiatives that work in parallel with Qatar National Vision - QNV2030 in addition to the Qatar Ministry of Environment MOE. Many concepts were established to maintain sustainable and healthy environments including international conferences, local environmental legislations, and campaigns. For instance, a very remarkable recent global event is hosting the UN Climate Change Conference- COP18 in Doha 2012. The mega event expanded local public environmental awareness as various interactive booths and activities were among many educational, commercial and recreational attractions in the city.
4.3.1 Qatar National Vision 2030- QNV 2030

In 2006, Qatar National Vision 2030- QNV2030 was released by General Secretariat of Development Planning. It is composed of four main pillars; including Human, Social, Economic, and Environmental Development. The Environmental Development pillar involves environmental management that embraces harmonious balance among economic growth, social development, and environmental preservation. It deals with local environmental challenges such as the impact of diminishing water and hydrocarbon resources, the effects of pollution and environmental degradation. Moreover, the vision supports a balance between development needs and environmental protection including air, land, and water diversity through several aspects. Some of them include a comprehensive legal system that protects all environmental elements and quickly responds to challenges as they arise. In addition, it involves a comprehensive urban development plan for Qatar that adopts a sustainable policy with regard to urban expansion and population distribution (GSDP, 2008).

Table 4 Qatar National Vision Pillars and objectives Source: (GSDP, 2008)

<table>
<thead>
<tr>
<th>Qatar National Vision 2030- context</th>
<th>Sector’s objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Human Development:</strong></td>
<td>1. To promote human’s health by avoiding health hazards and providing healthy food</td>
</tr>
<tr>
<td>- Health</td>
<td>2. To educate people about the local ecosystem in terms of nature and animal species</td>
</tr>
<tr>
<td>- Education</td>
<td></td>
</tr>
<tr>
<td><strong>2. Social Development:</strong></td>
<td>1. To provide a public urban space accessed by all social classes including adjacent social minorities</td>
</tr>
<tr>
<td>- Social care and justice</td>
<td></td>
</tr>
<tr>
<td>- Social structure</td>
<td></td>
</tr>
<tr>
<td><strong>3. Economic Development:</strong></td>
<td>1. To promote eco-tourism for educational and economic advantages</td>
</tr>
<tr>
<td>- Suitable Economic</td>
<td></td>
</tr>
<tr>
<td>- Diversification</td>
<td></td>
</tr>
<tr>
<td><strong>4. Environmental Development:</strong></td>
<td>1. To create a public environmental awareness</td>
</tr>
<tr>
<td>- Balance between Development needs and protecting the environment</td>
<td>2. To serve local needs in terms of natural public spaces</td>
</tr>
</tbody>
</table>
4.3.2 Green Qatar 2022

On the other hand, The Green Qatar 2022 Plan report issued by Qatar Supreme Committee 2022 highlighted the importance of applying a high environmental waste water management system. It emphasized on the importance of generating more renewable energy sources that would contribute to carbon neutral event. Moreover, Qatar 2022 FIFA World Cup bid has also included sustainability oriented enterprises (FIFA, 2010).

In reference to the country’s preparation of the mega sport event, FIFA world Cup 2022, treated waste water can be utilized for irrigation purposes of sport fields, outdoor infrastructure, and landscaping services (Abdelfattah & AL Meharibi, 2005). As a result, this would support the country’s national vision2030 in terms of creating a sustainable natural environment. Therefore, investing in recycling wastewater, along with renewable energies such as implementing a solar park, is believed to form a sustainable approach in terms of a future ecological balance. This however, will contribute in creating a green environment, hydro-carbon independent nation for the future mega event, FIFA 2022 as the bid aimed to develop “Green Qatar 2022” through an emphasis on achieving sustainable approaches.

4.3.3 Qatar National Food Security Program- QNFSP

In addition, local authorities have developed Qatar National Food Security Program-QNFSP to increase local agricultural production. The program follows the national vision QNV2030 in terms of obtaining a sustainable environment and diversified economy through securing energy and water requirements. As Qatar has limited fresh water resources, the program develops sustainable scenarios in order to achieve the national vision. For instance, sea water desalination industrial plants operating via solar energy is anticipating to provide sufficient water resources for agricultural needs. This however, will reduce the demand on natural underground water as it
will be acting as reservoirs. Investing in advanced technologies aiming to reduce expenses by generating solar energy of the desalination process is considered as an environmental degradation (QNFSP-Programme, 2011).

Irkayya Farmlands are believed to be a supporting project for QNFSP- Qatar National Food Security Program that would increase local agricultural production (Figure 40). The program follows QNV- Qatar National Vision2030 in terms of obtaining a sustainable environment and diversified economy through securing energy and water requirements. As Qatar has limited fresh water resources, the program develops sustainable scenarios in order to achieve the national vision (QNFSP-Programme, 2011).
4.3.4 Global Sustainability Assessment System- GSAS/ Qatar Sustainability Assessment System- QSAS

Defined as Global Sustainability Assessment System, GSAS/QSAS is a sustainability rating system in the MENA region. It is developed by the Gulf Organization for R&D- GORD with T.C Chan Center at the University of Pennsylvania, USA. The system addresses locally relevant aspects of sustainable urban environment in order to reduce the environmental impacts, yet satisfying local communal needs (GSAS/QSAS, 2013). Previously known as Qatar Sustainability Assessment System- QSAS, the system has gone through various revisions and was developed to be applied globally. GSAS/QSAS developed a standalone building energy standard that supports Qatar’s building energy rating in addition to addressing locally relevant aspects of sustainability, ecological impact, and green building design criteria. The criteria of GSAS/ QSAS are divided into eight categories that are of different weights, each with distinguished environmental stress mitigation and can measure a different aspect of the project’s environmental impact (GSAS/QSAS, 2013). The system was developed to encourage and promote the design, construction, and operation of responsibly and sustainably built environments. The forth criteria of GSAS/QSAS is named “Water” which is dedicated to rate the goals, environmental impact, and mitigation factors of the project (Figure 41) (GORD, 2013).

Working in the construction industry in Qatar, a lot of experience and knowledge about GSAS/QSAS was acquired. Currently it is expanding and becoming a mandatory legislation to follow for many contractors conditioned and requested by clients. The client’s consultant tends to specify the exact rating of GSAS/QSAS that the contractor shall deploy with reference to the client’s demand. Many aspects of the system involve pre-construction environmental legislation including Waste Management and recycling, Dust Control, Water recycling and more.
4.3.5 Central Cooling Districts- Qatar Cool Company:

Urban District heating has been used for centuries, starting from the United States by having a central boiler plant which provides steam to neighboring residents and other users. Most of the early systems distribute steam produced from a reciprocating engine that was primarily used to generate electricity. These early systems use the heat lost during the generating process to produce steam. In the twentieth century, Centralized Electrical Generating Systems continued to be the principal energy source for District Heating and Cooling. District Heating Systems are thermal energy networks which distribute hot water or steam through insulated pipes for commercial, residential, institutional, and industrial uses. It is used for space heating, and industrial purposes (National Academy Press, 1985). Recently, District Cooling has emerged as a
result of the advanced technology in pipe insulation, valves, and consumption monitoring systems (QatarCool, 2014). The system permits energy as distinguished from fuel, to be bought and sold as a commodity (National Academy Press, 1985). District Cooling entails the production and distribution of chilled water from a central location to be used for air-conditioning purposes. The chilled water is produced at a central cooling plant, and then pumped through a network of underground insulated pipes to customers’ buildings. The chilled water absorbs the heat of the water used for air conditioning through an energy transfer process once it is received at the customers’ building. Then, water returns back to the cooling plant to be re-chilled and re-pumped through the same piping network. (QatarCool, 2014).

In 2003, Qatar Cool District Cooling Company was established by Qatar United Development Company - UDC and UAE’S National District Cooling Company- Tabreed to provide environmentally friendly services that are aligned with the Qatar National Vision 2030. It provides continuous chilled water and District Cooling services to the public, commercial, and industrial sectors of Qatar. Currently, the company owns and operates three cooling plants covering the West Bay, and the Pearl- Qatar districts (Figure 41) with approximately 290 million tons of refrigeration sold. The company maintained to annually eliminate 250 million kilograms of Carbon Dioxide from the atmosphere (QatarCool, 2014).
4.3.6 Water Conservation Awareness campaign- Tarsheed Qatar

In 2010, the water consumption of municipal water in Qatar of potable quality reached 1.02 million m³/day which is 375 million m³/year while the population was 1.7 million. This gives an estimate of 600 Liters per day per capita of water consumption, which ranks one of the highest worldwide. The primary reason for such a high consumption of potable water is the politically motivated law excluding some customers from payment. The Qatari nationals get water without any payment, whereas the expatriates make 80% of the population pay a highly subsidized price of about $1.2/m³ about 35% of the real cost (Darwish & Mohtar, 2012). Under the slogan of “Keep Qatar Pulsing. Consume Wisely”, Tarsheed Qatar National Campaign was launched in 2012 by Qatar General Electricity and Water Cooperation- KAHRAMAA to raise awareness about water conservation and efficient use of water and electricity (Peninsula, 2012). Through public involvement and interactive participation, the program continues to educate the people
and engage them with various relevant activities including public events, short film challenges, interactive social networks and other activities.

4.4.0 Completed and ongoing Projects for solving the Abu Nakhla’s crisis

References show that treated waste water in Qatar is utilized according to local demands. TSE is supplied for landscaping and irrigation purposes, and animal fodder. In addition, it is discharged for some industrial and commercial use. A good example that can be referred to is the operation of the D-Line Project. It connects the Doha West Treatment Plant to Irkayya Farm and the Sand Washing Plants as shown in (Figure 42) (Ashghal, 2010).

![Figure 42 Geographic map illustrating D-Line which discharges TSE from Doha West Plant to Abu Nakhla to Irkayya Farmlands](source: Ashghal, 2010)

4.4.1 Abu Nakhla Defense Wall Project

Local government has developed some strategies to tackle environmental problems and health disasters that might occur in the area due to the rise of the water level of Abu Nakhla Wetlands.
Wells and underground pumps were constructed next to the existing treatment plants to reduce the amount of water discharged to Abu Nakhla Wetlands. Moreover, Ashghal, Qatar Public Works Authority has set strategies to develop the area’s irrigation booster set that pumps treated water to targeted farmlands (Ashghal, 2010). Ashghal has also maximized the size of Abu Nakhla’s Dam (Figure 43) to prevent the leakage of the treated water beyond the borders of the wetlands and thus avoid environmental pollution that could be generated. Following the drilling and injection works that were conducted to monitor the environmental impacts of the TSE discharged to the wetlands, the Public Works Authority had initiated a new defense protection wall that would shelter the surrounding neighborhoods, gas lines, and the central jail area from over flooding or water leakage (Ashghal, 2008).

![Figure 43 Abu Nakhla Defense Wall Project by Ashghal](source)

*Source: (Ahmed, 2013)*
Chapter 5 - Applying Best Urban Design Practices for Abu Nakhla Wetlands
5.0 Destination Abu Nakhla Wetlands: Doha’s new Environmental Park

5.1.0 Why Abu Nakhla Wetlands? The Significance of Abu Nakhla Wetlands

Abu Nakhla Lagoon was constructed in 1979 to store Tertiary Treated Wastewater that is also known as TSE. Throughout time, the lagoon’s has been expanding due to rapid increase in demographic growth over the past decades and becoming wetlands with its unique ecological diversity. The wetlands are considered a good ecological and attractive habitat for various animals as this pond is considered to be a good refuge for the survival of animals in the middle of the desert (Abdulfatih, et al., 2002). The wetlands currently mark the biggest TSE reservoir in the country with distinguished habitats and vegetation. Since Qatar has limited fresh water resources, if it was well managed, the wetlands would have so much potential to serve local irrigation and TSE demand. Locally in Qatar, a lot of emphasis is being paid toward environmental sustainability and implementing environmental principles, especially motivated by hosting the upcoming mega sport event, FIFA 2022 World Cup. As the population density is expected to reach 3.7 million annually by 2022 (DohaNews, 2013), wise use of Wetland Management is required for various benefits focusing on sustainability. TSE is considered as an investment for potential projects including landscaping, farming, sand washing and more, especially in a Semi-Arid country like Qatar. On the other hand, Qatar declared that the 2022 FIFA World Cup will attract 1 million international visitors to the Gulf state (Shane, 2013). Other than enjoying the games and supporting athletic teams, spectators are expected to explore Qatar and its unique local environment in various ways. Abu Nakhla Wetlands could add further value and enlightenment with its native habitats and wildlife in Qatar.

In order to save Abu Nakhla, there are various challenges confronting the Wetlands. Throughout some site visits, used rifle bullets were found on the floor, indicating that Bird Hunting activity is
taking place in the area. Other challenges include the quality of the TSE. Previously the reservoir was receiving pure waste water which threatens not only the wildlife, but also the neighboring residents in the area with hazardous gases and pollutants. Also, water seepage to underground water is resulting with massive contamination for the overall urban systems and environmental eco-system. The site’s significance in addition to its current challenges were the main drivers to analyze and solve this case.

5.2.0 Abu Nakhla Wetlands- Place Portfolio

The following sections analyze Abu Nakhla Wetlands from two perspectives. The first part includes the Site Analysis. Some analyses refer to the maps created for further illustration. The second part includes SWOT analysis for the Abu Nakhla site.

5.2.1 Site Analysis table

The below table explains site features, elements of each feature, and their analysis:

Table 6 Abu Nakhla Wetlands Site Analysis Table

<table>
<thead>
<tr>
<th>Site Feature</th>
<th>Elements</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical and Urban</td>
<td>Location</td>
<td>Located in Zone 81, approximately 12 kilometers at the outskirts of the city of Doha, Qatar along the Southern borders of Abu Nakhla Village (Figure 38)</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Neighborhood</td>
<td>• Mubeirek Residential Village</td>
</tr>
<tr>
<td></td>
<td>Context</td>
<td>• New Industrial Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Aqua Park Qatar- Water Theme Recreational Park</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Al Udeid Military Base (Figure 44)</td>
</tr>
</tbody>
</table>
Site and Zoning

Residential, Industrial, Recreational, and political surroundings (Figure 44)

Circulation and accessibility

As Salwa Road Express Way is the main route to reach the wetlands, a detour from Mubeirek Village leads to Abu Nakhla Wetlands which is an unpaved and rural area (Figure 45)

Climate

Dry, hot, desert climate with low annual rainfall, very high temperatures in summer and a big difference between maximum and minimum temperatures,
especially in inland areas (WeatherOnline, 2014) (Figure 46)

![Average min and max temperatures in Al Dawhah, Qatar](https://www.weatheronline.com)

**Figure 46 Qatar’s Annual Climate Overview Source:** (Weather and Climate, 2013)

<table>
<thead>
<tr>
<th>Environmental characteristics</th>
<th>Hydrology</th>
<th>Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water is TSE received from adjacent water plants</td>
<td>Vegetation system is divided into two distinctive zones throughout Abu Nakhla: Littoral and Wetland. Each of these zones embraces distinctive types of species</td>
</tr>
</tbody>
</table>

**Littoral Zone** maintains shallow water where light can easily reach the bottom floor of the pond (Figure 47). It contains several kinds of species such as fishes, frogs, and birds, and invertebrates. On the other hand, Wetland Zones contains numerous plants that germinate and grow in such habits where gentle slopes and flats are more frequent. Moreover, Eastern and Northern Banks of Abu Nakhla pond have high density of water plants (Abdulfatih, et al., 2002).
Wildlife

Through several site visits to Abu Nakhla, birds were very common in the area. Cattle like camel, sheep, and goats were found. Birds were the most abundant vertebrates in the pond such as Great Flamingos. Flocks of up to 200 birds were seen monthly (Figure 48) (Abdulfatih, et al., 2002). Camels are the most abundant visitors.
Topography

The lagoon is elevated approximately 37 to 38 meters above the sea level while the water depth is found to be ranging from one to two meters. The capacity of the wetlands is 5 million square meter (Ahmed Babiker, 2012)

Environmental Contamination

- Pharmaceutical waste, hazardous waste, and others were found in some areas because of improper treatment (Abdel-Wahab, 2012)
- In some areas of the pond, the water reaches to the underground, and thus contaminates the natural underground water of the area
- Potential of two main gases to be produced and released to the atmosphere which are Methane Gas, and Hydrogen Sulfide Gas (Abdel-Wahab, 2012)
- Water Seepage affecting the overall neighborhood context

Physical Characteristics

Dimensions 2 km length by 2 km width

Street/ Sidewalk frontage and The wetlands are surrounded by a high rise sand barricades for some visitor accessibility
<table>
<thead>
<tr>
<th>Context/adjacent properties</th>
<th>Utility Service</th>
<th>Transit Service</th>
<th>Characteristics of surrounding area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>The surrounding area of Abu Nakhla including Mubeirek Village is served by various modest amenities and public services as the population is very low.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Human And Culture</th>
<th>Architecture</th>
<th>Materiality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most of the architecture surrounding the wetlands consists of low rise- buildings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some of the buildings especially residential ones in Mubeirek Village adapted local Qatar Architecture (Figure 49), others were modern modest buildings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materials used in buildings are not different than ones observed in Doha, concrete blocks with some exterior GRC and bricks ornamentations (Figure 49)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 49 Architecture Morphologies and Buildings materiality of Mubeirek neighboring village to Abu Nakhla
Source: Author 2012
5.2.2 SWOT Analysis

Known as a study undertaken to identify internal Strengths and Weaknesses, in addition to its external Opportunities and Threats, the SWOT analysis was originated in 1990 (SWOT analysis: definition of SWOT analysis in Oxford dictionary (British & World English), 2014). Below is a diagram showing the SWOT analysis (Figure 50).

![SWOT Analysis Diagram](image)

Figure 50 SWOT Analysis of Abu Nakhla Wetlands
5.2.3 Stakeholders Analysis

The following table (Table7) showcases the stakeholders along with their contribution and related works of interest. Stakeholders’ roles and responsibilities are to be considered in preserving the Abu Nakhla wetlands; Qatar is also indicated in the table.

Table 7 Stakeholders Analysis

<table>
<thead>
<tr>
<th>Local Entity/Stakeholder</th>
<th>Action Plan/Sector</th>
<th>Responsibilities Towards Abu Nakhla Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of the Environment-MOE</td>
<td>Environmental</td>
<td>- To maximize TSA optimization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To maintain an ecological character</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To update site description and definition of ecological character</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To monitor the wetlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To offer in-situ wetlands management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To preserve the local wildlife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To adopt and to implement an environmental impact assessment</td>
</tr>
<tr>
<td>Ministry of Municipality and Urban Planning</td>
<td>Planning</td>
<td>- To implement a wetlands risk and impact assessment plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To provide a public urban space accessed by all social classes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>including adjacent social minorities</td>
</tr>
<tr>
<td>Ministry of Energy and Industry</td>
<td>Environmental</td>
<td>- To develop energy management programs for Qatari Wetlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To define the performance indicator(s) to use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to measure progress towards wetlands sites energy targets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To review plant progress periodically and to make adjustments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>as necessary</td>
</tr>
<tr>
<td>Ministry of Culture, Arts, and Heritage</td>
<td>Cultural - Education</td>
<td>- To develop recreational activities and opportunities of this</td>
</tr>
<tr>
<td></td>
<td></td>
<td>environmental public space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To create both formal and informal educational training opportunities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for the public</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To create environmental artistic appreciation</td>
</tr>
<tr>
<td>Ministry of Finance</td>
<td>Economic</td>
<td>- To develop wetland-based traditional marketing services</td>
</tr>
<tr>
<td>Ministry of Education</td>
<td>Cultural - Education</td>
<td>- To develop knowledge, belief systems and social practices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- To encourage scientific research and education</td>
</tr>
<tr>
<td>Organization</td>
<td>Type</td>
<td>Objectives</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **Public Works Authority (Ashghal)**             | Infrastructure            | - To enhance traditional knowledge  
- To encourage the practice of traditional medicine  
- Wise use of wetlands management  
- To integrate wetland site management  
- To develop management units, zonation and buffer zones  
- To develop monitoring programs that assist in measuring the works progress  
- To develop wetlands risk assessment plans  
- Storage and retention of water for domestic, industrial, and agricultural use  
- To develop plans for water purification and waste treatment retention  
- To develop a plan for recovery and removal of excess nutrients and other pollutants  
- To control water seepage and leakage  
- To control floods  
- To develop water related regulatory services  
- To provide rapid response toxicity tests                                                                 |
| **Qatar National Food Security Program - QNFSP**  | Environmental             | - To provide provisioning services: harvestable goods  
- To maintain natural processes and dynamics  
- To maximize the optimization of water for production of local fish, fruits, and grains  
- To enhance food processing techniques in Qatar                                                                 |
| **General Secretariat for Development Planning - GSDP** | Planning                  | - To offer supporting services that include: consultation with local stakeholders leading to the establishment of a cross-sectoral management committee  
- Enabling communication within and between sites organization and stakeholders  
- Ensuring compliance with location, national, and international policies,                                                                 |
| **Qatar Tourism Authority**                      | Economic                  | - To maintain aesthetic and beauty values in aspects of the wetlands ecosystems  
- To encourage eco-tourism and cultural tourism based on Abu-Nakhla location advantages                                                                 |
| **Qatar Environment & Energy Research Institute** | Environmental             | - To create a public environmental awareness  
- To issue regular reports about Abu Nakhla Wetland Environment and energy  
- To track Wetlands biochemical status                                                                 |
| **Qatar Green Building Council**                  | Environmental             | - To create a public environmental awareness  
- To develop wetlands legislations, laws, and
regulations
- To establish international associations with distinguished wetlands organizations such as Ramsar
- To create a public environmental awareness
- To address local wetlands related environmental concerns

In addition, other stakeholders not mentioned in the above table, are essential for the development of Abu Nakhla Wetlands. These include the following (Figure 51):

**Figure 51 Power/Interest Grid developed by (Mitchell, Agle, & Wood, 1997) and modified by Author 2014 for Abu Nakhla**
To make a better reference and understanding about Qatar’s environmental initiatives and interest development, the following table has been made (Table8).

Table 8 Timeline illustrating establishment of environmental oriented organizations/systems in Doha-Qatar

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Friends of The Environment Center</td>
<td>N/A</td>
<td>General Secretariat for Development Planning</td>
<td>N/A</td>
<td>Qatar National Vision 2030</td>
<td>QSAS - Qatar Sustainability Assessment System</td>
<td>“Green Qatar 2022” FIFA World Cup Bid</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
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<td>QGBC - Qatar Green Building Council</td>
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</tbody>
</table>

5.3.0 Restoring Abu Nakhla Wetlands

The following section are strategies and developed plans (Figure 52) with reference to the analysis previously made about the current conditions and the site characteristics of Abu Nakhla Wetlands. First, an assessment table (Table9) is made to outline all concerned issues to be tackled.

![Figure 52 Photo Montage for Abu Nakhla Wetlands Project](image)
Table 9 Assessment Table for Abu Nakhla based on previous analysis made

<table>
<thead>
<tr>
<th>Issues of Concerns</th>
<th>Suggested Action(s) to be taken</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Quality and Management</strong></td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td>Contamination to be treated from TSE to avoid consequences</td>
</tr>
<tr>
<td>Water management and sanitation</td>
<td>Adaptation of constructive wetlands system to control water treatment through inflow and outflow of water</td>
</tr>
<tr>
<td>Public Health</td>
<td></td>
</tr>
<tr>
<td>Generated diseases</td>
<td>Better wetlands management plans must be considered to control polluted areas</td>
</tr>
<tr>
<td>Food Security</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water seepage and leakage must be controlled to maximize the use of water for food production</td>
</tr>
<tr>
<td>Water Seepage</td>
<td></td>
</tr>
<tr>
<td>Effect on underground water</td>
<td>Water to be insulated and controlled in a basin to avoid direct contact with underground water and to avoid contamination</td>
</tr>
<tr>
<td>Effect on next by farmlands</td>
<td>Water barrier to be constructed in reference to annual rainfall rate and daily discharge to the wetlands to avoid flooding of neighboring farmlands</td>
</tr>
<tr>
<td>Effect on surrounding urbanized area</td>
<td>Water barrier and flow rate to be controlled to avoid flooding of surrounding residential villages and relevant consequences</td>
</tr>
<tr>
<td><strong>Environmental Sustainability</strong></td>
<td></td>
</tr>
<tr>
<td>Water reuse</td>
<td>Supporting the national vision and local goals, water must be reused and recycled</td>
</tr>
<tr>
<td>Wildlife Conservation</td>
<td>Local wildlife and nature must be protected from any harm and high sustainable measures must be achieved.</td>
</tr>
<tr>
<td>Water purification and treatment</td>
<td>Further water treatment must be implemented to achieve maximum optimization of TSE water</td>
</tr>
<tr>
<td>Reduced demand on costly measures for water supply</td>
<td>Maximizing TSE optimization and reducing the pressure on seawater desalination must be achieved</td>
</tr>
<tr>
<td><strong>Economic</strong></td>
<td></td>
</tr>
<tr>
<td>Generating energy</td>
<td>Local authority must work on generating energy from renewable sources plans</td>
</tr>
<tr>
<td><strong>Political</strong></td>
<td></td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Local authority must consider maintaining Abu Nakhla Wetlands in support of the Qatar national vision 2030</td>
</tr>
<tr>
<td><strong>Educational</strong></td>
<td></td>
</tr>
<tr>
<td>Public Awareness</td>
<td>Education on local environmental preservation must be provided to the public to sustain supportive and appreciative society</td>
</tr>
</tbody>
</table>
5.3.1 Water Quality Enhancement

There are various ways to enhance the current water quality of Abu Nakhla Wetlands to be used along with human interaction. Some of the most common and relevant ones are explained below. These include: Oxygenating Wetlands- Water Aeration, re-establishment of cost-effective constructed wetlands system, and terraced wetlands.

5.3.1.1 Oxygenating Wetlands- Water Aeration

Oxygen plays a vital role in maintaining a healthy wetland environment. Fish and other organisms need Oxygen to survive. Water that is rich with Oxygen allows efficient biological filtration. There are various ways to maintain appropriate Oxygen levels in the water through Aeration methods (Foster & Smith, 2014). These fall under two main categories which are
Surface Aeration and Subsurface Aeration. Under these two categories, a number of techniques and technologies are available for both. Natural Aeration includes both subsurface and surface aeration. It can occur through subsurface aquatic plants (Water-Aeration, 2014). Wetland plants such as reeds oxygenate and purify water and can directly improve the overall ecosystem. Plants perform two valuable functions in the wetlands. The first is dissolving nutrients which assist in reducing algae by conditioning the water. Second is that they provide a shady refugee for fish and their spawn. Yet the availability of oxygenating plants varies throughout the year, depending on many conditions (wetlandplants, n.d). On the other hand, there are some man-made actions and solutions that add further oxygen in the water to enhance its quality through the Surface Aeration approach. These include adding ornamental fountains that pumps jets of water, thus increasing Oxygen level in the system (Figure 54). The fountain system pulls water from the water surface through a motor that powers a rotating impeller. The impeller pumps the water from the first few feet and expels it into the air. This process utilizes air-water contact to transfer Oxygen. As the water is propelled into the air, it breaks into small droplets which have a large surface area through which Oxygen can be transferred. Upon return, these droplets mix with the rest of the water and thus transfer Oxygen back to the ecosystem (Tucker, 2005).
5.3.1.2 Re-establishment of cost effective Wetlands system

Often described as the “Earth’s kidneys”, the natural wetlands system filters pollutants from water that flows through it, to receiving lakes, streams, and oceans. As wetlands systems improve and enhance water quality, many engineers and scientists construct systems that replicate the functions of natural wetlands. Constructed wetlands act as a treatment system that uses natural processes involving wetland vegetation, soil, and their associated microbial assemblages to enhance water quality (EPA, 2004).

One of the most vital roles the wetlands plays is water filtration. As water flows through the wetlands, it slows down and many of the suspended solids are trapped by vegetation and settle out. Other pollutants are transformed to less soluble forms taken up by plants or become inactive. Therefore, wetlands’ plants foster the required conditions for microorganisms to survive in the system. Through a series of complex processes, these microorganisms also transform and remove pollutants from the water enhancing the water quality (EPA, 2004).
Wetlands can be constructed by excavating basins, by building up earth embankments which are known as Dikes or by a combination of the two. Dikes shall be constructed of soils with adequate fine-grained material that will compact into relatively stable and impervious embankments. The Dikes should be high enough to contain the expected volume plus ample freeboard to accommodate high flows as well as the build up of litter and sediment over time. Constructed wetlands must be sealed to avoid possible contamination to groundwater and also to prevent groundwater from infiltrating into the wetland (Davis, n.d). This is vital for Abu Nakhla’s case, as water seepage and leakage is a current challenge. The sealing method depends on the soil condition and typology. In some cases, it could be necessary to refer to a laboratory to analyze the right construction material to be used for the lining before choosing the method. In addition, the liner shall be strong, thick, and smooth to prevent root attachment or penetration. The liner also should be covered with soil in order to prevent the roots of the vegetation from penetrating the liner (Davis, n.d). On the other hand, flow control structures are essential to control water level. They allow flexibility so that the process can be easily optimized and adjusted in response to system changes. They are composed of two main functions: Inlets and Outlets. Inlets are open-ended pipe, channel, or gated pipe that releases water into the wetland. In Abu Nakhla’s case it’s the main line that discharges TSE from the Doha West and Doha South Treatment Plants. Whereas Outlets control water level by its variable structure, it should be designed to pass the maximum probable flow. The final discharge point from the wetland system should be placed high enough above the receiving water (Davis, n.d).

5.3.1.3 Terraced Wetlands
Terracing is a relatively new wetland- restoration technique that is used to convert shallow sub-tidal bottom to marsh. The methods use existing bottom sediments to form terraces or ridges at
marsh elevation (Figure 55). A terrace field is developed by arranging a series of these ridges into a certain pattern which maximizes intertidal edge and minimizes the fetch between ridges; the intertidal area is planted with marsh vegetation (Rozas & Minello, 2001). One arrangement is a checkerboard pattern with open corners. Prior construction, the intertidal levees are planted with marsh vegetation, and the sub-tidal areas between terrace levees may be planted with seagrasses or other species of submerged aquatic vegetation. As stated, it is the most common restoration technique which involves simply planting marsh vegetation on dredged material or on scraped-down uplands. Marsh terracing has been promoted as a means of enhancing deposition and retention of suspended sediments, reducing turbidity, increasing marsh-edge habitat, increasing overall primary and secondary productivity, and maximizing access for marine organisms. Other than providing further filtration for the water, Marsh Terracing provides habitat for fishery species (Rozas & Minello, 2001). Moreover, constructed wetlands, cascades, and terraces Oxygenate the water and remove pollutants, nutrients, and sediments (Shanghai Houtan Park).

Figure 55 Terraced Wetlands System that can be applied to Abu Nakhla as it is located on a high man-made relief
Source: Author 2014
5.3.2 Urban Wetlands Restoration

The following strategies aim to restore the wetlands from an urban perspective. These include site clearance and waste removal. Also, they include implementing wetland buffer zone concepts. There are various Wetlands restoration methods and techniques available, some were chosen within this study.

5.3.2.1 Site Clearance and waste removal Plan

In preparation of working on the Abu Nakhla Wetlands project, there are various strategies that are necessary in order to maintain a successful project. After setting up a strategy and a comprehensive plan, it is vital to clear the site from any waste seen. One of the major problems observed in several site visits to Abu Nakhla, is used shotgun shells found across the site indicating Bird Hunting activities by humans (Figure 56).

![Figure 56 Used shotgun shells found in many areas across Abu Nakhla Wetlands Site](source: Author 2012)
5.3.2.3 Wetland Buffer Zones

The term “Buffer Zone” is an area of vegetation which usually begins from the boundary of Wetland dependent vegetation and extends outwards, ending at the interface with another land use. Buffer Zones vary in size and nature depending upon the specific purpose for which it was created (Water-Notes, 2000). The size of the buffer is based upon the resource value, the intensity of adjacent land use, buffer characteristics (slope, soil…etc.), and specific buffer functions (Boyd, 2001). The Buffer Zone enables reducing storm water volume and removes sediments, Nitrogen, and Phosphorus from water flowing through it; thus, protecting adjacent neighboring communities and urban morphologies. Connectivity to adjacent habitats is measured by the amount of human disturbance within 500 meters of the Wetlands and the percentage of the Wetland connected to upland area (Neiber, 2011). Buffer Zones protect wetlands and water bodies from adverse actions taking place in adjacent upland areas. Adverse actions include agriculture, urban development, and industrial uses. Adverse actions in the buffer zones of wetlands can result in changes to the biological, chemical, and physical properties of these aquatic resources. Accordingly, such changes may reduce Wetland functional value. Generally, a buffer zone is thought of as a buffer against human generated disturbance in areas adjacent to the Wetland. In fact, the adjacent land of the Wetland is a life zone not just a buffer zone, protecting species from adjacent human activities (Boyd, 2001). The Wetland buffer zone may perform functions such as:

- Reduces surface water runoff from surrounding land into the wetland
- Maintains good water quality by reducing sediments, nutrient, and pollutant loads in runoff
- Provides feeding and breeding habitat and shelter for wetland fauna
• Contributes to wildlife corridors between the wetland and adjacent urban morphologies
• Reduces disturbances of native fauna from surrounding development
• Provides a buffer area between residential districts and nuisance insects such as mosquitoes
• Provides an area for passive recreational activities such as bird watching, photography, and bush walking (Water-Notes, 2000)

Fencing the buffer zone is a vital management tool used to prevent livestock grazing, trampling of wetland vegetation and to limit human activities. The type of fence will differ depending on its purpose and the compatibility of the material use along with aesthetic values of the area (Water-Notes, 2000).

5.4.0 Planning and Design Standards

There are three different situations that planners encounter in wetlands issues. First, existing, natural wetlands are often a vital part of the landscape. Therefore, planners must be conscious and aware of ways to design development with minimum impact. Second, existing wetlands maybe degraded and in such case, wetland restoration is considered as significant part of the development planning and design. Third, there may be a need to construct wetlands where none exist, demanding a careful balance of wetland standards with other design standards. In fact, proper planning and urban design will make wetlands important amenities that would benefit an entire community (Steiner, Butler, & APA, 2007).
There are some practices that should be considered when a development will affect a wetland; these include the following:

- Identifying appropriate geology and soils as healthy wetlands require a balance of surface and ground-water, as well as soils
- Treatment Wetlands to be constructed on uplands and outside floodplains in order to avoid damage to natural wetlands and other aquatic resources, unless pre-treated effluent can be used to restore degraded systems (EPA, 2004)
- Role of treatment wetlands to be considered within the watershed (EPA, 2004)
- Use water control measures which enable easy response to changes in water quantity, quality, depth, and flow (EPA, 2004)
- Identifying proper vegetation both within and around a wetland as it provides shading moisture, contributes to soil conditions, and provides physical barriers
- Paying attention to visual characteristics which are an important part of the design incorporating access to views of plants and animals by residents and visitors
- Considering legal constraints on wetlands development such as private property boundaries, easements and rights of way, comprehensive plan provisions, zoning, and other limitations on use (Steiner, Butler, & APA, 2007)
- Create and follow a long-term management plan which includes regular inspections, monitoring, and maintenance (EPA, 2004)
5.5.0 Abu Nakhla Wetlands Urban Program Plan

Recently, Ashghal Ministry of Public Works announced that Abu Nakhla Lagoon will be drained by the end of this year and the area rehabilitated prior to studying the best environmental solutions. Local authorities declared a long-term strategy for Inner Doha Re-sewerage Implementation Strategy- IDRIS for upgrading and expanding the current sewerage infrastructure, especially for center and southern Doha. IDRIS plan includes extension of more than 100 km of pipelines connecting the deep main trunk sewer with the lateral interceptor sewers, pumping stations, a main truck and facilities for the treatment of sewage effluent in southern Doha. Until completion of IDRIS project, the project will accommodate up to 500,000 m$^3$ per day (Gulf Times, 2014). There have been many plans and initiatives by local authorities tackling draining the lagoon as it is believed to be the best solution possible. Such news raises questions and concerns about the location or the method that the water that is currently present at Abu Lagoon will be discharged. Analyzing the situation, if the water was discharged to another rural area, the new area will attract diversified wildlife and consequently many vegetation and new life will start, resulting in a similar case to Abu Nakhla Wetlands now. Therefore, it is assumed that the case of Abu Nakhla will be repetitive over and over in case the same principle will be applied. To prove such theory, Qatar General Electricity and Water Corporation-KAHRAMAA has lately issued tender to build the world’s biggest reservoirs including five huge reservoirs and associated pumping station packages. These will be based at several locations, one will include Abu Nakhla. The objective of this project is to provide seven days’ potable water storage in new reservoirs, combined with existing and future secondary reservoirs to preserve Qatar’s water security (Fahy, 2014).

The following Abu Nakhla Wetlands Urban Program proposes some sustainable approaches that local authorities could consider and adapt in order to save the environment and habitats,
maximum smart optimization of TSE, promote human development in terms of health and education, and accordingly enhance economic measure (Figure 57). These approaches are divided to four categories; Environmental and Eco-Touristic, Food Production, Educational, and finally recreational and leisure.

5.5.1 Environmental/ Eco-touristic

First, to develop a deeper understanding of this particular approach, it is critical to define the term “Ecotourism”. It is tourism based upon natural resource attractions of a combination of natural resources and cultural attractions, and carried out in a manner consistent with the protection of these attractions. The natural attraction in this case is Abu Nakhla Wetland, its
habitats, wildlife, and interesting ecology. Ecotourism conducted in a manner consistent with the capacity of natural resources has also been referred to as “Sustainable Tourism”, Eco-tourists have also been referred to as “Eco-travelers”. Eco-tourism is the fastest growing type of tourism in the world. Bird Watching activity is an important form of ecotourism and is particularly common for wetlands. Other activities associated with wetlands include Canoeing, Kayaking, and fishing (Kusler, Christie, & Weaver, 2001).

In order to provide a satisfactory eco-tourism experience, eco-tourists need the following:

- Transportation to the area (private auto, trains, airline, buses, car rental…etc.)
- Access to the wetlands (Roads, walking trails, water access for kayaks, canoes)
- The ability to explore and observe a wide variety of birds, animals, plants, and other attractions
- Wetland interpretation and guide services (in some instances)
- Food and accommodation (Kusler, Christie, & Weaver, 2001)

Wetland-related facilities, if properly sited and designed can meet the needs of eco-tourists while protecting and maintaining resources. These include wetland trails adjacent to wetlands, boardwalks (Figure 58), interpretive signs, and canoe launching areas; in addition to interpretive centers, picnic facilities, parking lots, and food and lodging facilities on adjacent lands. Some common types of educational and interpretive materials include:

- Trail guides at strategic points along trail or boardwalk
- Wetland maps
- Interpretive signs
- Bird lists
- Fact Sheets and interpretive pamphlets
- Recorded and live lectures
- Guided walks, and boat tours (Kusler, Christie, & Weaver, 2001)

5.5.1.1 Significance of ecotourism in protecting wetlands and relevant ecosystem

Eco-tourism educates landowners and businesses with regards to the functions and values of wetlands (Kusler, Christie, & Weaver, 2001). In Qatar, wide awareness of water consumption and recycling would be raised. Due to the fact that Qatar is situated in a Semi-Arid zone with very limited fresh water resources, a lot of information and responsibility would be realized by every citizen with regards to water consumption and the importance of TSE. In fact, some people in Qatar perceive TSE as useless and contaminated fluids. However, being enlightened and educated about its importance and high beneficial rewards would increase TSE appreciation and recycling for local benefit. Eco-tourism provides local economic benefits and incentives to local
businesses and landowners for protection and restoration of wetlands through sales of gas, food, lodging, and gifts to eco-tourists drawn to a wetland area. When combined with educational programs, it can help educate businesses, landowners, students, and the general public with regards to functions/values of wetlands and techniques available to manage and protect such areas locally, regionally, and nationally (Kusler, Christie, & Weaver, 2001).

5.5.1.12 Applying “The Garden City” Concept by Howard

Defined by Sir Ebenezer Howard, who is known by his publication ‘Garden Cities of Tomorrow’

“the Garden City is not a suburb but the antithesis of a suburb: not a more rural retreat, but a more integrated foundation for an effective urban life”. The Garden City Movement has originated as a solution for the growing and crowded industrial cities. As housing workers were required in order to flourish industrialization, Howard developed the concept of new satellite towns allocated in the suburban sides of the central cities. The concept aimed to decentralize dense urban areas in central cities and connecting them with satellite towns including industrial and garden cities by mass transit. This proposal developed later on the zoning concept and greenbelts of cities that separated functional elements of the city. Moreover, it encouraged public awareness in terms of sustainability and environmental conservation (Strokbies, 2003).

Applying these concepts to Abu Nakhla Wetlands case, the wetlands is relatively located along the outskirts of the Doha, adjacent to the industrial area. The strategic location has high potentials of becoming a significant Garden City that provides the residents a healthy environment and lifestyle which foster human and environment development. Connected by various modes of transportation through high road- Salwa Road and an anticipating Rail system, Abu Nakhla Garden City would be easily accessible. As believed by the local ministry of environment, the Abu Nakhla Garden City would act as a greenbelt separating the function of
the industrial city from the residential zone on the opposite part; thus, providing an ecological remediation (Figure 59).

Figure 59 Applying the Garden City Concept and theory on Abu Nakhla Wetland
5.5.2 Food Production

As stated in the Doha Declaration on Food Security at the International Conference on Food Security in Dry Lands Doha, Qatar, countries underscored that food security, poverty, and climate changes are closely linked and should not be considered separately. The ministers and countries representatives were committed to cooperate at the international/ regional level to welcome and support Qatar’s initiative to establish a Global Dry Land Alliance (GDLA), a collaboration that creates new solutions to common food security problems and to provide mutual assistance in times of extraordinary need. Also, the commitment involves promoting investment projects in water and land that produce food for local markets (Figure 60). In addition, investment in research and development optimizing scarce water resource, tackling water management approaches, and sustainable use or water and land resources (Pedrick, Devlin, & Timmermann, 2012).

Figure 60 local harvest and crops proudly sold at one of the local hypermarkets in Doha- Qatar

Source: Author April, 2013
5.5.2.1 Utilizing constructed wetlands for food production

The delight of being acquainted with what is eaten is promised by growing food producers in cities. It is something experienced mainly through community gardens and urban farms. As questions about food security are being raised, nowadays due to challenges faced by cities including economic, environmental, social challenges of hunger and dependence on global industrial food systems; local food production is believed to be vital for developing food security. There are many advantages for growing food other than maintaining healthier lifestyle. Growing food connects people to their environment and to their neighbors; it builds trust and relationships that bond together social, economic, and ecological systems (Nairn & Vitiello, 2010).

As it presents less than 1% of the GDP (Gross Domestic Product), the contribution of agriculture to national economy is negligible. Statistics record that in 2005, it consumed 60% of the country’s water. Local development in the agricultural sector is hampered by various factors. These include the scarcity of fresh water resources, low quality of water, soil infertility, and crucial climatic conditions. These factors contributed to low production crop harvests which consequently led to importation of most agricultural products excluding dates (Darwish & Mohtar, 2012). However, local investment in terms of food production is taking place as some agricultural organizations are investing internationally in agricultural and livestock development sectors. For instance, Hassad Food Company- HFC invests in agricultural businesses and projects around the world, some international subsidiaries include Hassad Sudan and Hassad Australia which support local food demands (HASSAD, 2010).
5.5.2.2 Food production and social minorities

Due to high reservation wages from the 1980s onward, the GCC private sector switched to lower paid Asian workers, and continued hiring them even during economic downturns as an effective cost cutting strategy. This segmentation is further solidified under the sponsorship system, which strictly limits the labor mobility of foreign workers and serves as the legal basis for temporary residency and employment in the GCC. Workers cannot enter, work, change jobs or leave the country until they have permission from their sponsor (Ozer, 2011).

Regional residents of Mubeirek town will be benefitting from the community garden and Green Boulevard provided as they will have direct access. This is aimed to increase social interaction and communal ownership that supports sense of belonging to the space. People gathered coming from various educational, social, and cultural backgrounds will benefit from each other as they would develop a better understanding towards their experiences. Moreover, as more emphasis will be paid regarding the environment in terms of plantation and farming, wider appreciation and conservation for natural ecology would develop; thus, acquiring further indirect education and awareness for the environment. In addition, food production from these gardens is a significant result. Many low paid Asian workers and labors tend to be considered as minors throughout the society. They are accommodated mostly in the industrial area which happens to be adjacent and within the Abu Nakhla wetlands scope limits. The project dedicates a zone where these minorities can perform agricultural and framing activities at their convenience. In fact, most of the Asian workers are more acquainted with agricultural knowledge and background.
5.5.3 Educational- Learning in Wetlands

The following approach tackles the educational aspect of wetlands and how wetlands can be used to serve academic and intellectual skills. The first part discusses the 5 E’s Learning Cycle which is important to know before planning wetlands for educational purposes. The second part talks about learning in wetlands and what are the essential tools to be used. Finally, there is a proposal for having a learning center in the wetland that is an interactive learning hub for visitors.

5.5.3.1 The 5 E’s Learning cycle

The first step in any type of learning is to Engage learners through interactive techniques. This means to get the students interested in learning about a specific topic as learning does not occur without some level of interest. This can be achieved by a game, or other activity that students naturally find simulating, or by drawing on something relevant to the learner’s lives. The age and development level shall be considered when planning activities. Once students’ interest has been excited, the process of Exploration may begin. Students should be encouraged to make discoveries on their own, through guided experimentation and hands-on experience. Following this phase, and prior to allowing time for exploration, a new phase may begin called Explanation. In this stage, students may read about the issues they are studying, attend to audiovisual aids, or discuss the subject with the teacher and amongst themselves. At the end of an educational unit, Extension occurs. In order for students to continue learning about a set of concepts of ideas after the formal period of education is over, students should be provided with opportunities. Evaluation or feedback is important in gauging how students are learning and attending to their educational needs at all phases of the learning cycle (Figure 61) (UMS, n.d).
5.5.3.2 Learning in Wetlands

Wetlands are considered as an excellent site to conduct educational programs. They are habitats which provide easy opportunities to explore a variety of birds and other biodiversity (Cooper, 2005). Wetlands have various ecological and economic functions and benefits. They are a crucial part of many watersheds and are referred to as powerful places in which to learn. Wetlands can provide food and other resources to people and serve in enhancing water quality and purification. They create a unique learning atmosphere as their ecosystem contain a wide variety of physical and biotic features and serve as refuges for many types of plants and animals. Even if classroom activities are well designed and implemented, contact with an actual natural area can be more significant to the development of an environmental ethic than any classroom learning could ever be (Figure 61). It is a distinctive experience that children and adults learn to empathize with and care deeply about the natural world. By learning about wetlands, students learn valuable
ecological and social concepts; develop communication skill and critical thinking skill. All these skills are keys of success in the current academic atmosphere (UMS, n.d). Also, it is essential to organize training courses for teachers to enhance the education program. The course could provide information about the site of Abu Nakhla, ideas for programs and projects in the educational institute, training of environmental activities and games perhaps. If the training is done in an interactive way, it can be very popular with teachers and accordingly make a significant impact on the implementation of the program in the educational institution (Cooper, 2005). There are various plans and activities that the educational institution and schools could conduct for students before planning a trip to visit wetlands, as well as prior wetlands visit activities. These aim to enhance the learning experience of students in addition to preparing them to expand their knowledge by providing an initial background about wetlands. These activities also vary with accordance to students’ age and level of education to suit their needs. On the other hand, gaining communal support around wetlands is very important. By developing a community education program, key audiences can be identified. These audiences can influence the management and protection of wetlands. Significant audiences involved are educational institutions, their students, faculty members, scientists, and researchers (Cooper, 2005).

5.5.3.3 Friends of Abu Nakhla Wetlands Learning Center

The educational and interactive learning center is referred to as an open classroom where students and visitors expand their knowledge. Wetland Learning Center is proposed to include educational programs for students. It includes Gallery activities where students can learn about Abu Nakhla’s habitats and wildlife; thus acquire more knowledge about Qatar’s local environment (Figure 62). The center could also involve auditorium and lecture halls to provide continuous wetland education with audiovisual technologies for visitors’ experiences.
Figure 62 Photo montage for Abu Nakhla Wetlands educational park
5.5.4 Recreational/Leisure

Natural beauty in addition to wildlife diversity in the wetlands makes it an ideal location for recreational activities. A lot of the finest sites are preserved as National Parks or World Heritage Sites, and are able to generate considerable income from an array of activities available. In some countries, the resulting revenue contributes to national economy (RAMSAR, n.d). In recreational planning for the wetlands, it is vital to plan passive recreational activities and programs. Referring to non-consumptive uses such as wildlife observation, walking, biking, and canoeing, Passive Recreation provides the least impact on the wetland ecosystem, yet provides a satisfactory experience for visitors (Passive Recreation, 2014).

There are various ranges of recreational activities associated with wetlands which generate income locally and nationally, from boating, and other water sports to watching wildlife and even art and Literature. There are many wetlands that have great recreational value because visitors may utilize the area without direct payment. Tourism drives the economy, benefiting boat-rental operators, shops, restaurants, hotels, cafes, and other visitor attraction available on site (RAMSAR, n.d). One of the most critical issues in recreational planning of wetlands is accessibility. A recreation area shall provide access from various points for all types of visitors. The criticality in accessibility arises from the impact of public access on the overall wetland ecosystem. Some activities shall be avoided as they will disturb and fragment wildlife habitat. These include hunting, fishing, and motor boating. Combining issues of accessibility and recreational activities, a circulation system becomes another critical element in a recreational plan. Therefore, it is essential to have a clear circulation plan which illustrates accessibility, including physical and visual access, and trail systems. Trail systems incorporate educational and recreational uses, including interpretive trails, biking trail, and a seasonal canoe pass way
The following Master Plan, is a conceptual sketch that was developed with reference to Abu Nakhla Wetlands (Figure 63) and (Appendix E).

![Conceptual sketch for Abu Nakhla Master Plan](image)

On the other hand, some activities for recreational attractions include:

- **Hiking and Biking**
  
  Referred to as one of the best ways to discover natural beauty of wetlands, hiking and biking are great ways to explore wetlands.

- **Canoeing**
  
  The visitor can explore the wetlands from another perspective, through the pass way, people would gain knowledge about natural and cultural heritages.

- **Wildlife Observation**
  
  Structures such as observation screens and towers can be designed to prevent observation activities from disturbing wildlife activities. Different gaps on the observation screen can
be added to accommodate wide range of people of different heights, from children to adults. The design of the observation tower can provide different perspective and angles for better observation of wildlife.

- Mobility Plan and wildlife observation through Cable Cars:

In reference to some analysis and previous site visits to the Abu Nakhla Wetlands and supporting destinations of Irkiyya Farmlands and the Sand Washing Plants, the variation in land leveling between these sites are very interesting. Irkiyya Farmlands are located on a hill of 70 meters above sea water level; whereas Abu Nakhls’s topographical natural level is 10 meters above the sea level, noting that a landfill of 20 meters depth has been made as a design for the lagoon. In order to enhance urban connectivity in the area, and increase educational and recreational value, a proposal was suggested to install cable cars connecting three stations. The three stations include: Irkiyya Farmlands in the South Western side, Aqua Park Water Themed Park which is few meters away from the wetlands, and Abu Nakhla Wetlands. A reference was made to the Masada Cable Cars in Palestine which provide accessibility to the 30 meters height hill that embraces a historic fortress and overlooks the desert and the Dead Sea. The same principle could be applied, providing interesting views of the desert for visitors as well as the wetlands from top (Figure 64).

On the other hand, as the country is currently constructing the mega project, Doha Metro, the Golden Line of the metro is planned to connect the industrial area with the city. To utilize this opportunity and create more convenient accessibility to the site of Abu Nakhla, some public transportation including Public Buses or taxis could pick up passengers from the station and drop them at the Abu Nakhla Cable Car Station which will transport these passengers to an exciting environmental journey of an interesting system (Figure 65).
Other recreational activities involve interactive playgrounds for children to enjoy while they learn. In addition, it is vital to include public services such as toilets and a souvenir shop to satisfy the visitor’s experience (Figure 66).
Figure 66 Photo Montage for Abu Nakhla having an interesting playground for kids
5.6.0 Conclusion and Recommendations

In a growing metropolis, rapid economic growth is escalating population, and therefore resulting in hyper-dramatic acceleration of water consumption in Qatar within the last few decades. Recently, there are green initiatives and smart solutions that can be merged together along with advanced technology implemented around the world to come up with better strategies for water management through Constructed Wetland Systems.

Abu Nakhla Constructed Wetlands marks the biggest Treated Sewage Effluent reservoir in the Qatar with rich ecological diversity. With recent announcement by local authorities to drain Abu Nakhla due to various reasons including resident complaints on their health and safety concerns, Abu Nakhla’s habitats and preserved water are under big threat. In order to consider residents complains and maintain a healthier neighborhood for them, yet preserving the reservoir and its rich eco-diversity, the thesis outlines guidelines and urban design strategies to support the issues raised by both parties.

The study first introduces landscapes in Semi-Arid zones with reference to the water challenges and massive demographic changes in the urban metropolis of Qatar due to the catalyst of change, which is hosting the 2022 FIFA World Cup. In order to provide a clearer understanding about Wetlands, Chapter Two is dedicated to investigate different typology of wetlands with reference to geographic zones that will be tackled. The chapter also explains the different forms of wetlands whether they are constructed or natural. In addition, it highlights significant international organizations and associations which were established to protect and preserve wetlands around the world. These included a couple of the most remarkable ones such as the Ramsar Convention on Wetlands, and Wetlands International. Moreover, the chapter develops better understanding about Wetlands Management, as it is vital for preserving and maintaining
the wetlands. In order to support these concepts, few references were made to Traditional Islamic Water Management, the historical use of Water in the Islamic Garden, and the contemporary Water Management with the new environmental systems and technologies used to conserve water in the present days. All these concepts explained in Chapter Two were intended to establish a deeper understanding about the importance of water preservation in addition to identification of wetlands.

Moving to Chapter Three, several case studies were carefully chosen in order to share some similarities with Abu Nakhla’s case, as lessons will be learned from them to apply some strategies on Abu Nakhla. The chapter concludes with the significant information obtained from each case study by developing a comparison table with all the analysis. These included wetlands profile, ecological components, flora/fauna, animal communities, aquatic conditions of each wetlands uses and site activities. Finally the chapter outlines all relevant information that can be applied to Abu Nakhla, with comprehensive analyses to these strategies of each case study.

The forth chapter focuses more on Qatar in terms of its perspective on wetlands and most importantly, the use of TSE among the country. It distinguishes the current use of TSE or the process of water recycling in sustainable measures. This chapter also was the first introduction to Abu Nakhla wetlands with reference to the TSE usage in the country. It is important to clarify that Abu Nakhla was first planned to be as TSE reservoir, which by time has expanded due to the rapid increase of population, which resulted in an increased level of discharged TSE to Abu Nakhla. The reservoir has attracted many wildlife and vegetation that made it become a wetland with a unique ecosystem. Also, some challenges confronting Abu Nakhla wetlands were outlined, and in return how local authorities corresponded to such challenges and their initiatives toward sustainable wastewater management were clarified. It is essential to mention in the
chapter some environmental systems, visions, and strategies which are currently being taken seriously in the country. This is a good sign and great hope as such policies would support Abu Nakhla’s case. Moreover, the chapter concluded with some finished and ongoing projects dedicated to Abu Nakhla and developed by the local authorities.

With reference to all these analysis and studies, chapter five is the key summary as it sets all the foundations and studies for Abu Nakhla Wetlands. The chapter first clarifies the significance of Abu Nakhla Wetlands, and why this case was chosen in particular noting that the case could be a repetitive one across Qatar. Then, Abu Nakhla’s place portfolio was dedicated to develop a better understanding about the wetlands through two sections; Site Analysis, and SWOT analysis. The studies then included Stakeholders’ Analysis with reference to Abu Nakhla, which organization is considered to contribute in saving Abu Nakhla. By these analyses, division sectors, roles and responsibilities toward Abu Nakhla were outlined. Following this table, Power/interest Grid was applied to provide a better understanding for the case. Prior to these analyses, restoration of Abu Nakhla Wetlands took place by first highlighting issues of concern, and suggested actions to be taken accordingly. There were two key issues explained which included Water Quality Enhancement, and Urban wetlands restoration. Under these two issues, some possible solutions were mentioned to assist in restoring the wetlands. The chapter then talks about Planning and Design Standards exclusively developed for wetlands. Accordingly, the Abu Nakhla Wetlands Urban Program Plan was made. The program proposed some sustainable approaches that local authorities could consider and adapt in order to save the environment and habitats, maximize smart optimization of TSE, promote human development in terms of health and education, and enhance economic measure. These approaches were divided into four categories; Environmental and Eco-Touristic, Food Production, Educational, and recreational and leisure.
The research work investigates wetlands and wastewater management in the context of sustainable development in Semi-Arid zones. Some key aspects related to constructed wetlands were introduced and the analyses of relevant case studies were conducted to provide a framework for Urban Design strategies to be deployed in Abu Nakhla. Prior to this study, scenarios following four categories were proposed. These include Eco-touristic and Environmental, Food Production, Educational, and Recreational and Leisure.

The contributions of this research work included the following aspects: water security in the Semi-Arid state of Qatar as a raising concern for sustainable water uses; the significance of water recycling and maximum optimization of TSE in various purposes using Constructed Wetlands system; the preservation of existing wetlands rich ecology yet enhancing human health and safety conditions; the development of Urban Design Principles and strategies that best suit Abu Nakhla’s case to support national’s vision, environmental sustainability, and diversifying the local economy.

It is essential to preserve, wisely recycle and optimize the Treated Sewage Effluent for various uses. While such water reservoirs and wetlands are rich with environmental biodiversity, it is vital to conserve their natural ecological space, while meeting local health and security demands. Qatar’s Wetlands and TSE have so much potential, if well managed, to serve the local water supply and demand. There are various approaches to use these wetlands, since it is vital to protect and save them since they contribute so much to the environmental sustainability that the country is seeking for.
References and Appendices
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Appendix A
Putrajaya Constructed Wetlands
The below map illustrates the dams, pumping stations, and the phases of the six arms of the wetlands (PLWMOS, 2011)
Appendix B
**Hong Kong Wetland Park: Visitor Center Illustrative Map**

The below map indicates the spatial zoning and floor plans of the main Visitor Center (HKWP, 2014)
Appendix C
Qatar’s TSE Distribution Network
(Osman, 2013)
Appendix D
Abu Nakhla Wetlands Urban Expansion Maps
Appendix E
Abu Nakhla Lagoon Wetlands Geographic Location
1- Abu Nakhla Wetlands Center
2- Abu Nakhla Food Production & Animals Sanctuaries
3- Community Sports Hub
4- Water Treatment Station
5- Community Garden
6- Community crops/ Food Production
7- Green Boulevard
8- Wetlands Discovery Point (Canoeing, Kayaking, Birds Watch)
9- Wooden Bridges from existing pathways