Global Climate Change, Biodiversity and Sustainabilty: Challenges and Opportunities

AN INTERNATIONAL CONFERENCE FOCUSED ON THE ARAB MENA REGION AND EUROMED

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PAPER 1

Global Climate Change, Biodiversity and Sustainability: Challenges and Opportunities for the Middle East and North Africa (MENA) Region

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Abstract: An international conference titled, "Global Climate Change, Biodiversity and Sustainability: Challenges and Opportunities" was held in Alexandria, Egypt from 15-18 April 2013. Hosted by the Arab Academy for Science, Technology and Maritime Transport, in collaboration with the Smithsonian Conservation Biology Institute and the University of Prince Edward Island, the conference brought together over 500 top researchers, industry representatives and managers to share results and information in a pan-Arab MENA region and EuroMed event. Seventy papers were presented at the conference providing assessments of baseline data and systematic observation networks to assess biodiversity conservation, sustainability options and policy responses to global climate change; integrating our knowledge of likely future global changes reflecting both scientific and traditional knowledge; reporting on predictive models and decision support tools to guide the design and selection of adaptation strategies from local to regional scales; and establishing a framework for future collaborative research on climate change, biodiversity, and sustainable development with a focus on institutional capacity-building in governments, research centres and universities. This article provides a background to the conference, as well as brief introductions to each of the papers presented at the conference and published in this peer-reviewed book including the keynote addresses. A final statement was presented at the conference and accepted by all participants and is included as an appendix to this article.

Keywords: climate change, biodiversity, sustainability, Arab MENA

1. Introduction

Groups such as the European Parliament have recently described climate change, biodiversity and sustainable development as "the greatest challenges of our time". Recognizing that the well-being of humankind is severely affected by climate change and biodiversity loss and that it depends on healthy and resilient ecosystems, the integration of these issues is imperative. Hosted by the Arab Academy for Science, Technology and Maritime Transport, in collaboration with the Smithsonian Conservation Biology Institute and the University of Prince Edward Island, this academic conference focused on sustainability of the Arab Middle East and North Africa (MENA) region – which encompasses 18 countries, the West Sahara and the Palestinian territories (Environmental and Climate Change Policy Brief – MENA, 2010); and the European-Mediterranean (EuroMED) region – comprised of EU member states and 16 Southern Mediterranean, African and Middle Eastern Countries (ILO, 2014). Faced with current environmental, social and economic challenges that make this area of the world particularly susceptible to the impacts of climate change (Environmental and Climate Change Policy Brief – MENA, 2010), this conference provided a forum to explore crucial issues, challenges and opportunities for assessment, capacity building and response across its key themes.

Engaging over 500 individuals from around the globe, the conference brought together top researchers, Nobel Laureates, industry members, government agents, professionals and decision makers with the aim to provide a scientific basis for integrated approaches to planning and decision making for current and future impacts of global climate change, biodiversity and sustainable development. Issues such as adaptation responses to urban, infrastructure and coastal development; ecosystem, air and resource preservation; protection of public health; and risk management and response planning were explored.

Specific conference objectives included:

- critical analysis of systems and baseline data to assess and provide responses to sustainable development, biodiversity conservation and associated policy development;
- knowledge transfer and integration of both scientific knowledge and traditional wisdom;
- assessment and reporting out on predictive models and decision making tools and strategies for adaptation locally and regionally; and
- provision of a forum for the establishment of future collaborative research across all three integrated themes.

The conference was opened by the Egypt Minister's Speech and welcome notes by Professor Ismail Abdel Ghafar Ismail, President, Arab Academy for Science and Technology and Maritime Transport (AASTMT), and Professor Aziz Ezzat, Vice President, Education and Quality Assurance Affairs, AASTMT. Opening keynotes were provided by Mr. David Drake, Ambassador of Canada to the Arab Republic of Egypt, who provided an overview of Canada's Approach to Global Climate Change, Biodiversity and Sustainability; and Dr. Alaa Abd-El-Aziz, President, University of Prince Edward Island, Canada, who spoke about meeting the challenges of sustainability and the establishment of an innovative climate research lab at the University of Prince Edward Island.

Poster presentations were provided throughout the conference, and a special opening session of MENA and the Africa Arab International Women's Maritime Forum was held.

This publication provides a collection of peer-reviewed papers presented at the conference across its thematic priority areas, as a means to share and disseminate information and resources toward a better understanding and response to global change, with a particular emphasis on the Arab MENA and EuroMed Regions.

2. Overview of Integrated Themes of Climate Change, Biodiversity and Sustainability

Climate change, biodiversity and sustainability were key themes upon which the conference was based, with each providing a lens through which to view the interconnectedness of global change-related challenges and associated impacts and opportunities.

2.1 CLIMATE CHANGE

The impacts of climate change are observable around the world. The IPCC and major scientific groups assert scientific consensus that climate warming is unequivocal. Atmospheric concentrations of greenhouse gases - carbon dioxide, methane and nitrous oxide have exceeded the highest recorded values in 800,000 years. If carbon emissions continue to increase, continued global climate and ocean warming is predicted, along with a mean sea level rise (IPCC, 2013). The Arab MENA's current environmental challenges make it one of the most susceptible regions to reduced precipitation, increases in temperature and increases in sea level rise (World Bank, 2008). With a growing population of 380 million in 2000 (Hussein, 2008), this area is characterized by significant and enduring environmental challenges, not the least of which is water security (World Bank, 2008). Climate change projections for Northern Africa indicate that temperatures will continue to increase and precipitation will continue to decrease over annual and seasonal cycles (Boko *et al.*, 2007).

Among many environmental and socio-economic threats, predicted climate change could pose further risk to an already stressed water supply. In comparison to 1995 levels, by 2025, it is anticipated that 80-100 million people in this region could experience water scarcity (Warren et al, 2006). Given that approximately 85% of the total water resource in Egypt is attributed to agriculture, making up approximately 20% of its GDP, water scarcity could threaten agricultural productivity, economic prosperity as well as other potential impacts to ecosystems and human health (Boko *et al.*, 2007). Warming temperatures and associated sea level rise could also pose risks to delta and coastal zones in North Africa, including Alexandria and the Nile Delta (Boko *et al.*, 2007). At risk of flooding and coastal erosion, coastal communities and the livelihood upon which they rely, such as tourism and fisheries could be at risk (Naidu *et al.*, 2006; Kebede *et al.*, 2012, Kebede and Nicholls, 2012, as cited in *Boko et al.*, 2007).

2.2 BIODIVERSITY

Climate change and biodiversity are inextricably linked. The Millennium Ecosystem Assessment (2005) indicates that global biodiversity loss may be caused predominantly by climate change and its associated impacts. Evidence of biodiversity change in response to climate include the migration of species; changes in the reproductive patterns and number of species in a population; and an increase in the incidents of pest outbreaks and disease (Djoghlaf, 2008). These changes may in turn impact the overall health, productivity and biodiversity of associated ecosystems. While climate change poses a risk to biodiversity, the presence of biodiversity is critical because it contributes to the mitigation and adaptation of climate change (Djoghlaf, 2008). Vegetation and wildlife habitat are ecosystems that promote biodiversity and carbon sequestration. Adaptation measures to promote biodiversity exist in sustainable land management, the creation of natural wetlands, ecological corridors, refuges and buffer zones and the restoration of native ecosystems (Djoghlaf, 2008). The IPCC's 5th assessment report (AR5) indicates that Africa is particularly vulnerable to the impacts of climate change related biodiversity loss -to land, fresh water, ocean and coastal ecosystems (Abdrobo, M., *et al.*, 2014) – and is an important theme of research and adaptation actions for the Arab MENA (Middle East and North Africa) and EuroMed region.

2.3 SUSTAINABILITY

The World Commission on Environment and Development - commonly known as the Bruntland Commission after its Chair, former Prime Minister of Norway, Gro Harlem Brundtland - produced a global study titled *Our Common Future* that defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Three inter-related objectives of sustainable development described by Sneddon, Howarth & Norgaard (2006) arose from *Our Common Future*, which position sustainability at the forefront of international development : the improvement of human health and wellbeing; more equitable distribution of resource use benefits across and with societies; and development that ensures ecological integrity over intergenerational timescales. Marking the 10th anniversary of the 2002 World Summit on Sustainable Development (WSSD) and in follow-up to the 1992 Earth Summit/United Nations Conference on Environment and Development (UNCED), the United Nations Conference on Sustainable Development (UNCSD) – Rio+20 - was the third international conference on sustainable development.

A key outcome of Riop+20 was resolution 66/288, adopted by the United Nations General Assembly in 2012, titled *The Future We Want*. Affirming key political commitments to sustainable development, it provides a commitment by 192 government leaders of state in attendance to actions supporting the sustainable development goals to achieve social, economic and ecological imperatives. These include a commitment to action by countries to strategize critical support for sustainable development and resiliency in the Arab MENA and EuroMed Region.

3. Collection of Peer Reviewed Papers

This publication provides a collection of peer-reviewed papers presented at the conference across its thematic priority areas – climate change, biodiversity and sustainability. It is intended as a means to share and disseminate information and resources toward a better understanding and response to global change issues with a particular emphasis on the Arab MENA and EuroMed Region. Conference papers were presented on a variety of relevant topics including climate assessment and impacts on coastal zones, oceans and lakes; planning and policy approaches for climate-related risks; ecological and biodiversity restoration; green urban development; tourism and supply chain; sustainable treatment of wastewater and sustainable manufacturing. These papers have been organized into four main themes in the book – climate change, biodiversity, water and sustainability – and are preceded by a keynote address (Paper 1) presented by the Honourable David MacDonald, United Church Minister; former Member of the Canadian House of Commons; former Minister of Communications; former Minister responsible for the Status of Women and Secretary of State for Canada and former Canadian Ambassador to Ethiopia and Sudan. The theme and title of Hon. MacDonald's paper *Moving From Despair to Hope* presented the challenge of today. Hon. MacDonald asks us to think in large historic terms about healing the planet; which subsequently leads to healing ourselves.

3.1 CLIMATE CHANGE THEME

There are seven papers under first theme of climate change and starts with a keynote paper (Paper 3) by Dr. Adam Fenech, Director, Climate Research Lab, University of Prince Edward Island, (co-authored by Dr. Jerry Jien, University of Toronto) titled *The Changing Climate of the Middle East and North Africa (MENA) Region* (2015). The regions in the Middle East and Northern Africa (MENA) have experienced numerous extreme climate events over the past few years including the 2009 flooding in Jeddah, Kingdom of Saudi Arabia; the 2005 dust storm in Al Asad, Iraq; water scarcity throughout the Arab MENA; and the rising sea levels on the Nile Delta coast, Egypt. Fenech and Jien create a climate baseline for the MENA region by locating climate stations in the study area using the Climate Research Lab at the University of Prince Edward Island's dataset available to researchers called the Climate, Ocean and Atmosphere Data Exchange (COADE). Over the past 50 years, climate changes in the MENA Region have led to increases in annual mean temperatures and decreases in annual total precipitation. For projections of future climate, Fenech and Jien use COADE which provides easy access to the output from forty global climate models used in the deliberations of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5). Applying all four greenhouse gas emission futures on a base climate normal of 1981-2010 to an ensemble of forty global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) results in future temperature increases for the MENA Region ranging from 1.6 to 2.3 degrees Celsius, and in a range of future precipitation changes from reductions of 11 percent to increases of 36 percent by the 2050s (2041-2070). Fenech and Jien conclude that these preliminary results should assist the MENA Region in planning to adapt to changes in climate through increasing the understanding of how climate has impacted the region in the past, and how climate will impact in the future.

The second paper under the theme of climate change is by Taweel *et al.* titled *Sustainable Management of Climate Change: The Case of the Middle East and North Africa Region* (Paper 4) which identifies the MENA as particularly vulnerable to climate change due to its arid and low-lying coastal areas. While an economically diverse one, including both the oil-rich economies in the Gulf and countries that are resource-scarce in relation to their population. However, with about 23 percent of MENA's population living on less than $2 a day, the authors call for the adoption of climate change management strategies that are cost-effective and emphasize economic, social and human development while addressing the concerns arising from anthropogenic climate change. The paper turns to the example of Trinidad and Tobago in its attempt to reduce GHG emissions without affecting the competitiveness of its industrial and agricultural sectors. Using appropriate decision making tools and a policy environment based on a combination of regulations and incentives, the environmental challenges were turned into a vehicle for sustainable development. Taweel *et al.* discuss the factors that need to be considered while developing a sustainable climate change management approach for the MENA region and develop some recommendations that may be essential for achieving the desired climate change mitigation/adaptation actions while minimizing social disruption.

The third paper under the theme of climate change (Paper 5) by El-Geziry and Radwan (2015) is titled *A Decadal Sea Level Analysis off Alexandria, Egypt* and examines daily sea level records for one decade (1996-2005) to calculate both astronomical tide and surge elevations, and to examine the rate of sea level rise off Alexandria. Results provide a minimum annual Mean Sea Level (MSL) of 48.62cm and a maximum of 52.96cm, with an average over the study period of 50.67cm. The surge height over the study period varied between

14.64cm and 87.15cm, with an average of 50.66 cm. El-Geziry and Radwan show that astronomical tide accounts for 0.005% to 37.63% of the observed sea level, while surge accounts for 62.37% to 99.995%. The rate of sea level rise off Alexandria over the examined decade is 1.46 mm/year.

The fourth paper in the climate change theme (Paper 6) is *Flood Hazard Mapping in the Sinai Region* by Elsayad *et al.* (2015) and aims at defining the areas of the Sinai region with potential flood risk. Although Sinai is located in an arid region, its basins could receive a huge amount of rainfall during specific storm events that lead to flash floods that threaten lives, property and other assets. Elsayad *et al.* use GIS techniques to produce a potential flood hazard map by integrating all parameters that contribute to the formation of flash floods in the watersheds of this region. Study results show that 5% of the basins have very high susceptibility of flooding; about 25% have high susceptibility; about 5% have high-medium susceptibility; and about 20% have medium susceptibility. This article identifies basins in the Sinai Region that are classified as very high and high flood risk which allows for the development of detailed studies and actions plans to protect the local population from flood hazards.

The fifth paper under the climate change theme (Paper 7) is by Zanuttigh and Ismail titled *Opportunities from THESEUS EU - Innovative Project for Enhancement of Coastal Resilience of Nile Delta Shorelines* (2015). Zanuttigh and Ismail outline the FP7- THESEUS project's (Innovative technologies for safer European coasts in a changing climate) main contributions and relevance to planning the forthcoming phases of coastal zone management (CZM) of the Nile Delta coastal zone in Egypt. The paper presents a hydrodynamic assessment of the impacts of climate change, as demonstrated by strong winds of up to 60 km per hour with a surge of over 1.0 metre, which caused coastal flooding at the M. Ali seawall on the Abu Qir Bay coastline on December 12, 2010. Zanuttigh and Ismail provide recommendations to further upgrade the M. Ali Seawall cap and strengthen the adjacent beach dike, design recommendations that conform to THESEUS development technological schemes, for the sustainability of coastal zones as well as management and legislative recommendations to enhance coastal resilience.

The sixth paper under the climate change theme (Paper 8) is by Elkafrawy and Soliman titled *Potential Impacts of Natural Hazards on the Egyptian North Western Coast* (2015). Elkafrawy and Soliman provide a land-use study of basic spatial data covering the coastal zone extending from west of Alexandria to the El Sallum sector east and 60 km landward (south) along the North Western Egyptian Mediterranean Sea from 1984 to 2003 at a scale of 1:100,000. This study identifies causative processes and their rates involving time-lapse, sequential coverage of spatial data and the impacts (or risk) of increasing human activities. Results show that coastal features such as shoreline changes, sedimentation, and even some cliff formations are the product of currently acting processes, and their forms seem to represent a changing condition of balance between several controlling factors such as aspect, climate conditions, near shore processes, tides, or sand dune movements.

The seventh and final paper under the climate change theme (Paper 9) is *Climate Change Impacts on the Future Plan for Restoration of Lake Maryut, Alexandria, Egypt* by El Din and Ayoub (2015). Of the Mediterranean coastal wetlands, the most important are the six major coastal lagoons on the Mediterranean: Bardawil, Malaha, Manzala, Burullus, Idku and Maryut Lake. Maryut is an extended lake located parallel to the shoreline to the south of Alexandria City in an extended valley known as Maryut valley. The lake area used to be 250 km^2 and average depth of 90-150 cm. However, it has been continuously and gradually shrinking in area by illegal land fillings. Primary treated wastewater and waste water from a number of large industries have rendered Lake Maryut highly polluted and eutrophic. El Din and Ayoub present an integrated plan for restoration of Lake Maryut under future conditions of climate change that will improve biodiversity conservation in the lake ecosystem.

3.3 BIODIVERSITY THEME

There are four papers under the biodiversity theme, the first (Paper 10) is titled *Implications of Human Induced Changes on the Distribution of Important Plant Species in the Northwestern Coastal Desert of Egypt* by Halmy *et al.* (2015) who conduct spatially explicit modelling of plant species distribution in Egypt and assess changes in land use and climate on the distribution of the plant species. Results indicate that the changes in land use in the area over the last 23 years have resulted in habitat loss for all the modeled species, and that projected future changes in land use reveals that all the modeled species will continue to suffer habitat loss. The projected impact of modeled climate scenarios (A1B, A2A and B2A) on the distribution of the modeled species by 2040 varied. Some of the species were projected to be adversely affected by the changes in climate, while other species are expected to benefit from these changes.

The second paper under the biodiversity theme (Paper 11) is titled *Restoration of the Ecological Process in Alexandria, Egypt* by Aly and Weheba (2015) demonstrates the severity of the issue of degradation as an environmental problem and to introduce ecological restoration as a guideline to reduce degradation and eventually eliminate it.

The third paper under the biodiversity theme (Paper 12) is titled S*outh Mediterranean Coastal Landscape; Lush Lawns Versus Native Species - A Case Study of the North Western Coast of Alexandria, Egypt* by Galil and Salama (2015) provides a case study on the north-western coast of Egypt to demonstrate current landscaping practices, and to provide sustainable alternatives based on a set of landscape criteria developed for arid coastal landscapes.

The fourth and final paper under the biodiversity theme (Paper 13) is titled *Vulnerability Assessment of Bivalves Due to Climate Change and Coastal Pollution in the Nile Delta Coastal Region* by El-Gamal and Saleh, and assesses the bivalves' vulnerability to climate change and coastal pollution using its hard structure (shells). Comparison between the growth rate and calcium carbonate contents of Cardium edulis and Mactra corallina shells collected from the Nile Delta coast in 1999 with the recent shells collected during 2011 from the same place show that the Cardium shell thicknesses were thicker in 1999 than in 2011. It reveals that the availability of calcium carbonate, which is critical for the organism to build its shells, has decreased in the Nile Delta coastal environment since 1999.

3.4 WATER THEME

There are four papers under the water theme, the first (Paper 14) of which is *Towards a Water Based Regional Development Model for Siwa Oasis in the Western Desert, Egypt* by Mohamed A. Salheen (2015). This paper focuses on the Siwa Oasis, a depression which uses groundwater as the only source for everyday use as well as all development and economic activities. For thousands of years, the Siwa natural system was well preserved by the local community, ensuring sustainability and minimum environmental risks and threats. However, with emerging pressure from development, coupled with challenges posed by climate change consequences and threats, the issue of water management on Siwa became an urgent issue. Since the 1960s, the Oasis has experienced significant changes in human activities (agricultural activities, tourism, urban development, ground water mining, and food industries) having a great impact on land use and ultimately on water balance and management. Appreciating the need for economic development and the continuous pressure on natural resources, Salheen builds a model to integrate important and significant forces and impacts in projecting and understanding the future of Siwa and its region.

The second paper under the water theme (Paper 15) is titled *Measuring, Modeling Water Quality by Using Sensors and Statistical Analysis Techniques* by Morsi *et al.* (2015). The water quality of Alexandria, Egypt: The Mediterranean Sea, Mariot Lake, and mineral water extracted and bottled in the Siwa Oasis is measured for concentrations of Sodium (Na), Magnesium (Mg), Calcium (Ca), Nickel (Ni); pH; conductivity; and temperature, and compared with the standard of water parameters given by the World Health Organization (WHO). The results indicate that the Mediterranean Sea is recommended as an alternative water source, while Mariot Lake is contaminated to a high degree.

The third paper under the water theme (Paper 16) is titled *Statistical Analysis Techniques for High Quality Water* by Morsi *et al.* (2015). For industrial applications, high water quality is required for the protection of boilers and turbines as desalinated water is used, but there are still problems caused by its salts and silica concentrations. Results from this paper indicate that it is important to follow the desalination process by another purification process to improve water quality such as the demineralization process which can decrease ionic impurities significantly, so its use is recommended to protect industrial components from deposits and corrosion.

The fourth and final paper under the water theme (Paper 17) is titled *Biochar Usage as a Cost-Effective Bio-Sorbent for Removing NH4-N from Wastewater* by Saleh *et al.* (2015). In this study, the authors investigate the removal of ammonium ions from synthetic wastewater by novel adsorbents including biochar powder derived from peanut hulls, rice husk, sunflower seed husk, and wheat straw. After 24 hours of reactions, the average amount of NH4+ removed by different sources of biochar ranged from 39.00 to 77.05 % regardless of the type of associated anions (Cl- or SO42-). Sunflower biochar appeared to have the highest efficiency in NH4-N removal with the initial concentrations of NH4-N (40 and 200 mg L-1) while peanut biochar showed the adsorption peak with the high initial concentrations (400 and 2000 mg L-1). The results suggest the tested biochar materials are cost effective adsorbents with high adsorption capacities and a recalcitrant nature that can be used in wastewater treatments.

3.5 SUSTAINABILITY THEME

There are ten papers under the sustainability theme, and the first (Paper 18) is titled *Sustainable Manufacturing Indicators* by Moneim *et al.* (2015). Manufacturing is an indispensable activity to provide people with their basic necessities in food, shelter, safety and even entertainment, but leads to known adverse effects on the environment. Moneim *et al.* introduce sustainability indicators that sufficiently and effectively cover inputs, manufacturing operations and products produced by a facility with the ultimate intention to formulate a global indicator measuring sustainability of a manufacturing facility.

The second paper under the sustainability theme (Paper 19) is titled *Sustainable Tourism in Egypt: Western Desert as a Potential for Future Ecotourism* by Mohamed A. Salheen (2015) and focuses on one of the main sources of foreign currency with a direct and indirect contribution to the economy of around 10% of Gross Domestic Product (GDP). Yet, most of the tourism business in Egypt (around 90%) relies on the unsustainable beach tourism at the Red Sea, cultural tourism in Upper Egypt, and local beach tourism at the North Coast. Siwa Oasis is one of the most prominent and outstanding areas for sustainable tourism being advantaged by its remoteness and poor connection to main urban centres. There are other places in Egypt, especially on the Western Desert and around the Nile Valley like Fayoum and Aswan, which have the potential to develop in the direction of ecotourism or in a complementary direction. Salheen studies the conditions and components of ecotourism in Siwa and then tries to set the premise for a national road map to expand the sustainable tourism business in Egypt.

The third paper under the sustainability theme (Paper 20) is titled *Traffic Congestion Sustainable Solutions: Mass Transportation (Railway Upgrade)* by Dabbour and Tarabieh. Traffic congestion is a major problem in most Egyptian cities. It's a non-productive, time-wasting activity for most people especially private transportation resulting in the inability to forecast travel time accurately, leading drivers to allocate additional time to travel "just in case", thus spending less time on productive activities. The stress and frustration experienced by motorists encourages road rage and can negatively impact health. Traffic congestion also reduces air quality and is a major contribution to the use of enormous amounts of non-renewable energy and the associated generation of greenhouse gas emissions. Dabbour and Tarabieh study traffic congestion caused by the increase in private vehicle ownership and possible sustainable solutions, focussing on the upgrade of an existing railway. Mass transportation, such as rail, ensures safety, improves air quality and saves energy, time, money, and space.

The fourth paper under the sustainability theme (Paper 21) is titled *Maintaining the Cultural Sustainability of Canada and Prince Edward Island: Examples of the Role of Performing and Visual Arts in Sustainable Development* by Jessie Inman (2015). Cultural sustainability is an interdisciplinary approach aimed at raising the significance of culture in local, regional, and global sustainable development. It has been argued by UNESCO and other international groups that culture should be the "fourth and central pillar" of sustainable development, joining the original economic, social and environmental pillars, as culture underpins all of these. At the same time, in an increasingly globalized society, to ensure cultural diversity, Inman argues that it is important that these be maintained at the local level as well. Prince Edward Island's Confederation Centre of the Arts is an example of how cultural sustainability works across all pillars of sustainability. Through the performing and visual arts, the Centre contributes to the climate change, biodiversity, and sustainable development discourse using the language of art and culture.

The fifth paper under the sustainability theme (Paper 22) is titled *Environment Impact on Seafront Reinforced Concrete Structures in Egypt* by Hassan et al. (2015). The rapid deterioration of reinforced concrete buildings in Alexandria, Egypt has become a major problem for seafront buildings' dwellers. This paper examines the effect of steel corrosion on the durability of seafront reinforced concrete structures using a comprehensive experimental program and detailed numerical analysis at the Arab Academy. The corrosion of different types of carbon steel bars was evaluated for plain bars, un-coated deformed bars, and epoxy coated deformed bars. Results confirm the major impacts of the saline environment on increasing the rate of deterioration in such buildings.

The sixth paper under the sustainability theme (Paper 23) is titled *Green Urbanism: A Vision for Sustainable Urban Renewal in Alexandria, Egypt* by Maye Yehia (2015). This paper examines planning methods and decision-making tools that promote green urbanism in the context of issues facing cities in developing countries especially how sustainability can be mapped into decisions regarding deteriorated urban contexts. This problem is particularly evident in Egypt where recent civil unrest and an unstable political situation have provoked intensive illegal construction practices, aggressive transformation of the natural and built environment, as well as irreversible ecological transgressions. Using the French experience with green urbanism policies to draw lessons from urban renewal methods, the authors describe environmental strategies and projects that must be promoted in Alexandria in order to achieve sustainable development. Guidelines are proposed to develop an integrated framework that can be implemented, which is reflective of environmental local issues and priorities with particular emphasis on the urban regeneration of aging inner city areas.

The seventh paper under the sustainability theme (Paper 24) is titled *A Sustainability Assessment Framework for Waterfront Communities: Increasing the Resilience of the Abu Qir Waterfront Community in Alexandria, Egypt* by El Deeb et al. (2015). This paper investigates a number of sustainability frameworks and assessment rating systems for buildings, neighbourhoods, and communities using sustainable evaluation criteria specified within three difference assessment rating systems: LEED (Leadership in Energy and Environmental Design from the United States of America); BREEAM (Building Research Establishment Environmental Assessment Method from the United Kingdom); and Pearl (Estidama PEARL rating system from the United Arab Emirates). The paper concludes with a proposed framework of indicators for waterfront communities reflecting the similarities and differences among the three noted rating systems, with a particular focus on indicators that pertain to waterfront planning.

The eighth paper under the sustainability theme (Paper 25) is titled *Drivers and Barriers facing adoption of Green Supply Chain Management in the Egyptian Food and Beverage Industry* by Hassan *et al.* (2015). Green Supply Chain Management has become an initial key factor for corporate sustainability. This paper identifies drivers and barriers for Green Supply Chain Management in the Egyptian food and beverage industry. Results indicate that organization values are the main driver for adopting GSCM practices in the Egyptian food and beverage industry, while the lack of resources and governmental support are the main barriers.

The ninth paper under the sustainability theme (Paper 26) is titled *Influence of Cement Factories on the South Cairo District Regarding* SO_2 *,* NO_2 *and* PM_{10} *Emissions* by Belal *et al.* (2015). The cement industry plays a very important role in the growth of any country's national economy and social development but many pollutants are released in cement production including sulphur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), and particulate matter (PM). A model was applied to two currently operating cement plants, the Helwan plant and the Tourah plant, in Cairo, Egypt, to study the presence of environment pollutants emitted by both plants collectively on an area of 14 km by 14 km, located at a distance of 2.5 km from the Helwan plant, and about 15 km from the Tourah plant. The study showed that the emission concentrations of sulphur dioxide (SO2) based on the maximum daily rate (MD), and the emission concentrations of nitrogen dioxide (NO2) and particulate matter (PM10) based on maximum hourly (MH) and maximum daily (MD) rates were in the permissible range. However, the emission concentration of sulphur dioxide (SO2) based on the maximum hourly (MH) rate was higher than the allowable limits set by the Egyptian Environmental Law (EE) and Air Quality Standards for the United Kingdom (AQSUK).

The tenth and final paper under the sustainability theme (Paper 27) is titled *Application of Green Materials for Noise Control in Buildings with Simulation of MATLAB* by El-Brombaly and Mosalam (2015). This paper investigates the acoustical properties of local green acoustics materials, working with different kinds of residual harvesting plants: rice straw, karina of palm tree, palm fronds, palm leaf, grain zea mays (a.k.a. maize or corn) and sugarcane reed with different particulate sizes and compression loads, leading to different densities. By applying different methods of producing samples, a wide range of absorption coefficients was defined.

4. Conclusions

The *Global Climate Change, Biodiversity and Sustainability: Challenges and Opportunities* conference engaged over 500 individuals from around the globe. Bringing together top researchers, Nobel laureates, industry members, government agents, professionals, and decision makers, the conference aimed to provide a scientific basis for integrated approaches to planning and decision making for current and future impacts of global climate change, biodiversity, and sustainable development. This publication was produced to capture and share research and resources from the conference. It is hoped that this publication will promote knowledge and sustainable response to the many challenges associated with climate change, biodiversity, and sustainability in the Arab MENA and EuroMed Regions and around the world.

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All other references appear as individual papers in this book.

Appendix 1

Conference Statement

Global Climate Change, Biodiversity and Sustainable Development: Challenges and Opportunities

APRIL 2013, Alexandria, Egypt

BACKGROUND TO THE CONFERENCE:

From 15-19 April 2013, the Arab Academy for Science, Technology and Maritime Transport hosted an international conference in collaboration with the Smithsonian Conservation Biology Institute and the University of Prince Edward Island to examine the challenges and opportunities for integrating the three issues of Global Climate Change, Biodiversity, and, Sustainability. The conference brought together over 500 researchers, industry representatives and managers to share results and information in a pan-Arab MENA region and EuroMed event aiming to establish the scientific foundation for sound decisions on infrastructure, urban development, natural resources, public health, and insurance, as well as for planning – from community organizations to international disaster risk management.

Seventy papers were presented providing assessments of baseline data and systematic observation networks to assess biodiversity conservation, sustainability options and policy responses to global climate change; integrating our knowledge of likely future global changes reflecting both scientific and traditional knowledge; reporting on predictive models and decision support tools to guide the design and selection of adaptation strategies from local to regional scales; and establishing a framework for future collaborative research on climate change, biodiversity, and sustainable development with a focus on institutional capacity-building in governments, research centres and universities.

THE CHALLENGES:

1. Climate Change: The global average temperature has risen by 0.6°C (1.1°F) over the course of the 20th century. 2001-2010 was the warmest decade on record since modern temperature monitoring began around 160 years ago. The global mean temperature for the decade is estimated at 0.47°C (0.8°F) above the 1961-1990 average of 14.0°C (57.2°F). Globally, 2010 is estimated to be the warmest year ever recorded since modern measurement began, closely followed by 2005.

2. Biodiversity: The Arab world houses a unique biological diversity in terms of species and ecosystems represented by arid, semi arid, and Mediterranean biomes. The number of species in the Arab world is low in accordance with their natural environment with total documented animal and plant species ranging from 9119 species in Lebanon to 2243 species in Mauritania. However, regardless of species richness, it is the measure of the relative changes in species diversity which will give insight into the vulnerability of a region with respect to climate change. Although it is possible that dry-land species will be able to expand their distribution range, this is highly dependent on the species' dispersal habits and ability to overcome natural or human created barriers or human caused land transformations.

3. Agriculture: Projections suggest that the rate of increase in agricultural production in the Arab MENA will slow over the next few decades, and it may start to decline after about 2050. Most of the Mediterranean region, which supports 80 percent of production, is projected to have less rainfall and hotter conditions. This will increase water use and likely limit the productivity of some crops. Other areas, such as the Nile Delta, will have to contend with saline intrusion from the sea. Farmers will face additional problems from higher temperatures. For example, the chilling requirements for some fruits may not be met; new pests will emerge; and soil fertility is likely to decline. This is alarming because almost half of the Arab region's population lives in rural areas, and 40 percent of employment is derived from agriculture.

4. Food Security: It is often forgotten that the world's oceans are one of the largest food reserves on the planet. According to estimates of the Food and Agriculture Organization (FAO), globally some 200 million people depend on fishing and aquaculture. In a number of countries, consumption of fish provides close to or more than 50 percent of total animal proteins. Climate change is expected to bring increases in water temperature and storm frequencies that destroy natural habitat, threaten marine biodiversity and endanger the viability of fishing as a sustainable human livelihood.

5. Tourism: Tourism today contributes about US$50 billion per year to the Arab region, which is about 3 percent of its total gross domestic product (GDP), and tourism is projected to grow by about 3.3 percent per year for the next 20 years. It is also an important sector for jobs, because roughly 6 percent of the region's employment is tourism related. Higher temperatures are an obvious threat to tourism in a region that is already regarded as hot.

6. Water Resources: The Arab region has the lowest freshwater resource endowment in the world. All but four Arab countries (Arab Republic of Egypt, Iraq, Saudi Arabia, and Sudan) suffer from "chronic water scarcity," and over half of countries fall below the "absolute water scarcity" threshold. It is estimated that climate change will reduce water runoff by 10 percent by 2050. Currently, the region suffers a water deficit (demand is greater than supply), and with increasing populations and per capita water use, demand is projected to increase further, by 60 percent, by 2045.

7. Energy: The energy sector plays a vital role in the socioeconomic development of the Arab countries, many of which are endowed with vast hydrocarbon resources. The Arab countries hold nearly 58 percent of global oil reserves and nearly 29 percent of global gas reserves. In addition, there is a huge potential for the development of renewable energy resources such as solar and wind. Extreme weather events can result in devastating economic and social impacts on energy infrastructure. Oil- and gas-producing facilities in some coastal low-lying areas vulnerable to sea level rise and offshore facilities might also be vulnerable to extreme weather events such as storms, which would lead to breaks in production.

ADVICE AND GUIDANCE FROM THE CONFERENCE

1. Climate: Support the establishment of an Arabic language climate change database of past climate observations and future climate scenarios focused on the Arab MENA, similar to the UPEI climate scenarios database, to provide future climate projections for climate change vulnerability, impacts and adaptation studies.

2. Biodiversity: In addition to studying and projecting biological species' reaction to climate change, it is as important to support the prediction of which species will maintain their current distribution under future climate change as the net species loss in arid and semi-arid areas will lead to collapse of already marginal dry-land communities. Mapping those locations affected least and those affected most under different future climate projections will provide guidance for designing conservation networks in the Arab MENA.

3. Agriculture: Support for research on desert agriculture and sustainable agriculture in the Arab MENA including the investigation and preservation of arid lands and their natural resources, with specific projects on desert agriculture, medicinal plants, crop genetics, efficient irrigation and bio-fuel programs.

4. Food Security: Support development of Arab MENA fisheries resources, from the waters bordering the Arab states as well as inland water and aquaculture which, if rationally and scientifically exploited, could play a much more important role in meeting increased demand for food, and in activating the economies of several countries in the Arab MENA.

***5. Tourism*:** Support the documentation of best practices for water conservation under climate change in the tourism industry in the Arab MENA through an international conference on the subject and the sponsorship of a scientific book on the subject for guidance and reference.

6. Water Resources: Support research on desalination, a flexible and cost-effective water-supply solution in isolated areas, or tourist destinations, where retrieving water from distant water sources is prohibitively expensive. Advancements in using solar energy in desalination is making this option increasingly more competitive in the long term compared with fossil fuels, particularly given that oil prices are projected to continue their upward trend. The Arab region has vast areas that are rated as prime sites for solar energy production.

7. Energy: Support the promotion of renewable energies in the Arab MENA for energy security to meet the region's energy needs and potential socio-economic benefits arising from these technologies, and examine the influence that climate change may play in the future vulnerability of this infrastructure.

Signed by the 500 participants to the *Global Climate Change, Biodiversity and Sustainability: Challenges and Opportunities* Conference.

PAPER
2

Climate Change, Biodiversity and Sustainability: Moving From Despair to Hope

THE HONOURABLE DAVID MACDONALD

United Church Minister; former Member of the Canadian House of Commons; former Canadian Minister of Communications; former Canadian Minister responsible for the Status of Women and Secretary of State for Canada; former Canadian Ambassador to Ethiopia and Sudan; former Chair, Canadian Parliamentary Committee on the Environment 1989-1993

This book on global climate change, biodiversity, and sustainability is absolutely critical. It is something that we are all struggling with whether you live in the Mediterranean, the Middle East, somewhere in northern Africa or anywhere else on the globe. We must remember that we are all part of the same human family. This is an incredible challenge and it focuses on the theme of the conference which is sustainability. Sustainability has been defined by the book *Our Common Future* as "t*o meet the needs of the present without compromising the ability of future generations to meet their own needs.*" The theme of this conference is the challenge of our age. We are the generation which must respond with the right answers.

The history of sustainable development can actually be contained within the lifetime of many. As a child of the 1930's and the Second World War, concepts of planetary limits, accelerating environmental change and extremes of wealth and poverty were virtually unknown and unimaginable. The controversial publication of Rachel Carson's *Silent Spring* in 1962 and in 1972, the parallel events of the publication, *Limits to Growth*, by the newly formed Club of Rome; and the first UN Conference on the Human Environment in Stockholm, Sweden were setting the stage for less than half a century of grappling with challenges of environmental exhaustion and global poverty. Sadly, we can conclude that with successive attempts since the early 1970's, Rio in 1992, Johannesburg in 2002 and again Rio+20 in 2012, we are immobilized by the crisis. But, brilliant at stating the challenge and codifying it,

So where are our efforts to secure sustainability? What has happened after all our many meetings and global conferences? Our current situation is more and more dysfunctional and destructive economically, socially, environmentally and politically. Two of the biggest obstacles in reaching our desired goals are fear and finance. Fear and Finance are the twin evils that plague our era. One can even assign dates for the evolution of both of these challenges. With fear, August 1945 was the finale of the 2nd World War and the shock of those cataclysmic atomic bombs on Hiroshima and Nagasaki. Even as a young child of nine years old, when I witnessed those mushroom clouds in the movie newsreels, I knew my life would never be the same again. It was the end of innocence and the dread of a global holocaust. With finance, it was a global implosion, but in slow motion. It began with the end of the fixed exchange rate in the early 1970's and the loss of sovereignty for nation-states in the 1990's. Democracies were undermined and destroyed from within. Out sourcing, downsizing, privatizing are all symptoms of the dispensability of humanity in both an individual and a corporate sense.

At the UN Kyoto Conference of the Parties in Copenhagen in 2009, I was convinced that we had the wrong government ministers present for these deliberations. It was not Environment Ministers that we needed; but Ministers of Finance. Only they could make the decisions that the conference needed them to make. Sustainability for this Millennium may not be sufficient. We have passed the tipping point of sustainability. We are into crisis mode. We do not have the luxury of simply sustaining our situation for ourselves or future generations. We need a recovery plan. We need a reversal plan. We need an extremely tough transition and transformation strategy.

The center piece of "healing the planet" is how we value ourselves, our communities and one another. This is not just some academic issue. It goes to the heart of what our lives are all about. It relates to all the systems which make up and determine our daily lives. It means in the final analysis dealing with economic and financial systems. They cannot exist outside the purview or responsibilities to all the rest of society. Fundamentally, we need to change that.

We can choose hope or despair. Is this like being on the Titanic or are we with Noah preparing for the flood? Some suggest the Titanic as a dramatic example of our situation. We are going to hit those icebergs. What should we do? But, I prefer to remember Noah before, during and after the flood. He had hope not despair. He was prepared to do something about that. We have been warned. We have seen climate extremes and crises; as well as the rising oceans and the melting ice caps. There are voices arguing for no response. But tragically, they are the fearful and the vested interests.

There are fundamentally two inter-related issues. First, how do we end and reverse our assault on nature? That is, how can we live in a harmonious way with all the rest of creation? And second, how can we live in such a way that each human being can fulfill the potential with which they were born? What is it and how is it that life can have its true worth? What are ways in which as societies and communities we can create human social value and meaning? The goal is how do we bring these two challenges together in a way in which they can interact with one another to produce win/win situations? Sustainability seems a somewhat rather weak and limited ambition and may in the end be a blind alley or dead end.

Carbon based energies have been our 'drug of choice.' More and more people believe that we must end our carbon addiction. We are on the cusp of breaking free of fossil fuels and entering a solar age. Without a doubt, the central issue in transitioning to a sustainable and green economy is the challenge of moving from a carbon based economy to one primarily driven by sunshine. Our difficulty is that while we know a good deal about the components such as solar, wind, water and geo thermal, we do not have a clear understanding of how all these and other elements can be assembled in a way that allows us to both end the carbon dependency while ensuring current and more important future energy needs are adequately met. And, there are additional problems. The addiction to carbon is intimately related to vast amounts of wealth and power controlled by a very few.

Our biggest challenge is enabling our imaginations, energizing our democracies and courageously adopting the policies, programs and projects which move us into new transformed societies and communities. While the challenge is enormous, the alternatives are truly terrifying. What should we do to nudge this historic change? I believe our direction must be towards resistance, resilience, transition, transformation and healing. In simple terms, it is healing the planet and healing ourselves.

We must adopt a different worldview and address two fundamental challenges that are really the same one. Reversing and recovering from the damage we are doing to the planet; and creating just, caring and compassionate ways of sharing our lives together on this earth. So the time is now fast upon us to make a radical course correction. We are in a race against time as we are rapidly discovering that time is our enemy, and we have crises far beyond our knowing. We do not have years and decades. We have possibly a few months, a number of weeks and not that many days. We need to take back our power and take back the responsibility to move the world in a very different direction. We do not need to tinker. We do not need to make easy and convenient changes. We don't want reform. We need transformation.

Transformation that is life affirming. Transformation that is planet recovering. And transformation that is based on real hope and inclusion. This is an adventure in living with people and communities that are able to make the most of their potential both individually and in all of the social communities which they create and sustain.

It should be clearly stated and understood, no healthy society can exist with extremes of wealth and poverty. The healthy communities are those where the significant characteristic is the care and concern for one another and not the privatizing of wealth, power and instruments of violence. Freedom is meaningless and indeed nonexistent when corporate fear, unjust power and exploitation of people are characteristics of that society. It is about healing the planet and healing ourselves. It is hope not despair.

Chapter One

Climate Change

PAPER 3 | The Changing Climate of the Middle East and North Africa (MENA) Region

PAPER 4 | Sustainable Management of Climate Change: The Case of the Middle East and North Africa Region

PAPER 5 | A Decadal Sea Level Analysis off Alexandria, Egypt

PAPER 6 | Flood Hazard Mapping in Sinai Region

PAPER 7 | Opportunities from THESEUS EU— Innovative Project for Enhancement of Coastal Resilience of Nile Delta Shorelines

PAPER 8 | Potential Impacts of Natural Hazards on the Egyptian North Western Coast

PAPER 9 | Climate Change Impacts on Future Plan for Restoration of Lake Maryut, Alexandria, Egypt

PAPER 3

The Changing Climate of the Middle East and North Africa (MENA) Region

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Abstract: The leading authority on climate change, the Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the climate system is unequivocal, and will continue for centuries. The regions in the Middle East and Northern Africa (MENA) have experienced numerous extreme climate events over the past few years including the 2009 flooding in Jeddah, Kingdom of Saudi Arabia; the 2005 dust storm in Al Asad, Iraq; water scarcity throughout the Arab MENA; and the rising sea levels on the Nile Delta coast, Egypt. A climate baseline can be developed for regions in the MENA by locating climate stations in the study area using observations made in the Global Climate Observing System (GCOS). For projections of future climate, global climate models (GCMs), mathematical equations that describe the physics, fluid motion and chemistry of the atmosphere, are the most advanced science available. The Climate Research Lab at the University of Prince Edward Island has a dataset available to researchers, called the Climate, Ocean and Atmosphere Data Exchange (COADE), that provides easy access to the output from forty global climate models used in the deliberations of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) including monthly global climate model projections of future climate change for a number of climate parameters including temperature and precipitation. Over the past 50 years, climate changes in the MENA Region have led to increases in annual mean temperatures and decreases in annual total precipitation. Applying all four greenhouse gas emission futures on a base climate normal of 1981-2010 to an ensemble of forty global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) results in future temperature increases for the MENA Region ranging from 1.6 to 2.3 degrees Celsius, and in a range of future precipitation changes from reductions of 11 percent to increases of 36 percent by the 2050s (2041-2070). These preliminary results should assist the MENA Region in planning to adapt to changes in climate through increasing the understanding of how climate has impacted the region in the past, and how climate will impact in the future.

Keywords: climate, climate change, temperature, precipitation, MENA

1. Introduction

The leading authority on climate change, the Intergovernmental Panel on Climate Change (IPCC) has concluded that warming of the climate system is unequivocal, and will continue for centuries. Global temperatures could rise by between 0.3°C to 4.8°C during the 21st century with predictions of more frequent warm spells, heat waves, and heavy rainfall, and an increase in droughts (IPCC, 2014). The Middle East and North Africa (MENA) region of countries is the focus of much study. There is no standardized definition of MENA as different organizations define the region as consisting of different territories. The following are commonly included countries and territories in the MENA definition: Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, Yemen, and the United Arab Emirates. Sometimes also included in broader definitions of MENA are Armenia, Azerbaijan, Cyprus, Djibouti, Mauritania, Somalia, Sudan, Turkey and Western Sahara.

Recent studies of regional climate have shown that the climate of the MENA Region has experienced several extreme climate events including the 2009 flooding in Jeddah, Kingdom of Saudi Arabia (Saud, 2010); the 2005 dust storm in Al Asad, Iraq (Crook, 2009); water scarcity throughout the Arab MENA (Roudi-Fahimi, 2002); and the rising sea levels on the Nile Delta coast, Egypt (El-Raey, 1997). Quantifying the risk (estimation of likelihood and consequence) of, and developing an adaptation plan for, climate change to the region's ecology and economy is particularly important because of its inherent vulnerability. The MENA environment is expected to respond to climate changes "in atmospheric temperature projections made from many GCMs applied to the region, as well as projections summarized in the Fourth Assessment Report of IPCC" (Wasimi, 2010). The changes in the environment and economy of the MENA Region are expected to be more "creeping" – sneaking up in a gradual and less apparent manner - than those taking place in other regions. This paper will provide some results from a preliminary baseline of climate observations and projections of future climate to assist the MENA countries in adapting to changes in climate through increasing the understanding of how climate has impacted the region in the past, and how climate will impact in the future.

2. Methods

There are 64 climate stations in the MENA Region contributing to the Global Climate Observing System (GCOS) (see Table 1), a joint undertaking of the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU). The goal of GCOS is to provide comprehensive information on the total climate system, involving a multidisciplinary range of physical, chemical and biological properties, and atmospheric, oceanic, hydrological, cryospheric and terrestrial processes. GCOS is intended to meet the full range of national and international requirements for climate and climate-related observations.

Table 1: Global Climate Observing Stations (GCOS) in the MENA Region

Algeria	**4**	**Iraq**	**1**	**Oman**	**3**	**United Arab Emirates**	**1**
Armenia	**1**	**Jordan**	**2**	**Qatar**	**1**		
Azerbaijan	**1**	**Kuwait**	**1**	**Saudi Arabia**	**6**		
Bahrain	**1**	**Libya**	**5**	**Sudan**	**9**		
Cyprus	**1**	**Malta**	**1**	**Syria**	**3**		
Egypt	**7**	**Mauritania**	**5**	**Tunisia**	**2**		
Georgia	**1**	**Morocco**	**3**	**Turkey**	**5**		

A climate comparison across the MENA Region can be made using the US National Center for Environmental Prediction (NCEP) reanalyzed dataset which uses a state-of-the-art analysis/forecast system to perform data assimilation using past data from 1948 to the present available as 4 times daily format and as daily averages (Kalnay et al, 1996). The dataset is freely available at www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html.

A climate baseline can be developed for individual sites around the world by: locating GCOS climate stations in the study area using the National Climate Data Center of the US National Oceanic and Atmospheric Administration (NOAA, 2015); downloading the full climate record for each of the climate stations in the region; conducting quality assurance and quality control (QA/QC) measures for daily temperature (maximum, minimum and mean) and precipitation (total) values including range, visual and missing data checks; and preparing summaries of daily climate data for each month, season and year.

For projections of future climate, global climate models (GCMs) are the most advanced science available. Global climate models are strings of mathematical (differential) equations based on the basic atmospheric laws of physics, fluid motion and chemistry that, taken together with interactions with ocean, sea-ice and land components, describe the Earth's climate system. The largest supercomputers in the world are used to "run" the models by dividing the planet into a 3-dimensional grid (both horizontal and vertical), applying the mathematical equations, and evaluating the results. Results can vary widely between global climate models because of some fundamental differences between them such as the grid size used, the number of grids in the vertical, and the time period used between steps in the run. Some models do better than others at reproducing the historical climate in different regions; (Fenech *et al.*, 2012 provides a view of which models perform best where), especially in complex environments (coastal, mountainous, sea ice), where extra care is required for grid cell averaging and process parameterization. One must remember that no model perfectly reproduces the system being modeled. Such inherently imperfect models may nevertheless produce useful results. In this context, global climate models are capable of reproducing the general features of the observed global temperature over the past century (IPCC, 2007).

The largest uncertainties in the global climate models' future projections emerge from the greenhouse gas emission scenarios, or what human activities are anticipated in the future. Increases in the atmospheric concentrations of greenhouse gases (GHGs) (for example, carbon dioxide, methane, nitrous oxide and ozone) are what drive the climate warming. Future greenhouse gas emissions will be determined by three major factors: future human population growth; the strength of the future global integrated economy; and the future mix of energy sources (renewable versus non-renewable). These three factors will either influence the global climate in a major way (high emissions from all three), moderately (medium emissions from all three) or in a minor way (low emissions from all three) – yet it is uncertain as to how.

Attempts have been made by the Intergovernmental Panel on Climate Change (IPCC) to provide a range of scenarios of future greenhouse emissions, based on varied futures of human activities, formerly known as the SRES Scenarios (for the IPCC AR3 and the IPCC AR4), and now (as of the IPCC AR5) known as the RCP Scenarios. SRES scenarios, from the IPCC's *Special Report on Emission Scenarios*, refer to six families of future greenhouse gas emission scenarios - A1FI (highest), A1B (mid), A1T (low), A2 (high), B1 (lowest), and B2 (low) – each having been used to project future atmospheric greenhouse gas concentrations, and thus the magnitude of increases in global temperatures. The IPCC AR5 now uses RCPs or Representative Concentration Pathways for future greenhouse gas scenarios. RCPs are greenhouse gas concentration (not emissions) driven; still span a large range of stabilization, mitigation and non-mitigation pathways; and are named after a possible range of radiative forcing (W/m2) values in the year 2100 - RCP2.6 (lowest), RCP4.5 (low), RCP6 (mid), and RCP8.5 (high). There is no immediate comparison between the SRES and RCP greenhouse gas emission scenarios, but they are similar.

Global climate model output from all models used in the deliberations of the IPCC assessments can be accessed through the IPCC Data Distribution Centre (see www.ipcc-data.org/) or more recently through the World Climate Research Program (WCRP) Coupled Model Intercomparison Program (CMIP) 5 (see cmip-pcmdi.llnl.gov/cmip5/guide_to_cmip5.html). These websites, however, require specialized knowledge in computer languages and the climate data itself as well as significant resources (primarily time) to download, convert, format, interpret, analyze and map the model output. This makes it less suitable for an individual researcher to have access to the data. Going to each global climate modelling centre individually can also be problematic. There can be many delays in gaining permission for data, requesting data, receiving data, cleaning data, getting answers to questions about data, among other things.

The Climate Research Lab at the University of Prince Edward Island has a dataset available to researchers that disseminates climate change scenarios and other climate change impact and adaptation information. The dataset, called the Climate, Ocean and Atmosphere Data Exchange (COADE), provides easy access to the output from forty global climate models used in the deliberations of the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC AR5) including monthly global climate model projections of future climate change for a number of climate parameters including temperature and precipitation. COADE was queried for temperature and precipitation changes for the MENA Region using an ensemble (or average) of all forty IPCC AR5 global climate models. The *ensemble approach* has demonstrated in recent scientific literature to likely provide the best projected climate change future projection (see IPCC, 2010). This approach suggests that it is best to plan for the average climate change from all of the climate model projections by using a mean or median of all the models (or many models) to reduce the uncertainty associated with any individual model. In effect, the individual model biases seem to offset one another when considered together. Compared against historical observed gridded data, climate projections using the *ensemble approach* have been shown to come closest to replicating the historical climate.

3. Results

Two annual mean temperature climate normals from 1961-1990 and 1981-2010 are shown for the MENA Region in Figures 1 and 2 as retrieved from the US NCEP reanalysis dataset. The two figures show a strong increase in the annual mean temperatures across the MENA Region as demonstrated by the expanding regions of red colour.

When examining precipitation, two annual total precipitation climate normals from 1961-1990 and 1981-2010 are shown for the MENA Region in Figures 3 and 4 as retrieved from the US NCEP reanalysis dataset. The two figures show a strong decrease in the annual total precipitation across the MENA Region as demonstrated by the expanding regions of purple colour.

Applying an ensemble of forty global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) for all 4 Representative Concentration Profiles (RCPs) on a base climate normal of 1981-2010 for the MENA Region at the 2050s results in future temperature increases ranging from 1.6 to 2.3 degrees Celsius (see Figure 5), and in a range of future precipitation changes ranging from reductions of 11 percent to increases of 36 percent (see Figure 6). These preliminary results should assist the MENA Region in adapting to changes in climate through increasing the understanding of how climate has impacted the region in the past, and how climate will impact in the future.

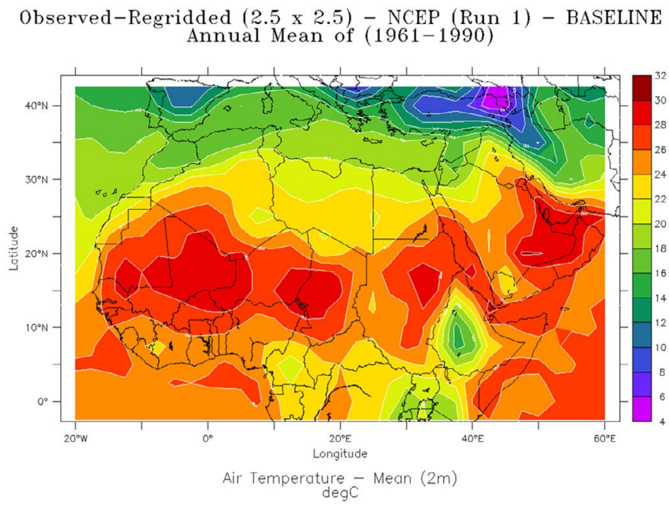

Figure 1: Annual Mean Temperature climate normal for 1961-1990 from the reanalyzed climate dataset of the US National Center for Environmental Prediction (NCEP) in degrees Fahrenheit

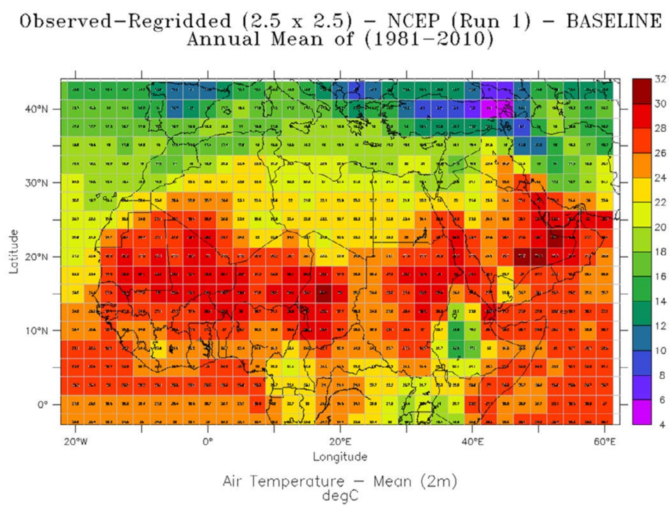

Figure 2: Annual Mean Temperature climate normal for 1981-2010 from the reanalyzed climate dataset of the US National Center for Environmental Prediction (NCEP) in degrees Fahrenheit

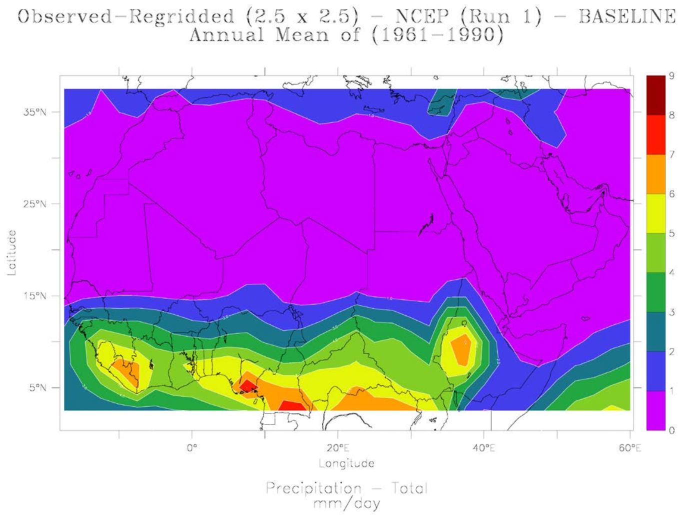

Figure 3: Annual Total Precipitation climate normal for 1961-1990 from the reanalyzed climate dataset of the US National Center for Environmental Prediction (NCEP) in inches

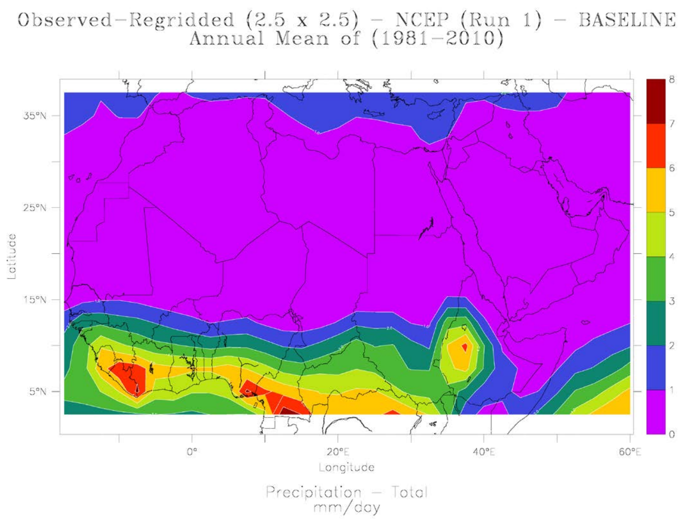

Figure 4: Annual Total Precipitation climate normal for 1981-2010 from the reanalyzed climate dataset of the US National Center for Environmental Prediction (NCEP) in inches

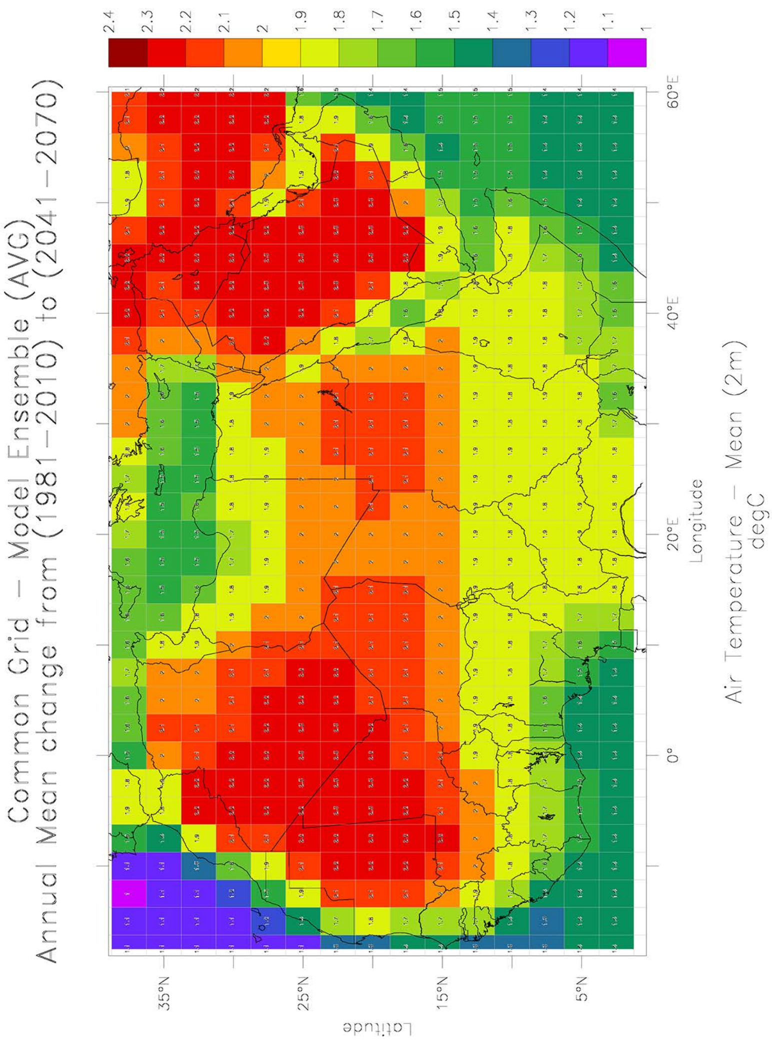

Figure 5: Annual Mean Temperature for climate normal of 2041-2060 (2050s) from the COADE climate dataset of the University of the Prince Edward Island (UPEI) in degrees Celsius using forty global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) for all 4 Representative Concentration Profiles (RCPs)

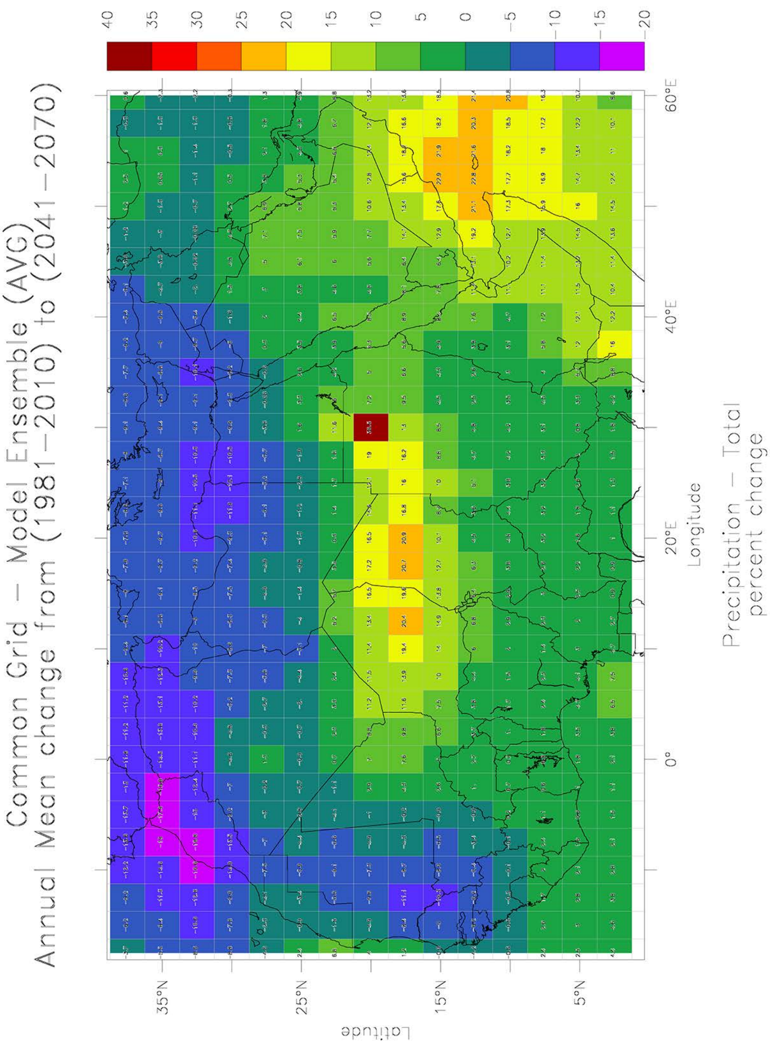

Figure 6: Annual Total Precipitation for climate normal of 2041-2060 (2050s) from the COADE climate dataset of the University of the Prince Edward Island (UPEI) in percentage using forty global climate models used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) for all 4 Representative Concentration Profiles (RCPs)

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PAPER 4

Sustainable Management of Climate Change: The Case of the Middle East and North Africa Region

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Abstract: Climate change is one of the major environmental challenges facing the world. Particularly vulnerable are arid and low-laying coastal areas, conditions that prevail through most of the Middle East and North Africa (MENA). This region is an economically diverse one, including both the oil-rich economies in the Gulf and countries that are resource-scarce in relation to their population. However, with about 23 percent of MENA's population living on less than $2 a day, it is imperative that the climate change management strategies adopted be cost-effective and emphasize economic, social and human development while addressing the concerns arising from anthropogenic climate change. Over the past decades, several national and international mechanisms were developed in an attempt to reduce the emissions considered to be mainly responsible for climate change, and to assist in coping with the adverse effects that are beginning to occur as a result of climate change. Unfortunately, many of these approaches are presently associated with economic penalties that often adversely affect the socio-economic welfare of the populace, particularly in low-, and medium-income countries. In this regard, it is informative to note the experience recently gained by Trinidad and Tobago in its attempt to reduce GHG emissions without affecting the competitiveness of the industrial and agricultural sectors. Using appropriate decision making tools and a policy environment based on a combination of regulations and incentives, the environmental challenges can be turned into a vehicle for sustainable development. This paper discusses the factors that need to be considered while developing a sustainable climate change management approach for the MENA region and develops some recommendations that may be essential for achieving the desired climate change mitigation/adaptation actions while minimizing social disruption.

Keywords: Climate change, MENA, global and regional energy production/consumption trends, energy and wealth, adaptation, GHG emissions, sustainable development, building local capacity.

Abbreviations:

CEBC *Clean Energy Business Council of the Middle East and North Africa*
CER *Certified Emission Reductions*
CNG *Compressed natural gas*
EU *European Union*
GCC *Gulf cooperation council*
GDP *Gross national product*
GNI *Gross National Income*
HDI *Human development index*
LNG *Liquefied natural gas*
PCGDPI *Per Capita Gross GDP*
PPP *Purchasing power parity*
tpa *Tonne per annum*
UN *United Nations*

1. Introduction

Energy is one of the key commodities required to sustain human existence and advancement and is one of the largest components of the world economy. Consequently, global energy consumption has been rapidly increasing over the past two centuries but the pace of change has recently accelerated due to the increase in the total world's population and the rapid improvement in the standard of living in a large segment of the world's populace. However, the negative environmental aspects associated with the increasing consumption of energy necessitate that such trends be properly managed for the overall benefits of humanity. Climate change is a multi-faceted problem that requires the numerous stakeholders to contribute knowledge, skills and energy to plan for the impacts of a warmer planet and to take action to mitigate rising GHG emissions. Such actions must however be based on meeting the socio-economic challenges faced in any particular country/region yet help in achieving the overall objectives of protecting the global environment.

Nowhere are the climate change and sustainability issues more acute than in the MENA countries which are likely to be severely affected by climate change. The predicted rise in temperature and sea level may affect coastal areas, while the current severe water stress is likely to be exacerbated. Water supply sources in MENA, two-thirds of which originate outside the region, are being stretched to their limits threatening to lead to national confrontations over this vital resource. Adapting to climate change is not a new phenomenon for the MENA region. For thousands of years, the people in this region have coped with the challenges of climate variability by adapting their survival strategies to changes in rainfall and temperature. But over the next century, global climatic variability is predicted to increase and MENA countries may experience unprecedented extremes in climate.

This paper discusses the factors that need to be considered while developing a sustainable climate change management approach for the MENA region. Some of the recommendations developed in this paper may be essential for achieving the desired climate change mitigation/adaptation actions while minimizing social disruption particularly in low-income countries.

2. The Impact of Energy Production and Utilization on the Socio-economic Conditions in MENA Countries

The evolution of population, prosperity, and energy consumption has been substantially different in different parts of the world, resulting in large disparities amongst nations and regions in terms of wealth and the state of human development. This is particularly evident in the Middle East and North Africa, a region which includes both the energy-rich economies in the Gulf as well as countries that are amongst the poorest in the world. Figure 1 clearly illustrates this phenomenon where the 22 MENA countries considered in this investigation (Algeria, Bahrain, Egypt, Eritrea, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, UAE, Yemen) were organized in ascending order in accordance to their economic wealth using the World Bank data for the annual per capita gross domestic product (PCGDP). Although the cost of living variation between the different countries is already taken into consideration through the purchasing power parity (PPP) factor, the value of the per capita GDP was found to vary between these countries by a factor of up to about 150, thus creating a very difficult situation in which it is virtually impossible to develop a singular strategy that meets the needs of the whole region. Conversely, the presence of countries depicting a wide spectrum of developmental stages can create an opportunity for complementary/synergistic action that that can benefit the population of both the wealthy and poor countries. Appropriate strategies and frameworks are however needed in order to achieve such goals.

The discrepancy between the various countries in the MENA region becomes less severe when one utilizes more comprehensive indicators of the socio-economic development stage for any particular country. The Human Development Index (HDI) used in Figure 2 is a composite indicator introduced by the UN in 1990 and provides a better measure of the socio-economic state of development of the populace by combining three basic dimensions: life expectancy, educational attainment (through literacy index and registration combined index) and economic performance (through per capita PPP GNI in international dollars). The use of this more appropriate indicator reduced the inter-country discrepancy within the MENA region to about three-fold. However, it is worthwhile to note that whereas only three countries in the region have achieved a high stage of human development ($HDI \geq 0.8$), five countries can be considered as still being in a low stage of human development ($HDI < 0.5$), with the remaining 14 countries being in the moderate stage of human development ($0.5 \leq HDI < 0.8$).

A significant part of the GDP generated by prosperous MENA countries can be attributed to the production and utilization of non-renewable energy resources (energy-related revenues can be as high as 55% of the GDP for countries that are primarily oil exporters). Two-thirds of the Organization of Petroleum Exporting Countries (OPEC) are thus located in the MENA region, which has 57% of the world's proven conventional oil reserves and 41% of proven conventional natural gas resources. These reserves generated an estimated US$ 785 billion in revenues in 2011 (Fattouh and El-Katiri, 2012) and sovereign investment funds are being increasingly considered as means for ensuring the prosperity of future generations in countries presently endowed with large non-renewable natural resources.

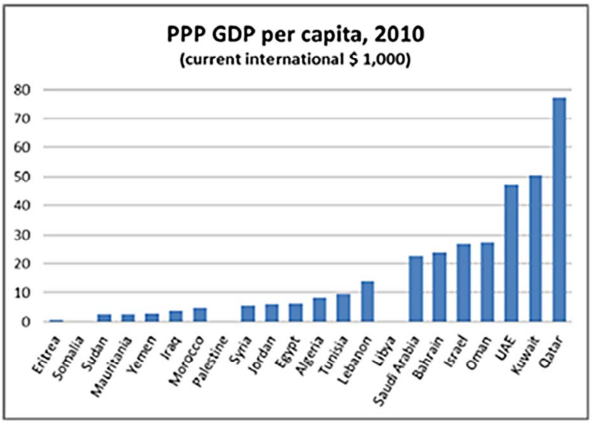

Figure 1: Regional variation of the Per capita GDP (Source of data: World Bank Databank, PPP 2011).

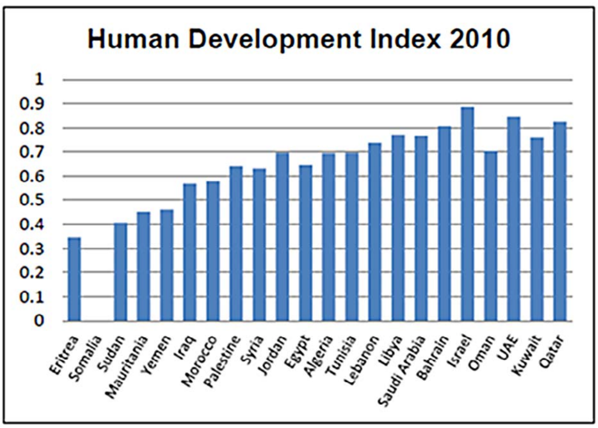

Figure 2: Regional Variation in the Human Development Index (2011).

The importance of the energy sector in determining the state of prosperity in MENA countries becomes very clear when one considers the per capita level of GHG emissions and its variation amongst the different countries of the region (see Figure 3). With the exception of Israel, the most prosperous MENA countries are those with abundant energy resources and energy-based industries (e.g. the processing of petroleum and natural gas as well as primary petrochemicals).

However, the activities associated with the extraction, processing and export of the oil and gas resources, and the rapidly-expanding energy-based industrial sector, are large GHG emitters. Continued development of these energy resources along historic lines is therefore expected to result in exacerbating the level of GHG emissions unless certain measures are taken to reduce the overall environmental impact of such development. On the other hand, any viable GHG emission reduction strategy will have to consider the fact that the near-term demand for fossil fuels is predicted to increase as a result of the increase in the world's population, and the increased per capita demand particularly in the rapidly expanding economies such as China, India, and Indonesia. Policies and procedures aimed at implementing cleaner energy extraction/production/utilization are therefore urgently needed, particularly in the wealthy energy-rich countries. Such measures can strongly reduce the environmental impacts of present and future development of energy resources in the region.

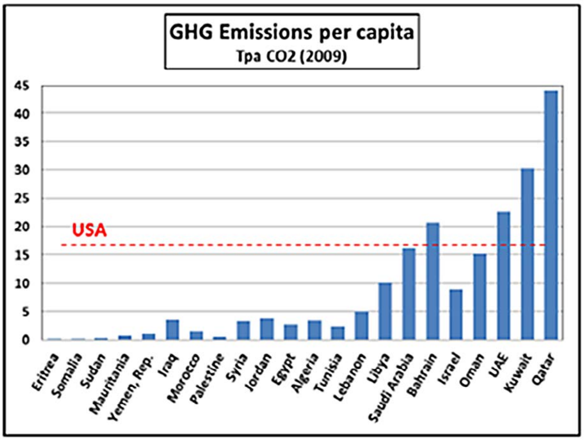

Figure 3 - Regional variation in GHG emissions (Source of data: World Bank Databank)

Previous studies confirmed the existence of strong correlation between the wealth of the citizens of a country and their energy consumption pattern, a situation that applies to all countries regardless of their state of human development. Prosperous and developed countries thus have a high level of energy consumption that is used for the production of goods and services, to support the transport and telecommunications sectors, and to achieve a high level of comfort for the citizens. A large part of their energy demand is presently supplied (directly and indirectly) by fossil fuels whereas a significant part of the energy demand in low-income countries is supplied by traditional biomass (wood and charcoal). The increasing use of biomass for energy purposes in middle and low-income MENA countries is one of the major forces driving the desertification process and is driven by the local availability of relatively inexpensive biomass in a world where the price of fossil fuels is continuously rising.

As shown in Figure 3, the same qualitative relationship exists in the MENA region. The average fossil fuel energy consumption in the major oil and gas producers (Bahrain, Iraq, Libya, Qatar, Saudi Arabia, UAE) are more than 300-fold higher than that in the low-income countries in the region. Unfortunately, these emission levels are also manifold higher than the present day world-average emission levels (4.6 tpa CO_2 equivalent) as well as the emission levels in developed countries that are strongly dependent on the exploitation of natural resources (Canada = 15.2 tpa CO_2 equivalent; Australia = 18.2 tpa CO_2 equivalent). Amongst the factors contributing to this state of affairs are: the heavy dependence of affluent MENA countries on energy-intensive industries, the export of raw materials with limited local value-added (e.g. crude oil and LNG), and the limited contribution of the agricultural and service sectors to the overall prosperity of the citizens. Concerted efforts have been ongoing to change this situation, but special attention should be given to the use of low-emission-development routes (e.g. energy efficiency and waste minimization) in order to ensure that the increase in the level of local value added does not result in further exacerbating the environmental problems.

The heavy dependence of a country's prosperity and the level of energy resource utilization is reflected in the essentially linear relationship between the per capita GDP and the level of GHG emissions in MENA countries (see Figure 4). This is mainly caused by the heavy dependence of affluent MENA countries on energy-intensive industries, the export of raw materials with limited value-added processing, and the limited contribution of the agricultural and service sectors to the welfare of the citizens.

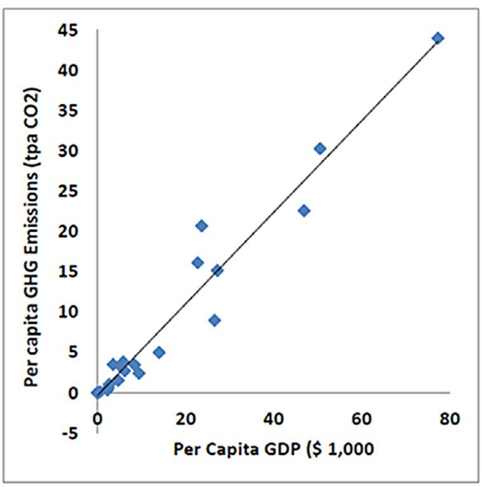

Figure 4: The relationship between PCGDP and the GHG emissions level (Source of data: World Bank Databank, MENA region).

3. Energy Consumption, Power Generation and the Standard of Living

Accepting that most countries do not want to suffer a reduction in their prosperity level while attempting to address the climate change challenge, the question becomes how the level of GHG emissions can be reduced while maintaining the prosperity at its present level or even higher. An indication of the efficiency by which energy is utilized to generate wealth can be obtained by calculating the amount of GHG emissions associated with every $ 1,000 PPP GDP produced. This indicator which is frequently used for benchmarking purposes is based on the fact that most of the world's large consumers of energy still rely heavily on fossil fuel for power generation.

The large intra-regional variation in the energy use per unit GDP is depicted in Figure 5. An in-depth investigation of the factors contributing to this phenomenon (e.g. internal strife, the contribution of the service sector, the emphasis on high-value added production, the role of the agricultural sector, the role of hydro power) is needed to develop better understanding of the factors hindering the accelerated development of this region as a whole, and to identify novel means by which the prosperity of the region can be enhanced. It is however noteworthy that the prosperous MENA countries are about 3-7 fold less efficient in converting their energy resources into national wealth than it is the case in the USA and EU (see Figure 6). This suggests that there is a substantial potential for improving the efficiency by which energy resources are converted into revenue-generating economic activities in the prosperous, hydrocarbon-rich MENA countries. On the other hand, the high energy utilization efficiencies exhibited by the poorest three MENA countries are not indicative of high energy utilization efficiencies but are typical of their developmental stage (HDI < 0.5) where energy (fossil fuels in particular) plays a less significant role in determining the GDP. The very low energy utilization efficiency observed in the case of Iraq in 2009 could most probably be attributed to the internal strife in the country and its negative impact on the GDP.

In that regard, it is important to note that although China has been rapidly increasing its power generation capacity to cope with the escalating demand, it has been able to achieve a remarkable increase in the energy use efficiency over the past 30 years. This is largely due to the use of better manufacturing technologies and the gradual shift towards the production of high-value added products and services.

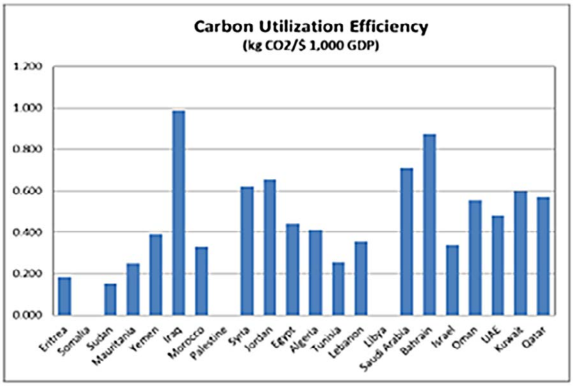

Figure 5: Regional variation in energy utilization efficiency

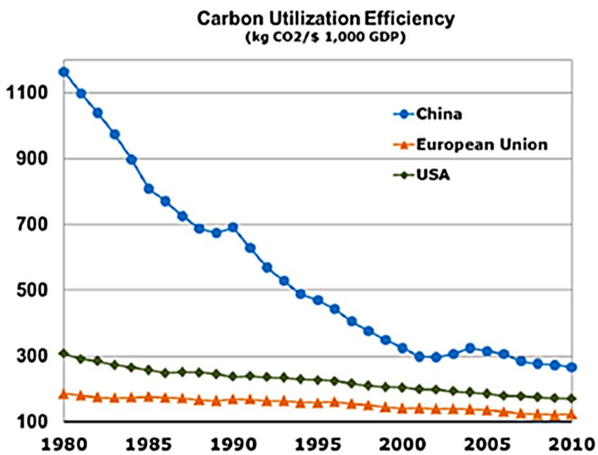

Figure 6: Evolution of energy use per unit of GDP (Source of data: World Bank Databank).

4. Can One Expect a Uniform Reduction in GHG Emissions in the MENA Region?

In order to develop sustainable MENA-focused strategies for coping with the problem of climate change, it is important that, in a fashion similar to other rapidly-developing regions of the world, the MENA region assumes its responsibility with respect to reducing its GHG emissions while undertaking unquestionably necessary adaptation projects (Verner, 2012). In the meantime, it should also attempt to achieve two important socioeconomic objectives:

- Avoid socially disruptive situations by reducing the large discrepancy in prosperity levels of the citizens within the MENA region,
- Address the need for securing long-term prosperity for the citizens of the countries whose present prosperity levels depend on exhaustible non-renewable energy resources.

The question is how these apparently contradictory demands can concurrently be met particularly by governments that have limited funds and need to spend them in a fashion that addresses urgently needed socio-economic challenges while trying to reduce emissions? Considering the fact that about 23% of the population in MENA lives below the poverty level of less than $2 a day, a concerted effort aimed at improving the standard of living in the region as a whole is desperately needed if social turmoil is to be minimized. It is however imperative that the strategies adopted emphasize economic, social and human development objectives while addressing the concerns arising from climate change. However, the financial and human resources needed for such an effort can be limiting factors considering the multi-faceted needs in the region in a period of budgetary constraints throughout much of the world.

In a recent study based on data from 112 countries (Ugursal, 2013), it was noted that the relationship between the HDI and energy consumption depends very much on the country's developmental stage (see Figure 7). Thus, for example, a substantial increase in the per capita energy consumption is needed before any significant improvement in the human development level can be noted for countries with HDI < 0.5. On the other hand, significant reductions in the energy consumption levels can be achieved without substantial reduction in the standard of living in countries with HDI ≥ 0.8; meanwhile, small increases in energy consumption result in substantial increases in the HDI of countries within the moderate HDI range (0.5-0.8).

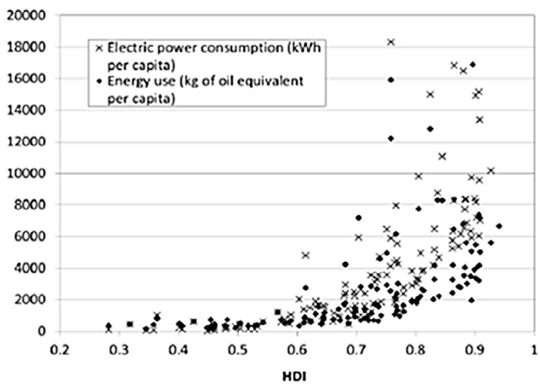

Figure 7: Relationship between a country's HDI and its per capita energy consumption rate (Source: Ugursal, 2013).

It is therefore projected that substantial investment in power generation and utilization will be needed in most of the 19 countries having HDI less than 0.8. Such a massive undertaking will adversely affect climate change with the impact being mitigated if low emission development (LED) strategies are adopted in the new projects and measures for improving the efficiency of existing operations are adopted (Clapp *et al.*, 2010). Considering the fact that the population of the region is in excess of 330 million with an average per-capita GHG emission of 5.85 tpa CO_2 equivalent per year, the full impact of unplanned development is equivalent to adding a GHG emitter that is equivalent to 2/3 that of the USA (until recently, the world's largest emitter).

Innovative means for the planning, financing, execution, and managing such a major undertaking are therefore needed in order to avoid the adverse impact of combined social, economic, and environmental upheavals. The concept of "Sustainable Development" with its emphasis on balancing the needs of the society with those of the environment in an economically viable fashion represents one of the most promising avenues for achieving the aforementioned balanced objectives. However, the challenge of managing this global problem in a sustainable fashion is quite daunting particularly considering the conflicting interests of the various regions and countries, particularly those at radically different stages of development.

The increase in GHG emissions associated with the accelerated development of low-, and medium-income MENA countries can be partially compensated by improving the environmental efficiency of the enormous oil and gas sector operating in various MENA countries. Many such countries (e.g. Algeria, Egypt, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia, UAE) have very large oil and gas operations, a situation that offers the opportunity for achieving significant reductions in GHG emissions at little, or even negative, costs. A review of the GHG mitigation efforts in most of the MENA countries was recently given by Abdel Gelil (2009). Once identified, the private sector may be interested in profitable emission reduction schemes but some additional incentives may be needed for high-risk border line cases. Typical examples are:

- reducing the wasteful release of undesired energy by-products (e.g. flares);
- replacing high-carbon fuels with low-cost low-emission alternatives;
- enhancing the efficiency of power generation plants and power transmission systems;
- enhancing the efficiency of energy utilization in large industrial operations; and
- identify opportunities for reusing some of the CO2 captured in the many petrochemical plants present in the region for enhancing oil recovery in nearby fields.

It is hard to overemphasize the importance of energy efficiency as an economically-viable tool for mitigating GHG emissions. The experience in many European countries, combined with the recent financial crunch, resulted in the recent adoption by the EU of "Directive 2012/27/EU" on energy efficiency. This Directive establishes a common framework of the promotion of energy efficiency within the EU in order to ensure the achievement of its 2020 target on energy efficiency, and to pave the way for further energy efficiency improvements beyond that date. It also lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of indicative national energy efficiency targets for 2020.

Borderline cases may be eligible for financial support through various international programmes such as the Clean Development Mechanism (CDM) program and the Global Environment Facility fund. It is however imperative that such border-line project meets the sustainability criteria and address urgently needed the socio-economic needs of the population.

The potential for significantly reducing GHG emissions at little or no cost is not a situation that is unique to MENA and was identified to exist in several countries. For example, it is estimated that a significant reduction in Australian GHG emissions can be achieved (30% below 1999 levels by 2020) without major technological breakthroughs or lifestyle changes (e.g. changing their power mix, installing insulation and energy-efficient lighting in buildings, improving the efficiency of electric motor-drive systems in the mining industry). These reductions can be achieved using existing approaches and by deploying mature or rapidly developing technologies to improve the carbon efficiency of the Australian economy (Gomer and Lewis, 2008).

It is however essential to redress the imbalance presently existing in the various methodologies used to estimate GHG emissions. For example, equitable mechanisms may have to be developed by which the GHG emissions associated with the production, export, and transport of natural gas (10-12% of the carbon content in the case of LNG) can be split between the exporting counties and those which use it to replace coal in power generating plants.

5. An Example of a Sustainable Climate Change Mitigation Effort: Using Alternate Fuels in the Transport Sector

Over the past few years, several national and international mechanisms were developed in an attempt to reduce GHG emissions, and to assist in coping with the adverse effects that are beginning to occur as a result of climate change. Unfortunately, many of these approaches are presently associated with economic penalties that often adversely affect the socio-economic welfare of the populace particularly in low-, and medium-income countries. In this regard, it is informative to note the experience recently gained by Trinidad and Tobago (T&T) in its attempt to reduce GHG emissions without affecting the competitiveness of its industrial and agricultural sectors.

Although the GHG emissions of T&T are not very large when compared to larger countries (53 M tonne CO_2 Equivalent per year), it is one of the world's largest GHG emitters per capita (40 tpa CO_2 Equivalent in 2009). Initial attempts to meet its international obligations focused on policies/measures similar to those used in developed economies (energy efficient cars, replacing incandescent bulbs etc.); however, a recent inventory of the sources of GHG emissions clearly showed the inability of such simple measures to achieve substantial reductions in GHG emissions (see Figure 8), since more than 80% of the GHG emissions are generated by industrial activities.

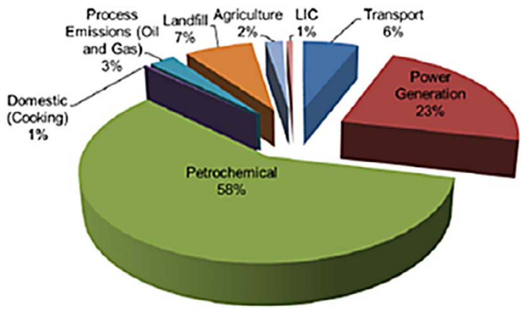

Figure 8: Sources of GHG emissions in T&T, 2010 (adapted from Boodlal and Al Taweel, 2013).

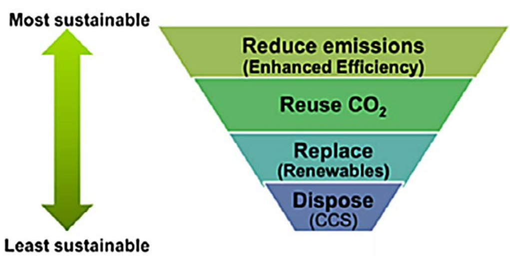

Figure 9: Identifying the most sustainable GHG reduction strategies

Conventional environmental management concepts were applied to identify means by which GHG emissions can be reduced without significantly affecting the value of the welfare of the country (see Figure 9). Based on the results of an inventory of GHG emissions in T&T, and the costs associated with each GHG reduction option, an indigenous action plan was proposed which includes identification of the optimal carbon reduction opportunities in the country (see Figure 10).

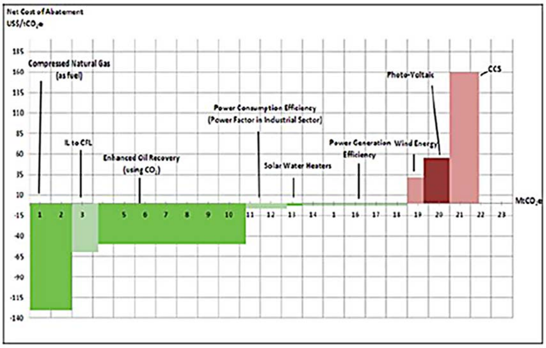

Figure 10: Cost associated with the various options for reducing GHG emissions in T&T (adapted from Boodlal and Al Taweel, 2013).

Very conservative cost estimates were used in this study since its primary purpose is to serve as a policy development tool rather than for profitability analysis; yet several negative-cost opportunities were identified (see Figure 10). This suggests that the implementation of such measures will be beneficial for the country's economy while simultaneously reducing its GHG emissions. A policy environment based on a combination of regulations and incentives was also recommended to attract investment to cost-effective emission reduction measures. In this way, environmental challenges can be turned into economic opportunities and a vehicle for sustainable development. To achieve this goal it is however necessary to use appropriate decision making tools and adopt innovative site-specific solutions that take into consideration the socio-economic welfare of the disadvantaged segment of the population.

The most financially attractive option for reducing GHG emission in T&T is the replacement of liquid fuels (diesel and gasoline) by compressed or liquefied natural gas. For the past several decades, diesel and gasoline have been heavily subsidized in T&T in order to facilitate the transport of individuals and goods, particularly for the low-income citizens. The price of liquid fuels has been fixed for many years at the fixed prices of: TT$ 1.50/liter of diesel, TT$ 2.60/liter of regular gasoline, and TT$ 4.20/liter of premium gasoline (6.5 TT$ = 1 US$). In addition to encouraging energy-wasteful behaviour, the annual subsidy for these fuels was about US$ 500 per person with large quantities of the subsidized diesel fuel being illegally exported. Significant savings can therefore be achieved by converting cars and trucks so that they can use natural gas instead of the aforementioned liquid fuels. In addition to the financial benefits accrued by such conversions, the air quality is expected to improve as a result of using the clean-burning fuel and the GHG emissions are lower than those achieved when using the conventional heavier fuels.

The need for promoting such a conversion has been recognized many years before and both CNG and LNG are easily available as a by-product of the existing LNG production facility (used to export 58% of all the natural gas produced in T&T). However, the progress achieved on that front has been slow because of the lack of a concerted effort to promote such conversion and the limited number of re-fueling stations equipped to handle CNG.

Following the drop in the price of natural gas and its impact on the country's royalties, this issue is being more seriously addressed. The price of premium gasoline was recently raised to TT$ 5.75 and a plan for increasing the number of stations equipped to handle CNG is being implemented. A growing number of public transport buses are being converted to CNG while the Environmental Management Authority has launched a programme to convert its vehicle fleet to CNG.

This approach is not a novel one since natural gas is a commonly used alternative fuel used by trucks and transit bus fleet operators interested in reducing the cost and environmental impact of their operations. Many factory-built natural gas vehicles are available which incorporate engine technologies that have been designed specifically for natural gas with power, torque, and fuel efficiency similar to diesel engines. Warranty coverage is also comparable to what is available on diesel engines.

Natural gas presently powers more than 15 million vehicles around the world and the number of natural gas fueled vehicles has been increasing by more than 15% a year over the past decade (NGV Global, 2012). There are more than 20,000 refueling stations in use globally, with the majority of these stations dispensing CNG, although LNG projects have been announced in several countries for both on-road truck and marine use. The trend of using CNG/LNG to power vehicles is expected to grow as the price differential between natural gas and liquid fuels increases as a result of the abundant availability of natural gas in the market place (see Figure 11).

The development of a cost-effective natural-gas based alternate to LPG could similarly benefit NEMA countries that are heavily dependent on the use of this type of fuel for domestic purposes.

6. Integrating Climate Change Abatement Measures with Developmental Needs and GHG Reduction Activities

Global climate change is projected to result in a set of diverse and regionally-specific impacts on natural ecosystems and human societies. A growing literature suggests that while mitigation strategies are necessary, those alone are unlikely to be sufficient to cope with these changes. Therefore, pursuing a complementary strategy of enabling countries to adapt to global change and negate many of the expected adverse impacts is equally, if not more, urgent

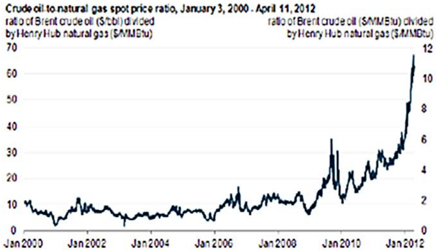

Figure 11: Price ratio of crude oil to natural gas (Source: U.S. Energy Information Administration).

(Burton *et al.*, 2002; Verner, 2012). However, with about 23% of MENA's population living on less than $2 a day, it is imperative that the climate change management strategies adopted be cost-effective and emphasize economic, social and human development while addressing the environmental concerns arising from anthropogenic climate change.

Poverty alleviation is often linked with economic development resulting in job creation, increased energy production and consumption, GDP growth, energy security, and reducing inequality, which usually translates into increased emissions levels. Policy makers in low-income countries are therefore faced with the dilemma of having to allocate limited resources in an attempt to alleviate poverty while, at the same time, try to slow down GHG emissions. The need for integrating the environment in development planning has been strongly promoted for many years (Tolba, 2008) and it may be now necessary to emphasize the need for integrating development into environmental planning particularly for low- and middle-income countries

Over the past few years, several tools have been developed to facilitate rational decision making and achieving a balance between development needs and protecting the environment; for example, Low-Emission Development Strategies (LEDS) and Mitigation Action Plans and Scenarios (MAPS). A detailed discussion of these tools is beyond the scope of this investigation but a quick introduction to their recent application to developing countries was given by Clapp *et al.* (2010) and Boyd (2013).

Though no formally agreed definition exists, LEDS are generally used to describe forward-looking national economic development plans and strategies that encompass low-emission and/or climate-resilient economic growth. LEDS can serve multiple purposes but are primarily intended to help advance national climate change and development policy in a more co-ordinated, coherent and strategic manner. By providing integrated economic development and climate change planning, a LEDS can provide value-added to the myriad of existing climate change and development related strategies and reports that already exist. Because of its benefits, the Copenhagen Accord recognised that a LEDS is indispensable to sustainable development.

7. Financing Sustainable Integrated Development Projects with Climate Change Mitigation/Adaptation Components

Achieving sustainable development goals that integrate climate change adaptation/mitigation measures within a holistic framework requires that announced commitments be translated into strategies, policies and actions. The scale of such anticipated efforts in the MENA region requires massive multi-billion dollar financing that needs to be secured from internal and external sources. The financial aspects of climate change issues in the MENA region has recently received much attention from a large number of investigators (Abaza, 2008; Babiker and Fehaid, 2011; Fattouh and El-Katiri, 2012; Nakhooda *et al.,* 2012; Saidi, 2012), whose findings provide valuable insight into the real state of affairs.

A high level of investment in climate change related projects by resource-rich MENA countries is already underway largely supported with domestic and private sector financing. Many large scale wind and solar energy projects are also being invested in for both domestic use and export, while significant investments are being planned in energy efficiency and carbon reduction projects. However, the financing of similar projects in resource-limited MENA countries faces many challenges.

Climate change funding by international agencies has been rather limited in the MENA region. Although about US$ 1 billion in finance has been dedicated since 2004, less than US$ 200 million was approved as grants in support of a large number of relatively small-scale projects which are concentrated in 12 MENA countries (Nakhooda *et al.,* 2012). Similarly, the region's share of the CDM funding is less than 2% of the global CER market in spite of the multitude of oil, gas, and petrochemical operations that are spread throughout the region and usually offer good opportunities for CDM support. To further complicate matters, prices for CERs collapsed from about US$20 a tonne in 2008 to less than US$ 1 by the end of 2012. This is mainly driven by the Eurozone debt crisis reducing the industrial activity and the over-allocation of emission allowances under the European Union Emissions Trading Scheme. Furthermore, some of the projects contemplated for support can hardly be considered as being "sustainable" when, for example, the citizens of a developing country end up supporting the development of a promising technology by substantially subsidizing the cost of the power generated over the project's life span (typically 20-30 years in this case).

On the other hand, there exists excellent opportunity for drawing upon the substantial financial resources that are generated within the MENA region itself. These can be utilized to accelerate the development of equitable, holistic, and sustainable climate change projects in the region provided that a proper framework is developed that secures the equity, long-term viability, and security of such financing efforts. A similar example is presently being considered for the case of the BRICS countries where the need for financial cooperation in the five-nation bloc has led to recent agreement to establish a BRICS development bank which could properly utilize the huge savings pool of the bloc countries.

In this regard, it is worthwhile to note that the high oil and gas prices have generated an extraordinary level of international assets and liquidity in the hydrocarbon exporting countries of the MENA region, with gross foreign assets forecast to reach some USD 2.3 trillion by end-2012 (Saidi, 2012). Consequently, governments and corporations have traditionally been cash rich and not reliant on market financing. However, the global financial crisis, the contagion effects of the Eurozone's continuing crisis and retrenchment of EU banks, along with growing financial sophistication of both the public sector and private businesses in the GCC countries, changed their financial strategy particularly since the GCC countries are keen to lead in innovative finance as they develop financial centers and diversify their economies (Saidi, 2012). In this context, Shariah-compliant financing may be a suitable investment instrument for the MENA region as it would meet the investment requirements of investors from the GCC, Asia and other Shariah-compliant global institutional investors.

In light of the above, the Clean Energy Business Council of the Middle East and North Africa (CEBC), the Climate Bonds Initiative and the Gulf Bond and Sukuk Association have launched a Green Sukuk Working Group. The group aims to channel market expertise to develop best practices and promote the issuance of sukuk for climate change solutions investments, such as renewable energy and clean tech projects (Saidi, 2012). Green Sukuk are Shariah securities and investments that use criteria for climate solutions developed by the International Climate Bond Standards scheme. The CEBC plans to help investors more easily identify Shariah-compliant opportunities while assisting in providing the debt capital for clean energy and other climate-friendly projects in the region.

Another financing option to be considered is based on the development of a framework by which MENA countries with high per capita GHG emissions can gain credit in exchange for financing climate change mitigation/adaptation projects within low-, and intermediate-income countries in the region.

8. Building the Capacity to Manage Climate Change and Development Challenges in MENA

The development of sustainable solutions to the multitude of climate change issues facing the MENA region requires in-depth knowledge of site-specific conditions prevalent in the various countries and the ability to identify/develop appropriate solutions that can meet the socio-economic needs of the local population. Much of the expertise needed is already available in the region but is scattered amongst many countries, ministries, universities and NGOs. It is therefore necessary to develop a regional network of institutions that have the knowledge and ability to accomplish such goals, and equip it with a project management team that can coordinate the efforts of the various individuals. This network should encourage flexibility in problem-solving, the development of cost-effective innovative approaches, and emphasize the importance of addressing the needs of the various stakeholders and the balance of power among the various interest groups.

Such a network can also draw upon the world-wide pool of expertise but the translation of the experience of others into a MENA-specific plan of action could best be handled on the local level where the active participation by the various stakeholders (particularly the most vulnerable sectors of the population) is a necessary condition for the success of any sustainable development program.

9. Conclusions and Recommendations

Based on the analysis presented in this investigation it can be concluded that:

- Socioeconomic analysis of the MENA countries and their GHG emissions shows that they can be split into three categories: the affluent resource-rich countries, the middle-income countries, and a few low-income countries. The former group of countries have the world's highest level of per capita GHG emissions while the latter have almost negligible emissions. Although the variation in per capita GDP amongst these countries is very high, this does not reflect in a similar disparity of human development level.
- Massive investments are needed to accelerate the pace of economic development in the less fortunate countries in order to minimize social disruption. Such efforts will be accompanied by an increase in the emission levels that can be minimized by adopting low emission development strategies and by implementing cost effective means for reducing the emissions associated with the development of the oil/natural gas/petrochemical sectors.
- With about 23% of MENA's population living on less than $2 a day, it is imperative that the climate change management strategies adopted be cost-effective and emphasize economic, social and human development while addressing the concerns arising from anthropogenic climate change. This will avoid duplicating efforts, minimize the capital requirements, and facilitate the acceptance of such measures by the population at large.
- The carbon reduction experience of T&T clearly identified several negative-cost opportunities for reducing carbon emissions. The savings accrued by implementing such measures can be used for adaptation or economic

development purposes. In this fashion, environmental challenges can be turned into economic opportunities and a vehicle for sustainable development.

- Converting cars and trucks so that they can use natural gas instead of gasoline or diesel reduces the GHG emissions and improves the air quality in urban centers. Significant financial benefits can also be accrued by such conversions due to the large difference in the cost per unit energy of the two fuels and the elimination of the subsidies needed to make transportation more affordable. It is however essential that such conversion plans be carefully implemented in a fashion that renders it the natural choice of the consumer rather than the socially disruptive price hikes.
- The extent of financial support received from international agencies by MENA countries for mitigation/adaptation measures is relatively low. This is most probably driven by the financial difficulties through which some of the world's leading economies are presently going through, a situation which is not predicted to change in the near future. The region should therefore rely primarily on internally-generated financing driven by intelligent self-motivated interests.
- There apparently is a growing interest in developing Shariah-compliant financing instruments that can be used for climate change solutions investments. This is driven by the high liquidity levels prevalent in the public and private sectors in many resources-rich countries and the desire of the GCC countries to diversify their economies and develop financial centers that lead in innovative finance. This approach is similar to the recent agreement by the BRICS countries to establish their own development bank which could utilize their huge savings pool to enhance their collective interests.
- An alternate financing scheme may be achieved by having large GHG emitters gain credit for financing climate change mitigation/adaptation projects within low-, and intermediate-income countries in the region.

Although no single formula can apply to a collection of countries as diverse as those in the NEMA region, it is recommended that the various MENA countries undertake the initial four steps needed to create a Low-Emission Development strategy (LEDS) which entail:

- **Development of vision/goal:** An over-arching vision or goal is needed to help guide in the development of long-term policy decisions related to economic development and climate change priorities.
- **Assessment of current situation:** A clear understanding of major GHG emitting sectors and the socio-economic indicators is fundamental to determining the path forward.
- **Emission projections, mitigation potential and costs:** Planned pathways for business-as-usual emissions can help provide a sense of the national

emission trajectory, while mitigation potential and costs associated with the various emission reduction options are needed as a first step towards identifying promising mitigation actions.

- **Vulnerability assessment:** Indications of how a country may be impacted by climate change can help engage stakeholders, including the general public, and can help identify adaptation needs and the range of possible adaptation outcomes.

Much of this information is already available in the many MENA-related studies conducted by several local and international agencies. What is needed is to collect and update the information and ensure its correctness, fill in any gaps, and analyse the findings in a fashion that allows for the identification of cost-effective projects that emphasize economic, social and human development while addressing the environmental concerns arising from anthropogenic climate change.

Acknowledgement

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PAPER 5

A Decadal Sea Level Analysis off Alexandria, Egypt

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Abstract: Daily sea level records for one decade (1996-2005) have been used to calculate both astronomical tide and surge elevations, and to examine the rate of sea level rise off Alexandria. The tidal harmonic constituents have been constructed using the T_TIDE program. Surge elevations have been calculated by subtracting the astronomical height from the observed sea level. The minimum annual Mean Sea Level (MSL) was 48.62cm, while the maximum was 52.96cm. The MSL over the study period is 50.67cm. 35 tidal constituents have been produced based on the present data. Both the Mm (Lunar monthly) and the Msf (Lunisolar synodic fortnightly) constituents in the present study have the largest constituent amplitudes, being 2.03 cm and 7.06 cm, respectively. The surge height over the study period varied between 14.64cm and 87.15cm, with an average of 50.66 cm. The results of the present research show that astronomical tide accounts for 0.005% to 37.63% of the observed sea level, while surge accounts for 62.37% to 99.995%. The rate of sea level rise off Alexandria over the examined decade is 1.46 mm/year.

Keywords: sea level, tidal constituents, astronomical tides, surge, Alexandria, T_TIDE program.

1. Introduction

The observed sea level variation at any part of the world depends on many factors, e.g. storm surges, astronomical harmonic components, the seasonal cycle, inter-annual to secular variability and, finally, variations at geological and interglacial scales (Pugh, 1987; Jorda *et al.*, 2012). The amplitudes and phases of the astronomical harmonic constituents are heavily influenced by the local geography (Bryden *et al.*, 2007).

The observed sea level variations in the whole Mediterranean basin, and hence along the Egyptian Mediterranean coast, result mainly from the combination of two elevations: astronomical tides and surges. While the former is of minor importance, being ±20 cm, the latter may reach 1.0 m elevation under the effect of the meteorological factors. These factors include the air temperature, the wind system, the atmospheric pressure and the steric effect (Sharaf El-Din, 1975; Eid, 1990; Saad *et al.*, 2011). The impact of these meteorological factors on both the sea level variability and rate of sea level rise in the whole Mediterranean basin and along the Egyptian Mediterranean coast off Alexandria has been studied by many authors; for example, Sharaf el-Din (1975), Eid (1990), Mosetti and Purga (1990), Frihy (2003), Gomis *et al.* (2008), Ullmann *et al.* (2008), Tsimplis *et al.* (2005); Hussein *et al.* (2010), Saad *et al.* (2011); Jorda *et al.* (2012) and Said *et al.* (2012).

Alexandria Western Harbour can be considered tideless or of weak tide as the tidal amplitude of the M_2 constituent is only 6.9 cm (Tayel, 2008). Tides are recorded by the Hughes mechanical tide gauge located within the Harbour (31° 11' N, 29° 52' E; Fig 1). This, indeed, represents the most accurate and continuous data source of tides and sea level variations off Alexandria.

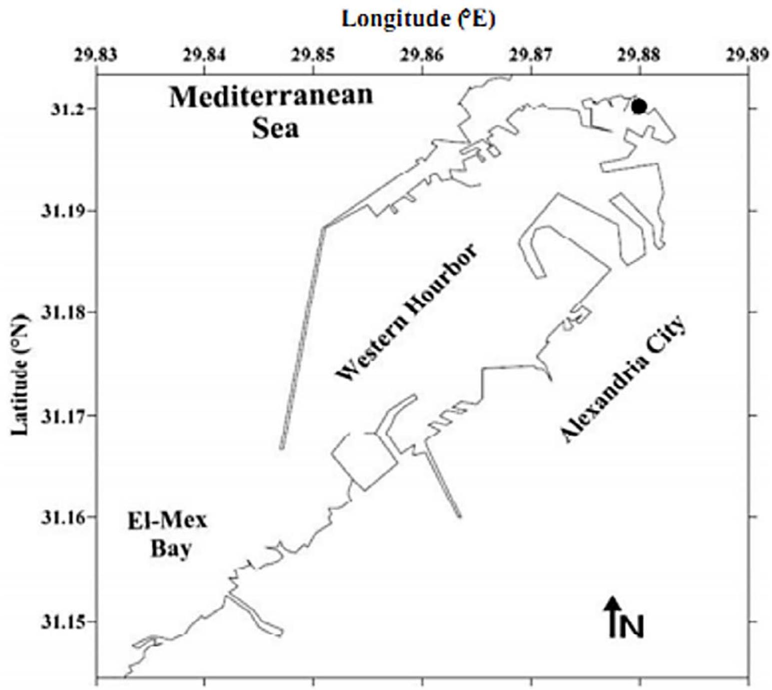

Figure 1: Alexandria Western Harbour and location of tide gauge use (●).

The present paper aims to draw the general pattern of the sea level off Alexandria over one decade (1996-2005) based on daily sea level records. The astronomical tidal constitutes are produced using the T_TIDE program and the surge elevations are also calculated. Moreover, the rate of sea level rise, over the study period, is also calculated and compared to results of some previous investigations.

2. Data and Methods of Analysis

Continuous sea level records for one decade (1996-2005) are used in the present study, given by the approval of the Alexandria Port Authority.

Tidal harmonic constituents (astronomical tide) are produced in the present work using the T_TIDE harmonic analysis toolbox as described by Pawlowicz *et al.* (2002). The T_TIDE program is a package of routines that can be used to perform classical harmonic analysis with nodal corrections, inference, and a variety of user specified options (Pawlowicz *et al.*, 2002). Moreover, the software can be used for predictions using the analyzed constituents.

Using the output from this harmonic tidal analysis, the type of the tidal cycle off Alexandria is determined using the following constituent factor (Pugh, 2004):

$$F = (H_{O1} + H_{K1}) / (H_{M2} + H_{S2}) \quad (1)$$

where,
H_{O1} is the tidal height of the principal lunar diurnal constituent;
H_{K1} is the tidal height of the luni-solar diurnal constituent;
H_{M2} is the tidal height of the principal lunar semidiurnal constituent; and
H_{S2} is the tidal height of the principal solar semidiurnal constituent.

According to the value of the factor F, the type of a tidal cycle may be defined as follows: if F ranges between 0 and 0.25 then a semidiurnal cycle results; if F ranges between 0.25 and 1.25 then a mixed mainly semidiurnal tide occurs; if F ranges from 1.25 to 3 then a mixed mainly diurnal tide occurs and finally a diurnal tide results for F values great than 3 (Pugh, 2004).

The calculation of the surge elevation is made by subtracting the astronomical tide from the observed sea level. This approach was previously applied by (Richardson and Gilman, 1983; Eid, 1990; Svensson and Jones, 2004).

Using the linear regression technique, the rate of sea level rise off Alexandria has been calculated.

3. Results and Discussion

The daily variation in the sea level at Alexandria over the study period (1996-2005), is shown in Figure 2. This elevation is the combination of both the astronomical tide and the surge effect. During the study period, the minimum recorded sea level was 20.10 cm on 12th April 1997, while the maximum was 82.88 cm on 04th January 1996. This results in a tidal range of 62.78 cm.

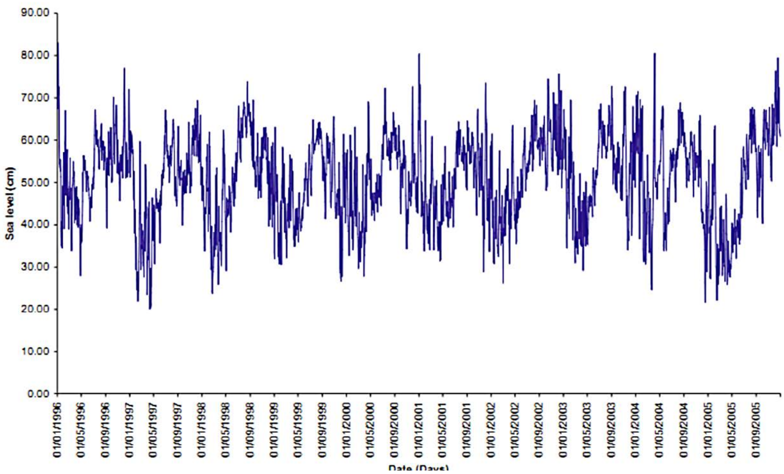

Figure 2: The daily recorded sea level off Alexandria during the study period.

The calculated Mean Sea Level (MSL), in the present study, is 50.67 cm. This was previously calculated to be 40.00 cm for the period 1944-1989 (Frihy, 1992), 50.60 cm for the period 1997-2004 (Hussein *et al.*, 2010), 51.80 cm for the period 1995-2005 (Saad *et al.*, 2011) and 47.90 cm for the period 1974-2006 (Said *et al.*, 2012). The annual MSL over the investigated decade is shown in Figure 3, where the dashed line is the MSL (50.67 cm) during this period. The minimum annual MSL was 48.62 cm (1997) and the maximum was 52.96 cm (1996).

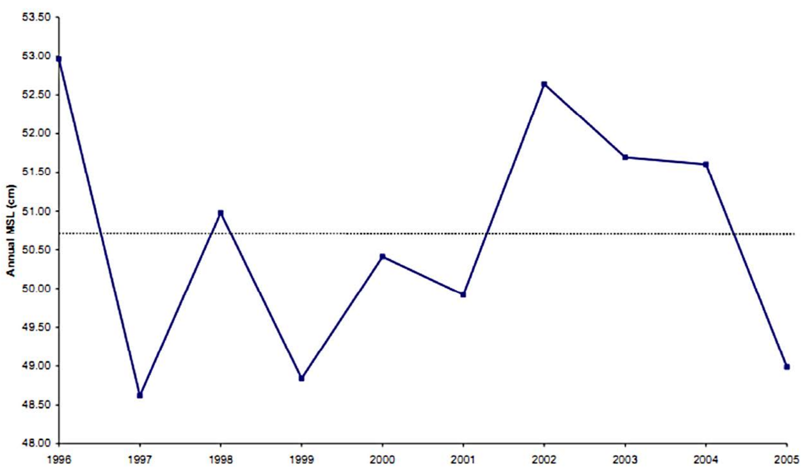

Figure 3: Annual mean sea level off Alexandria during the study period.

35 tidal harmonic constituents, over the investigated period, have been produced. Each of these constituents has its own frequency, period, amplitude and phase as shown in Table 1. Using Equation (1) and the T_TIDE outputs (see Table 1), the tidal cycle factor (F) off Alexandria is calculated to be 0.631, which clearly specifies the mixed mainly semidiurnal tidal type in the area of investigation. The astronomical tidal elevations over the period of investigation are shown in Figure 4. The amplitudes of these elevations vary between -11.12 cm and 10.57 cm, with an average of 0.001 cm.

Table 1: The 35 Tidal harmonic constituents produced by the T_TIDE Program.

Tidal Constituents	Frequency (Hz)	Period (hrs)	Amplitude (cm)	Phase (degrees)
MM	0.001512	661.29	2.0318	283.71
MSF	0.002822	354.37	7.0622	256.02
ALP_1	0.034397	29.07	0.5585	117.94
$2Q_1$	0.035706	28.01	0.2508	112.07
Q_1	0.037219	26.87	0.1029	125.67
O_1	0.038731	25.82	0.6238	136.36
NO_1	0.040269	24.83	0.1637	261.60
K_1	0.041781	23.93	0.4963	351.15
J_1	0.043293	23.10	0.4811	215.72
OO_1	0.044831	22.31	0.0840	173.66
UPS_1	0.046343	21.58	0.3894	50.99
EPS_2	0.076177	13.13	0.2385	208.73
MU_2	0.077690	12.87	0.3321	289.38
N_2	0.078999	12.66	0.1337	119.53
M_2	0.080511	12.42	0.3856	0.67
L_2	0.082024	12.19	0.2518	188.10
S_2	0.083333	12.00	0.1717	36.01
ETA_2	0.085074	11.75	0.3223	92.29
MO_3	0.119242	8.39	0.0242	37.26
M_3	0.120767	8.28	0.0859	200.87
MK_3	0.122292	8.18	0.0784	159.14
SK_3	0.125114	7.99	0.0895	177.63
MN_4	0.159511	6.27	0.1401	270.85
M_4	0.161023	6.21	0.2453	12.81
SN_4	0.162333	6.16	0.1391	261.77
MS_4	0.163845	6.10	0.2124	35.70
S_4	0.166667	6.00	0.0363	89.74
$2MK_5$	0.202804	4.93	0.0876	312.97
$2SK_5$	0.208447	4.80	0.1227	53.29
$2MN_6$	0.240022	4.17	0.1293	300.05
M_6	0.241534	4.14	0.1073	112.04
$2MS_6$	0.244356	4.09	0.2192	124.66
$2SM_6$	0.247178	4.05	0.1412	158.27
$3MK_7$	0.283315	3.53	0.1372	287.39
M_8	0.322046	3.11	0.0882	336.90

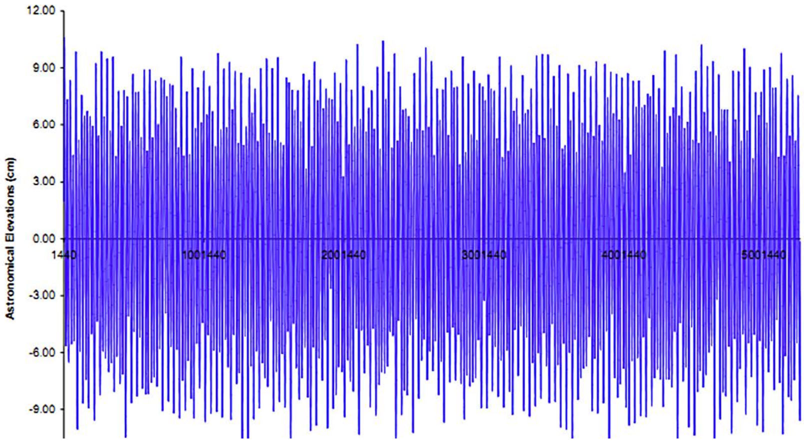

Figure 4: Astronomical tidal elevations off Alexandria during the study period.

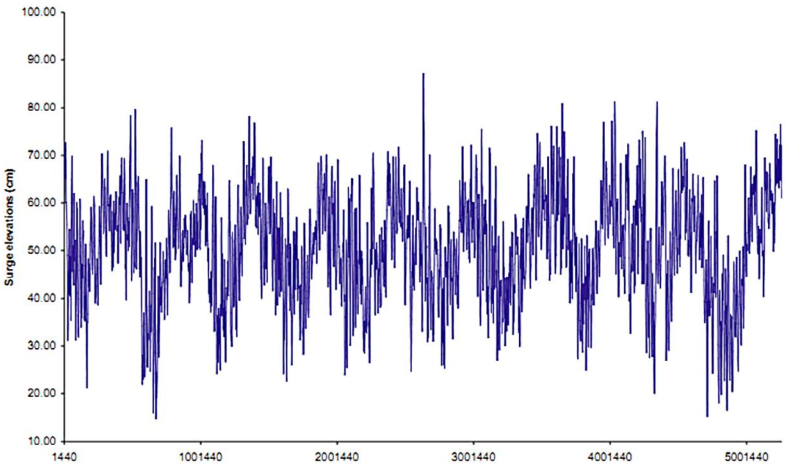

Figure 5: Surge elevations off Alexandria during the study period.

Figure 5: shows the calculated surge elevation in the present study. This varies between 14.64 cm and 87.15 cm, with an average of 50.66 cm. The standard deviation from the mean over this decadal period is 11.41 with a variance of 130.1.

The rate of sea level rise off Alexandria during the study period has been calculated, using the linear regression technique (see Figure 6). The calculations reveal that this rate is 1.46 mm/year.

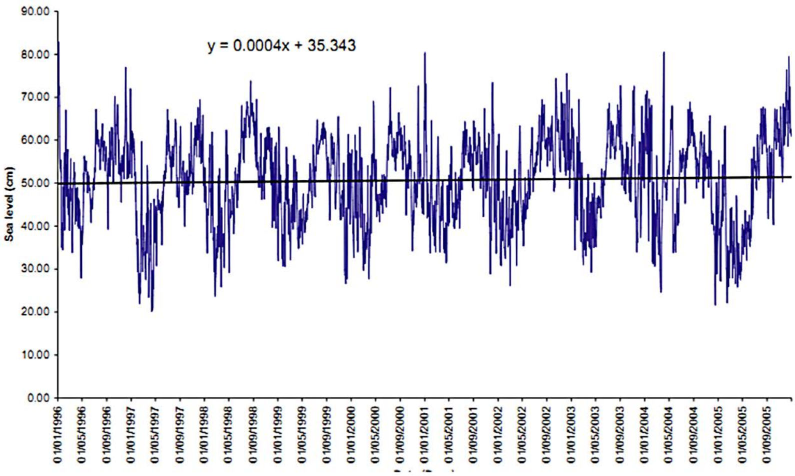

Figure 6: The trend of sea level rise off Alexandria during the study period.

4. Conclusions

The sea level variation within the Mediterranean basin is the result of two contributors: astronomical tide and surge. Alexandria, along the Egyptian Mediterranean coast, is not an exception. The present paper draws the sea level pattern off Alexandria over one decade (1996-2005). Both astronomical tide and surge are represented, and the rate of sea level rise over the given decade is also calculated.

In the present study, both the Mm (Lunar monthly) and the Msf (Lunisolar synodic fortnightly) constituents have the largest constituent amplitudes, being 2.03 cm for the former and 7.06 cm for the latter. This is in contrast to the outcome of Mosetti and Purga (1990) and Tayel (2008) who showed that the M_2 (Lunar component) is the largest constituent with 6.7 cm amplitude. This difference may be attributed to the longer investigated period in the present study than in Mosetti and Purga (1990) who used data of two years (1985-1986) and Tayel (2008) who used only a one year of sea level data (2004). Another cause may be the applied harmonic analysis techniques used to calculate the tidal constituents.

The results of the present research show that astronomical tide accounts for 0.005% to 37.63% of the observed sea level, while surge accounts for 62.37% to 99.995%. This might refer to the meteorological and climatic effects, which are very developed at Alexandria region. Moreover, the developed local seiches may have some impact on the observed surge elevation. The greater contribution of surge over tidal elevation assures the nature of low tides at Alexandria, as in the whole Levantine Basin. The great impact and strong contribution of surge in the sea level variation concluded in the present paper are in agreement with the conclusions of Eid (1990), Moursy (1989, 1994) and Saad *et al.* (2011).

Over one decade (1996-2005), the sea level rise off Alexandria had a rate of 1.46 mm/year. This is in good agreement with the rate previously calculated for the same area by El-Sayed (1.2 mm/year; 1988), Frihy (2 mm/year; 1992) and Frihy (1.6 mm/year, 2003).

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PAPER 6

Flood Hazard Mapping in Sinai Region

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Abstract: This study aims at defining the areas with potential flood risk in Egypt. Different zones have been studied and detailed analysis was carried for the Sinai region. Although Sinai is located in an arid region, its basins could receive a huge amount of rainfall during specific storm events. These amounts of water lead to flash floods that threaten lives, property and other assets. This research uses GIS techniques to produce a potential flood hazard map and integrates all parameters that contribute to the formation of flash floods in the watersheds of this region. The outcome of the study shows that 5% of the basins have very high susceptibility of flooding; about 25% have high susceptibility; about 5% have high-medium susceptibility; and about 20% have medium susceptibility. Basins of very high and high flood risk are delineated and classified. They require detailed studies and action plans to protect the local population from flood hazard.

Keywords: flood hazard, Sinai, watershed, surface runoff, flash flood, hazard mapping

1. Introduction

Natural hazards are cyclic natural phenomena that threaten lives, property and assets. They refer to all atmospheric, hydrologic and geologic phenomena that have the potential risk to adversely affect humans, property and social activities because of their severity, frequency and location. Climatic hazards are extreme weather events that cause damage and losses such as cyclones, storms and subsequent floods. Flash floods are considered to be one of the worst weather-related natural disasters. They are dangerous because they are sudden and are highly unpredictable following brief spells of heavy rain. Flood hazard seems to be increasing as climate change takes effect. Floods cause about one third of all deaths, one third of all injuries and one third of all damage from natural disasters (Askew, 1999). As reported in *Egypt's Review*: *In depth Assessment of Progress in Disaster Risk Reduction* (CMDRS, 2008), floods are the most widely distributed natural risk to life compared to all natural risks.

The Sinai region, characterized by its plains and high mountains, is identified as a flood prone area where flash floods are recorded frequently and result in significant infrastructure damage, population displacement and sometimes loss of life. Most of the flood management strategies in this area have been geared towards preventing flood by dam construction. However, these dams' capacities are not sufficient to cover the 100-year return period rainfall and very little attention is paid on land use planning to reduce the risk of flood disasters.

2. Description of the Study Area

Sinai Peninsula (Sinai) is a triangular peninsula occupying an area of 61,000 km^2. It is situated in the northeastern part of Egypt and bounded by the Gulf of Suez to the west, the Gulf of Aqaba to the east and the Mediterranean Sea to the north.

2.1 TOPOGRAPHY

The topography of Sinai has an elevation difference of 2640 m between its highest point and lowest point. The elevation of the northern part of Sinai ranges from 1626 m above sea level to the lowest level at the Mediterranean Sea. The elevation of the southern part of Sinai ranges from 2640 m above sea level to the lowest level at the Gulf of Suez and Gulf of Aqaba. The elevation of the peninsula is shown in Figure 1 as extracted from a digital elevation model (DEM) with point data at 30m intervals.

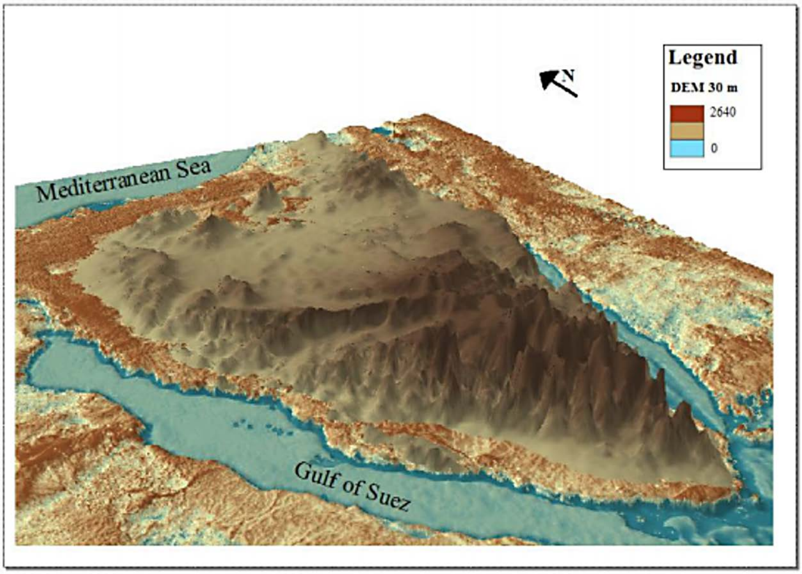

Figure 1: Digital Elevation Model representing Sinai topography

2.2 CLIMATE

The climate is characterized in general by volatile rainy winters and hot and dry summers. In autumn and spring, the climate is less volatile than winter, with sometimes heavy rainfall. In winter, rainfall on the northern region close to Mediterranean Sea reaches its maximum. According to the Water Resources Research Institute's and the Egyptian Meteorological Authority's rainfall measurement stations (see Figure 2), average rainfall varies from 60 mm to 100 mm per year near the Mediterranean Sea and decreases towards the West. The range of average annual rainfall in the south is between 30 mm and 60 mm.

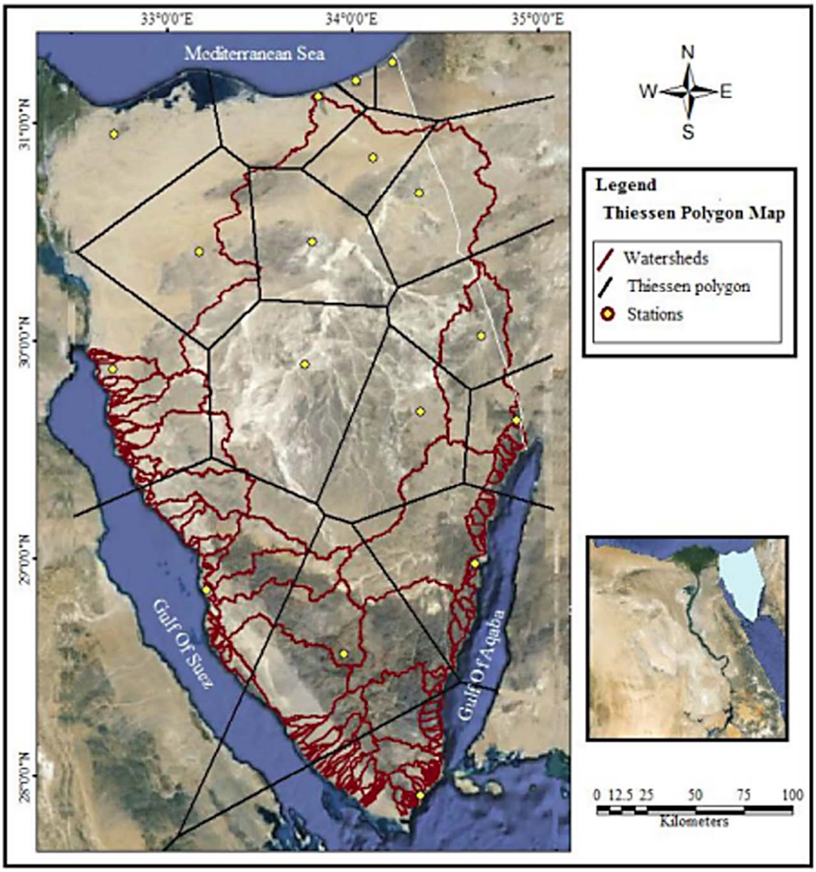

Figure 2: Thiessen polygon map of Sinai.

To estimate the amount of rainfall for a 50-year return period, statistical software (Hyfran) is used to analyse all available records of maximum yearly rainfall from each rainfall measurement station. Figure 3 shows the statistical analysis of Nekhl Station as an example, while Figure 4 shows the maximum daily storm rainfall for a 50-year return period of all stations for Sinai.

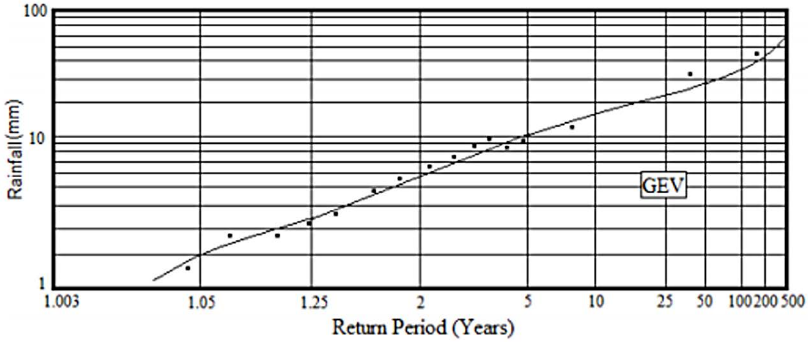

Figure 3: Statistical analysis of Nekhl Station.

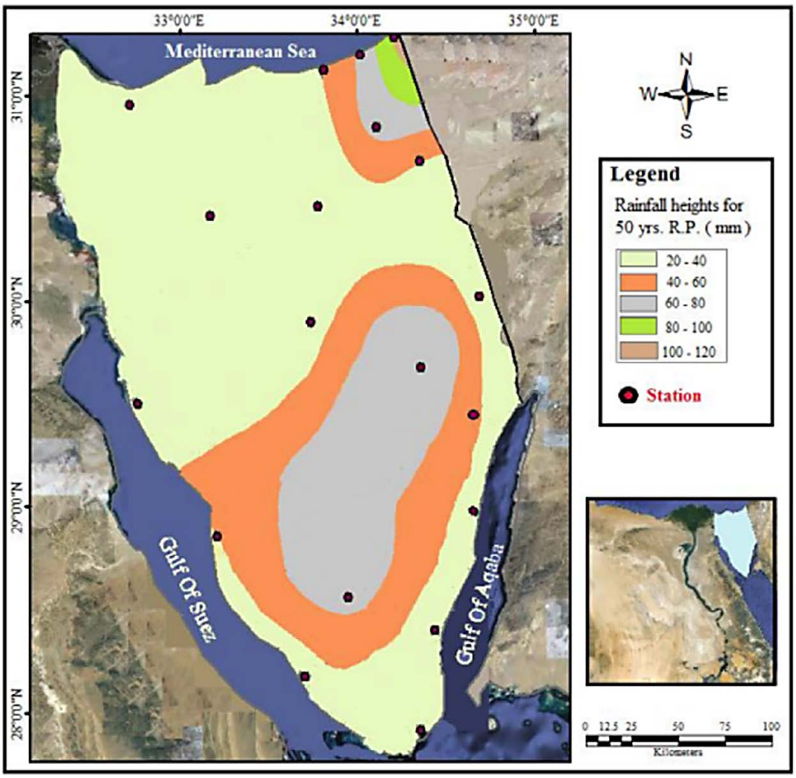

Figure 4: Isohyetal map of rainfall heights for 50-year return period in Sinai

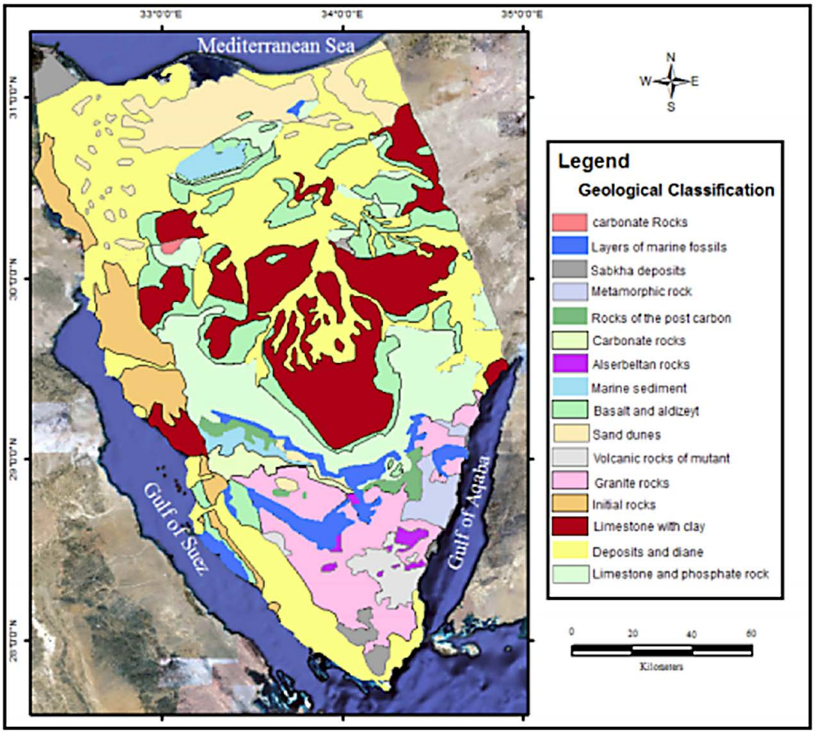

Figure 5: Geological setting for Sinai

2.3 GEOLOGY

A variety of soils can be found in Sinai. The causes for this variety are related to the extreme conditions that formed these soils: climate, arid in the south and wet in the mountainous ridge and the Mediterranean Seaside. Physical weathering from both water and wind also modified the soils. Variable geology formation is shown in Figure (5); it includes sedimentary rocks, volcanic rocks, granite rocks, sand dunes, alluvium, limestone, sabkha (i.e. salt flat), etc. Different topography covers the region varying from 5m above the Mediterranean sea level in the north of Sinai to 2640m in south-east.

3. Delineation of the Watersheds in the Study Area

To identify the watersheds for the surface, the elevations of all points on the surface are collected. These values are extrapolated from the global Digital Elevation Model. Using DEM with 30 m intervals, all watersheds of the Sinai were delineated. The watersheds are classified according to their areas (see Figure 6) and the geomorphology characteristics for each watershed are used. The characteristics for each basin are summarized in Table 1 and include the area, length, slope, perimeter, maximum stream length, maximum stream slope and mean elevation of the basin.

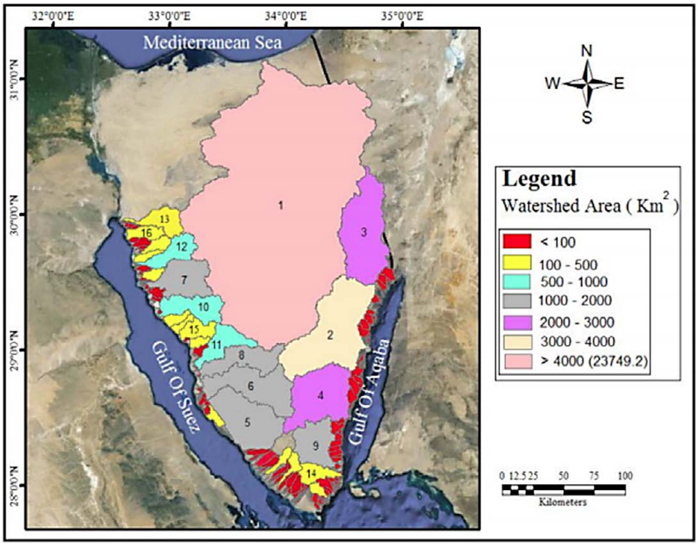

Figure 6: Delineated watersheds of Sinai classified by the area of the basin

Table 1: The geomorphology characteristics of the basins of Sinai

ID	Basin Name	Area (Km²)	Basin length (m)	Basin Slope (m/m)	Perimeter (m)	Max stream length (m)	Max. stream slope (m/m)	Mean Basin Elevation (m)
1	Al Arish	23784.9	238040	0.0469	1213900	354250	0.0037	499.23
2	Watier	3521	76110	0.1446	483620	118450	0.0122	912
3	Al Grafee	2610	84713	0.0334	412010	114110	0.0051	640
4	Dhab	2070	56686	0.2217	353930	93238	0.02	1062.9
5	Al Aawag	1914	55070	0.1967	278530	75529	0.0082	549.1
6	Fieran	1780	80341	0.1949	420050	132660	0.0177	1015
7	Wardan	1180	59345	0.1025	273720	86222	0.0113	523
8	Ghrandal	1074.1	78119	0.1536	340680	105380	0.0134	801.73
9	Kied	1045.9	47766	0.3465	258500	679.14	0.0206	928.8
10	Sidry	868.6	56292	0.1438	243580	82224	0.0107	570.24
11	Paapaa	712.7	54971	0.1386	232620	71005	0.0154	600.24
12	Sidr	623.45	54196	0.0862	205660	79078	0.0073	417
13	Al Rahaa	452	42466	0.105	181690	51580	0.0134	488
14	Om Adwy	367.6	35744	0.2589	151320	47503	0.0282	659.75
15	Tieba	333.9	43354	0.303	158240	51471	0.0311	999.5
16	Lehataa	276.44	31331	0.0571	114790	43528	0.0142	214.64

4. Surface Runoff

All watersheds of Sinai are analyzed using the Watershed Modeling System (WMS) hydrologic model. Due to lack of runoff measurement, the Soil Conservation Services (SCS) Unit Hydrograph method is used to compute the runoff hydrographs. Rainfall data for 50-year design storm is entered into the HEC-1 hydrologic model in the WMS software. For the SCS method, the land use and soil type maps are used to estimate the curve number that estimates the water losses from each basin. The simulation carried for the runoff volumes in each watershed and the corresponding hydrograph is determined.

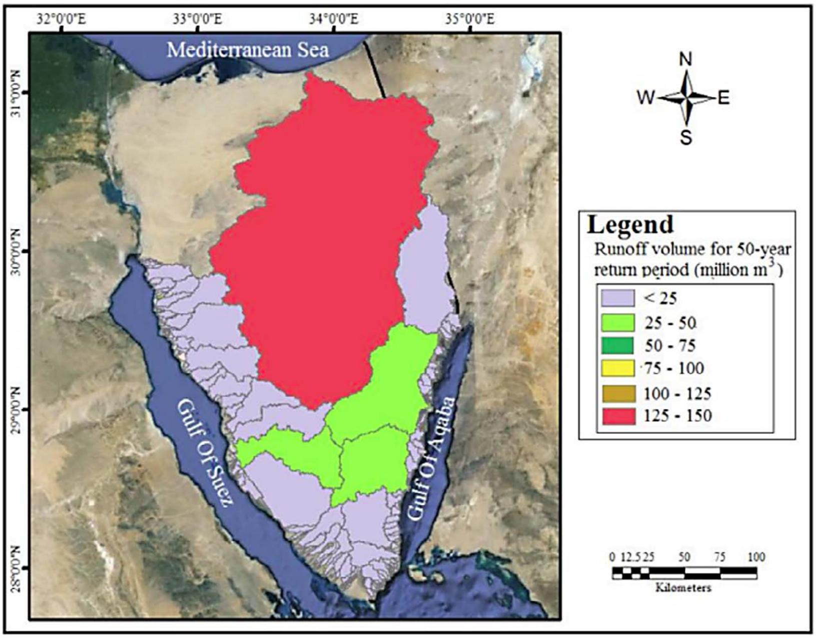

Figure 7: Runoff volumes for design storm 50-year return period.

As a result of the hydrological analysis, runoff volumes estimated for design storm of 50-year return period are shown in Figure 7. This runoff volume ranges from 2 to 132 million m^3. Figures 8 and 9 show the hydrograph for the two largest basins in Sinai, Al Arish & Watier Wadi, respectively. Another output from the hydrograph is the discharge for all basins. The watersheds discharge range from 26 m^3/s to 1717 m^3/s. Figure 10 shows all watersheds discharge.

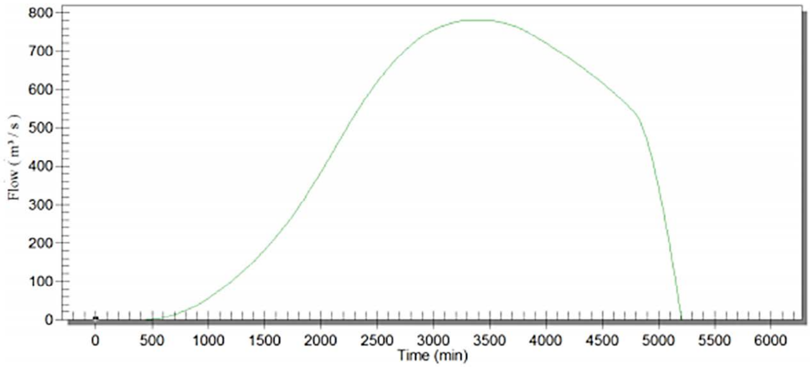

Figure 8: Runoff hydrograph at 50 -year return period for Al Arish basin.

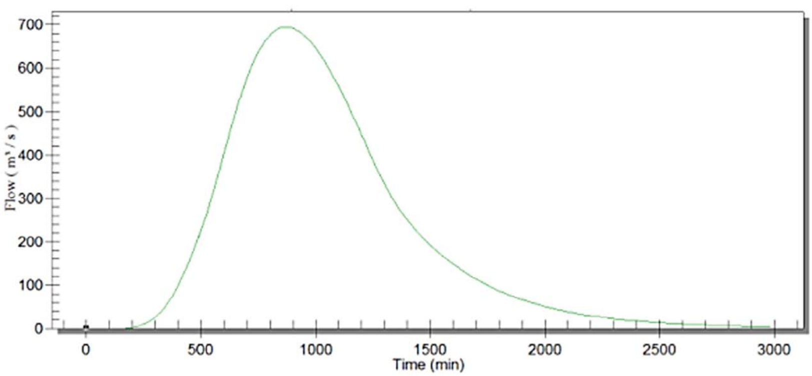

Figure 9: Runoff hydrograph at 50 -year return period for Watier basin.

5. Mapping of Hazard Areas

The term hazard identifies a potential event that could cause damage to property. The selection of criteria that has spatial reference is an important step in decision analysis (Malczewski, 1996). The most important factors that affect flash floods in every watershed are rainfall height, basin slope, drainage density, size of watershed, land use and the soil type (Cruden and Varnes, 1996; Henderson *et al.* 1996; National Weather, 2006).

Flash floods occur when rainfall is too intense, the infiltration of the ground is low and high slope of the watershed exists. Therefore, the selected critical factors are rainfall height and ground infiltration. The infiltration

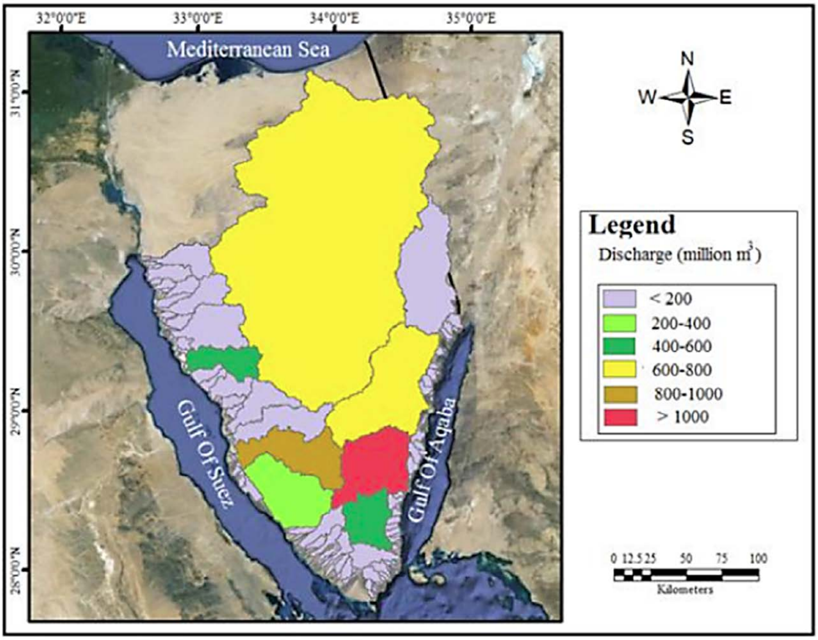

Figure 10: Sinai watersheds discharge.

capacity is the ability of the ground to quickly absorb water. It has a direct impact on the quantity of the runoff and it is related to the soil type of the study area. Another factor affecting the runoff volume is the land use. Soil covered by impervious material like roads have no infiltration capacity and result in a much higher risk of flood hazards than soils that are vegetated. However, the combination of soil type and land use is expressed by a soil conservation system curve number (Chow *et al.*1988).

Each factor is weighted based on its estimated significance in causing floods (Pramojanee *et al.*, 2001):

- Maximum daily rainfall amount for a 50-year return period (Factor weight = 3)
- Slope of the basin (Factor weight = 2)
- Type of soil and land use (Factor weight = 1)

Each factor was divided into four classes (e.g. very high, high, medium, low) and each was assigned a score (class weight) according to the estimated significance in causing flooding (i.e. 8, 6, 4, 2). The total weight used for considering the probability of flooding is calculated by the equation:

Total weight of each factor = factor weight * class weight

A summary of the total weights is shown in Table 2. For example, rainfall of 65 mm gives a weight of 18 towards the final value (a factor weight of 3 multiplied by the weight class of 6).

Table 2: The class weights, factor weights and total weights used to determine hazard risk.

weight of factor class	Rainfall		Basin Slope		Curve Number	
	Value (mm)	Weight	Value (%)	Weight	Value	Weight
8	>70	24	>20	16	>80	8
6	50-70	18	10-20	12	70-80	6
4	30-50	12	5-10	8	60-70	4
2	<30	6	<5	4	<60	2

Hazard in the present study is estimated from the total sum of the weight of each selected factor. The flood hazard areas are defined according to these values as follows:

- Very high risk = Area with total weight > 40
- High risk = Area with total weight 30 – 40
- Moderate risk = Area with total weight 20 – 29
- Low risk = Area with total weight < 20

For example, an area with 40mm of rainfall (weight = 12), a basin slope of 25% (weight = 16) and a curve number of 65 (weight = 4) gives a total weight of 32, defining this area as one with a high risk of flash floods.

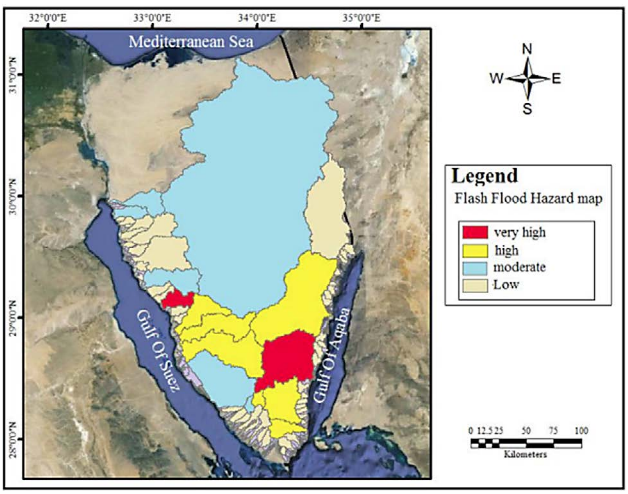

Figure 11: Flash Flood Hazard Map.

The overlaying of all maps and calculation of the total weight were obtained by applying ARC/INFO and using raster calculator in ARC-GIS. According

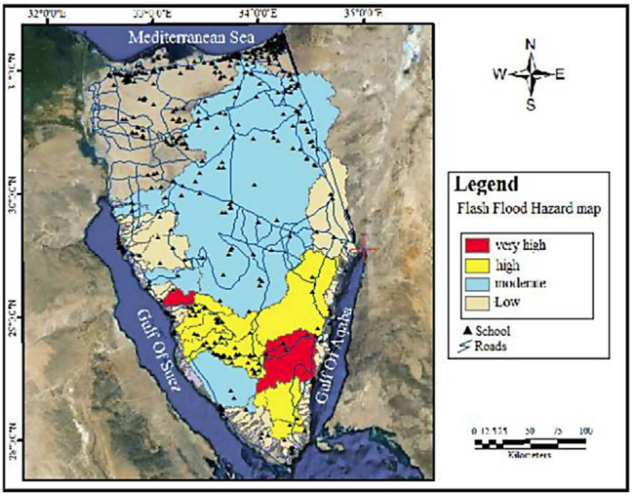

Figure 12: Flash Flood Hazard Map with schools and roads.

to these layers and calculation, the Flash Flood Hazard Map was produced as shown in Figure 11. Figure 12 shows the locations of schools and roads in Sinai and the intersection between both maps indicate the vulnerability of such structures.

6. Conclusions

Large amounts of data were collected for the Sinai region in Egypt in order to study the exposure of important structures to flash flood hazards. The Watershed Modeling System Hydrologic model has been applied to analyze and simulate the surface runoff storms using HEC-1 model. GIS techniques have been used to create flood risk or hazard maps. This study has developed a systematic methodology for estimating flood hazard areas using the GIS program. The flood hazard map from this study can be used to identify zones of Sinai region that are prone to flooding and to design flood preventing structures and plan new land use for future development.

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PAPER 7

Opportunities from THESEUS EU—Innovative Project for Enhancement of Coastal Resilience of Nile Delta Shorelines

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Abstract: This paper provides an overview of the implementation strategy of FP7- THESEUS (Innovative technologies for safer European coasts in a changing climate), which is the largest integrated project funded by the European Commission. It will outline the project's main contributions and relevance to planning the forthcoming phases of coastal zone management (CZM) of the Nile Delta coastal zone in Egypt. The impact of anthropogenic modifications and threats of climate change – sea level rise, progressive storm activity, coastal flooding, potential land subsidence and tsunami generation –drive international cooperation to reduce natural disasters in coastal lowland areas. The global dimension of climate change requires focus on making predictions and studying impacts, mitigation methods and adaptation strategies. The inherent complexity of this issue has led to the development of a number of international collaborative research efforts, in which the USA and Europe have played, and continue to play, a leading role. The success of these international projects is inspiring to coastal authorities in Egypt and the world if they elect to benefit or take a parallel path to tackle the impacts of climate change. As the Nile Delta coastline experiences increasing impacts of climate change, such as observable, progressive coastal flooding since 2003, a new master adaptation project – CZM Plan II – led by the Coastal Research Institute (CoRI) and Shore Protection Authority (SPA) is underway. This new phase will complement the Nile Delta CZM Master Plan I, which was initiated in 1981 to mitigate the effects of the 1965 Aswan high dam operation on the delta coastline. The paper presents a hydrodynamic assessment of the effects of climate change, as demonstrated by strong winds of up to 60 km per hour with a surge of over 1.0 m, which caused coastal flooding at the M. Ali seawall on the Abu Qir Bay coastline December 12, 2010. In light of this paper's conclusions, recommendations to further upgrade the M. Ali Seawall cap and strengthen the adjacent beach dike are provided. The design recommendations conform to THESEUS development technological schemes for the sustainability of coastal zones. Management and legislative recommendations to enhance coastal resilience are provided.

Keywords: coastal zone management (CZM), climate change impacts, US policies in adaptation to climate change, EU policies in adaptation to climate change, Nile Delta coastal projects, innovative coastal systems.

1. Climatic Change and Coastal Vulnerability

One of the greatest environmental, social and economic threats our planet is facing–climate change and its impacts–became a key international problem of the 21st century. There is no scientific doubt that human-induced climate change is a fact and that society is facing enormous challenges as a result.

Currently, most sandy beaches worldwide are eroding despite a wide range of coastal defense measures. The prospective impact of climate change and the mismanagement of erosion-prone areas in the past imply that coastal erosion will be a growing concern in the future, as it causes significant economic loss, ecological damage and problems/conflicts for communities. Many worldwide coastal locations of lowland, barrier islands and river deltas share similar risks and would benefit from exposure to international technology projects. Among these localities are those in the US East Coast, US Gulf of Mexico coast and lowland and river delta coastlines in Italy and Egypt (Figure 1).

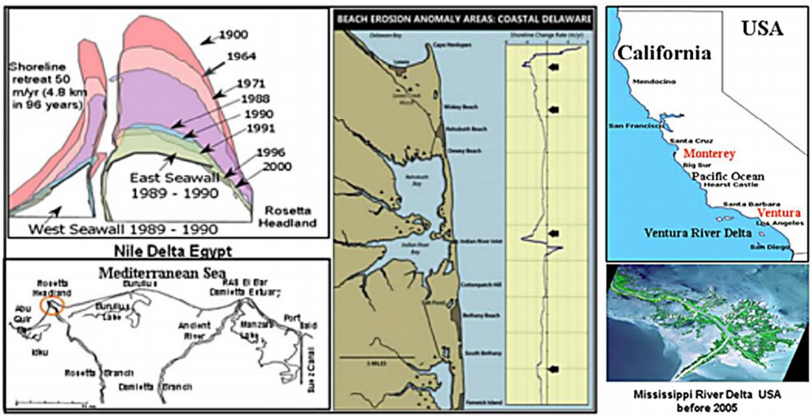

Figure 1: Nile delta and Rosetta headland and location of case studies in Delaware, US East coast and the Gulf of Mexico, California, Pacific Ocean, USA.

The effects of accelerated climate change was demonstrated at the global scale in autumn 2010 when Storm Becky reached Santander Bay, Spain. As reported by THESEUS, an FP-7 EU project (2009-2013), the peak of nearshore significant wave height was approximately 8.0 m and the storm surge reached 0.6 m, with a tidal level at 90% of the tidal range. This storm reflected at least a 20 year return period event.

More recently, in October 2012, Superstorm Sandy hit the United States and was worse than 2005's Hurricane Katrina in some ways. Sandy's storm surge at the end of October raised the water level in New York harbour by an unprecedented 4.3 m, filling subway lines and tunnels with water and disrupting the northeast's major oil distribution centre located there. Hurricanes and historic droughts, floods and heat waves occuring across the United States have not occurred by chance, but are in fact due to the climate warming at a much faster rate than previously thought.

On the Nile Delta coastline, Egypt (Figure 2), coastal flooding in Alexandria occurred on December 12, 2010 and provides a striking example of the severity of more progressive events. Egypt was hit by strong winds of up to 60 km per hour for 10 hours, and heavy precipitation. These weather conditions resulted in waves higher than 6.5 m with a surge of over 1.0 m, which forced the closure of Alexandria's main harbour. The reported significant wave height is typically about 1.0 to 1.5 m for NW/WNW waves under normal weather conditions. Maximum wave height during storm conditions is an average of 4.5 m. Typical values of storm surge on the Delta coast range from 40 to 50 cm, while the measured value of 1.2 m for storm surge was provided by the Egyptian Navy during the latest storm. The tidal range typically varies from 40 to 60 cm at Alexandria. The latest storm left a pronounced impact on the Alexandria coastal highway, its adjacent Abu Qir Bay and lowland shorelines between the two river Nile promontories, Rosetta and Damietta. The damage mechanisms resulted from direct wave and wind forces, wave run up, wave overtopping, and flooding and sand overwash.

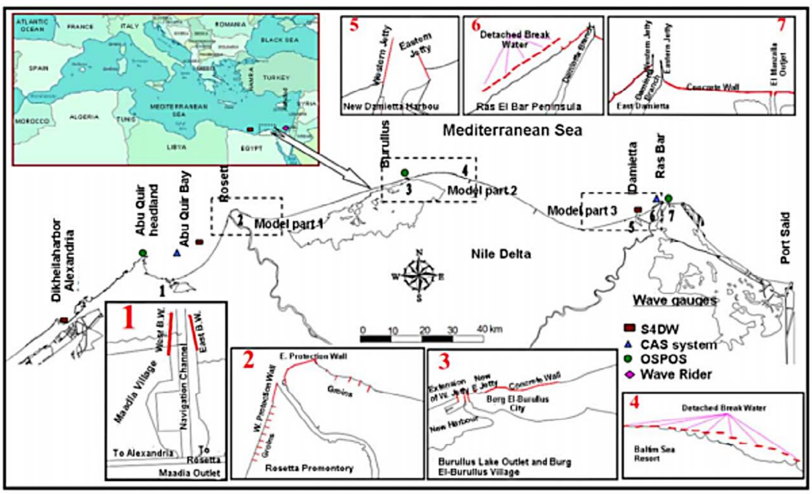

Figure 2: Map of the European Mediterranean coastlines, Nile delta coastline, and the coastal structures executed according to the Nile delta master plan in 1981 (1981-2007).

1.1 MOTIVATION FOR THE CURRENT WORK

River deltas and lowland coastlines are particularly susceptible to the effects of climate change, such as sea-level rise. Resultantly, urban areas, such as Cairo, Alexandria, and New Orleans are highly vulnerable to climate related risks (Williams, 2010). The Intergovernmental Panel on Climate Change (IPCC) reported in its 2007 fourth assessment report that nearly 300 million people live in a sample of 40 deltas worldwide, including all the large deltas as estimated by Ericson *et al.* (2006). The report states, "Deltas, some of the largest sedimentary deposits in the world, are widely recognized as highly vulnerable to the impacts of climate change, particularly sea-level rise and changes in runoff, as well as being subject to stresses imposed by human modification of catchment and delta-plain land use." (Nicolls *et al.*, 2007). Similar conclusions about the vulnerability of the world's river deltas were reported by Syvitski (2008). The author stated that under a subsistence scenario, the fragility of deltas make them less resilient to rare events such as tsunamis and hurricane-induced coastal surges. To address these issues and start the planning process for sea-level rise at overseas locations, the USGS assisted Costamarine Technologies in the United States in organizing the First International Conference on Coastal Zone Management of River Deltas and Low Land Coastlines, held March 6-10, 2010, in Alexandria, Egypt (www.nwrc-egypt.info).

According to a new technical report (Burkett and Davidson, 2012) by USGS and NOAA scientists, the effects of climate change will continue to threaten the health and vitality of U.S. coastal communities' social, economic and natural systems. This report – *Coastal Impacts, Adaptation, and Vulnerabilities: a technical input to the 2013 National Climate Assessment* – emphasizes the need for increased coordination and planning to ensure that U.S. coastal communities are resilient against the effects of climate change. A key finding in the report is that all U.S. coasts are highly vulnerable to the effects of climate change.

Thus, sustained assessment processes currently under development by international institutes represent steps forward to advance the understanding of coastal challenges associated with climate change and the far-reaching implications to our nation and the world. A prime example of an integrated approach to address these challenges is the THESEUS project (Innovative technologies for safer European coasts in a changing climate) funded by EU-FP7. This initiative, which is the largest integrated project funded by the European Union, is being managed by a team with the senior author as the general manager. The project (2009-2013) is critical for many nations around the world such as the Nile Delta.

2. Meeting the Climate Change Challenge in Europe

The European Union's coastline extends 17,000 km across 20 of 27 Member States and coastal areas covering approximately 2 million km^2. Over the past 50 years the population living in European coastal municipalities has more than doubled to reach 700 million inhabitants in 2001. Large stretches of the European coast, which are highly populated and economically essential, are already threatened by coastal erosion and flooding. Europe, as well as many parts of the world, has not yet developed an integrated approach for the assessment and management of erosion and flood risks, required to address multiple human and environmental challenges even though climate change research has been present in the EU's Framework Programs since the 1980s. THESEUS–a large, integrated FP7 project consisting of 31 partner institutes–is aimed to develop a systematic approach to ensure safe coasts for human use and healthy coastal habitats as the climate changes, sea levels rise, and the European economy continues to grow.

2.1 THESEUS MAIN OBJECTIVES

The main objective of THESEUS is to develop a framework that creates sustainable mitigation and adaptation measures against coastal erosion and flooding. This framework will address the technical, social, economic and environmental aspects of such measures, which are primarily designed to create healthy coastal habitats while ensuring low-risk human use and development in the face of sea level rise and climate change. Validation of the outcome is being conducted on data from eight coastal sites in Europe (Figure3).

Integrating a systematic approach in the development of a Decision Support System (DSS) is beneficial to Europe and will be inspiring to other coastal authorities if they elect to follow.

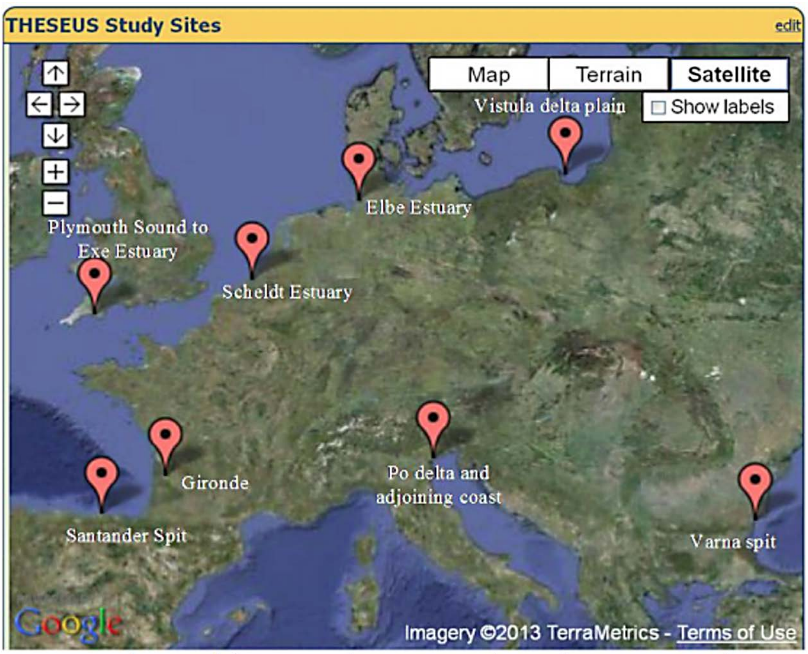

Figure 3: Study sites of the EU-FP7 THESEUS project (www.theseusproject.eu)

2.2 THESEUS STRATEGY IMPLEMENTATION

The strategy used to meet the THESEUS objectives required examination of the resilience of the coastal systems in selected study sites in the short, medium and long term, and application of this information to the development of innovative "climate proof technologies". An integrated approach would then be used to choose the proper mitigation option from among these technologies, for each particular study site. This overall strategy allows:

- Strong relation with end users and coastal managers;
- Continuous feedback between research and practice;
- High quality of scientific research on innovative technologies; and
- Real improvement of safety and economic development in given coastal areas.

The project's technical and management work is being coordinated through seven disciplinary Work Packages as demonstrated in Table 1. The procedure of coordination could be running either in series or in parallel among the different work packages. The work plan is illustrated in Figure 4. Meeting the project targets of project deliverables on schedule has been due to the successful implementation of the logical work plan. (THESEUS)

Table 1: EU-THESEUS Work Packages.

1.	WP1: Risk assessment, policy, management, and planning strategy in study sites
2.	WP2: Mitigation of flooding/erosion hazard: innovative coastal structures and sediment management
3.	WP 3: Ecologically based mitigation measures and design
4.	WP 4: Impact mitigation: society and economy
5.	WP 5: Risk mitigation options and tools for defense planning strategies in study sites
6.	WP 6: Project dissemination
7.	WP 7: Project management

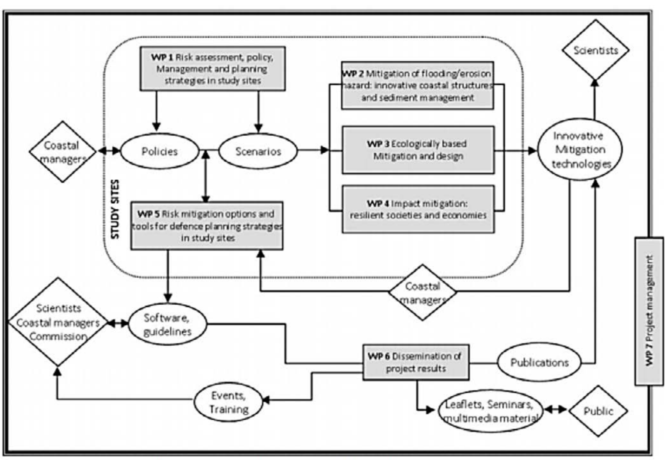

Figure 4: Strategy of executing THESESUS work packages (THESEUS).

2.3 THESEUS COASTAL DEFENSE TECHNIQUES

One of the projects aims is to examine the application of innovative combined coastal mitigation and adaptation technologies. The primary objective is to provide an integrated methodology for planning sustainable defense strategies for the management of coastal erosion and flooding, which addresses technical,

Figure 5: Technical Research and Applications on Coastal Defenses. *a) submerged reefs, b) coastal dikes and simulation, c) vegetated coastal revetment, d) sand dunes stabilization, e) offshore detached breakwaters with beach preservation.*

social, economic and environmental aspects. Work Package 2 ensures the development of these innovative hard and soft technologies for mitigation of flooding and coastal erosion hazard in the context of increasing storminess and sea level rise. These technologies (Figure 5) include:

I Improvement of existing defense structures
- Upgrading or elevating existing rubble mound breakwater armours and groynes
- Stabilizing coastline through careful dredging, shore nourishment and reactivation of the littoral drift
- Expanding upon low environmental impact concepts like floating breakwaters

II Development of innovative new techniques (see articles from the THESEUS official deliverable)
- Creating low environmental impact barriers like artificial reefs of geotextile sand containers or reef balls
- Improving the stability of dike inner slopes to create overtopping resistant dikes
- Promoting the restoration or development of natural barriers as mitigation method
- Reducing incident wave energy with innovative multipurpose solutions such as near-shore wave energy converters or artificial reefs aimed to improve spot surfability

III Natural habitats for coastal protection and relevant multi-stressor coastal risks
- Salt marshes in Europe and temporal variability
- Biogenic reefs of Europe and temporal variability
- Dynamics, threats and management of dunes
- Dynamics, threats and management of salt marshes
- Dynamics, threats and management of biogenic reefs

Objectives of the proposed protection systems are measurable and verifiable as the projects show steady progression from innovative concepts through modeling to verified results. A risk based approach, based on the climate scenarios developed within THESEUS Work Package 1 as well as literature review, is applied. All progresses with physical model testing, numerical modeling and selected prototype activities within THESEUS follow a verifiable design methodology and the best practices for innovative defenses will be documented.

2.4 DECISION SUPPORT SYSTEMS FOR COASTAL ZONE MANAGEMENT

Effective coastal zone management requires sophisticated scientific input and consideration of a wide range of associated social, economic, and political factors. The breadth of knowledge and experience required to effectively account for inputs from varied disciplines, without the reliance on specialized expertise is uncommon. THESEUS facilitates this process by providing a Decision Support System (DSS) that integrates several complex models to assess environmental impacts with transparent database access. The DSS provides a Graphical User Interface for site selection and hypermedia to provide the user with the opportunity to obtain detailed information about the evaluation process without an exhaustive review of information. This approach provides a model that contemplates many aspects of coastal zone management and offers a means for managers to effectively manage increasingly complex and sophisticated scientific information associated with the effect of human activities on coastal environments.

3. Coastal Zone Management of the Nile Delta and Climate Change Adaptation

The Nile Delta, like other global deltas at risk, is subject to shoreline morphological changes, subsidence resulting from anthropogenic modifications and progressive climate changes. These changes induce coastal erosion, flooding, inland land loss and soil salinity, and threaten fragile coastal ecosystems.

Previous analyses indicated that due to the direct static effect of sea level rise, a large percentage of the Nile Delta is directly vulnerable to inundation and saltwater intrusion that could drive millions from their homes. In addition to direct sea level rise, there is also an associated increase in storm frequency and storm surge which are considered main challenges of climate change impacts. These parameters significantly affect wave run-up and wave overtopping which result in flooding of low land coastal areas.

3.1 ANTHROPOGENIC MODIFICATIONS IMPACT

The Rosetta headland, on the western coast of the Nile delta, has been subject to the most severe erosion of the delta coastline from a decrease of Nile sediments since 1890 and its absence from 1964. Severe retreat of Rosetta headland as well as significant morphological changes of the Nile Delta Coastline occurred after the operation of the Aswan High Dam in 1965 (Figure 1). The Rosetta headland is currently protected by two flanking seawalls since 1990 (Figure 1), according to the Nile Delta Master Plan formulated in 1981-1986. In the process, other systems of coastal hard structures have been placed at other locations along the Nile delta coast such as Burullus Lagoon inlet and Damietta branch headland (Figure 2).

These coastal structures have mitigated and considerably slowed coastal erosion in major locations. However, the structures also caused successive downdrift coastal erosion and accretion along the Nile Delta coastline. This also occurred at the Rosetta headland, as a result of the construction of two seawalls in the nineties. To hinder the downdrift shoreline recession, two sets of groins were planned for implementation in the last decade and were recently constructed on both sides of the Rosetta headland seawalls (Figure 1). Despite these measures, wave runup and flooding of the lowland (-2.0 to +1.0 m) at several locations around Rosetta headland, its adjacent Abu Qir Bay (Figure 2) and other portions of the Nile Delta shoreline occur during major storms.

3.2 MOVING FORWARD WITH CLIMATE CHANGE ADAPTATION

It is compelling to develop sustainable solutions to eliminate flooding of the coastal and agricultural zones and furthermore to make ecological use of the coastal fringe. Increased attention to the sustainability of the Nile Delta coastline has been described in many articles. The development of a new project proposal entitled *"Adaptation to Climate change in the Nile Delta through Integrated Coastal Zone Management"* has been awarded to the Coastal Research Institute (CoRI) by the Global Environmental Facility through the Special Climate Change Fund. The project was endorsed in August 2009 and is currently being implemented through cooperation between the UNDP-Egypt and the Ministry of Water Resources and Irrigation. Parallel co-funding has been availed by the Ministry through Shore Protection Authority (SPA).

The project aims to integrate the management of SLR risks into the development of Egypt's Low Elevation Coastal Zone (LECZ) in the Nile Delta. It will achieve this by (i) strengthening the regulatory framework and institutional capacity for Integrated Coastal Zone Management as a framework for climate change adaptation; (ii) implementing innovative and environmentally friendly measures that facilitate and promote adaptation in the Nile Delta. As the understanding of natural shoreline function improves, there is growing acceptance that structural solutions often lead to unintended adverse outcomes. Therefore the project intends to introduce a "Living Shorelines Approach". This will address the need to design and implement "soft" stabilization methods in conjunction with "hard" stabilization practices, the latter of which has been historically solely practiced in Egypt (source?). Bank stabilization and habitat restoration techniques such as sand dune rehabilitation and stabilization, vegetative plantations, cobble berms, and artificial wetlands can reinforce the coastline, minimize coastal erosion, and maintain coastal processes while protecting, restoring, enhancing, and creating natural habitat for natural resources and productive activities; and (iii) establishing a monitoring and assessment framework and knowledge management systems on adaptation.

4. Impact of Climatic Changes on Existing Defense Structures at the Nile Delta Coastline (Case Study)

The recent coastal flooding on December 12, 2010, on the Nile Delta Coastline is a striking example of the severity of more international progressive events due to climate change. Egypt was hit by strong winds and heavy precipitation, up to 60 km/hr with a surge of over 1.0 m and more than 5.5 m wave height. This paper presents an assessment of the performance of a shoreline revetment, M. Ali Seawall, placed to protect the land behind it against flooding and over-topping at the coastal site, within Abu Qir Bay, East of Alexandria along the Nile Delta coast. The storm, fortunately, only resulted in a partial and modest flooding of the zone behind the seawall particularly in the beach segment, located in the middle of the seawall. The seawall was constructed in 1830 and it underwent maintenance several times between 1920 - 1930. In 1981, under the terms of the Nile Delta Master Plan conducted jointly with Tetra Tech Inc. of Pasadena, CA, USA (Kadib, 1986), the protection work modified the seawall to revetment with a front slope of 1:2 and 0.50 ton of concrete cubes as an armor layer.

To protect the lowland agricultural area sitting at 2.0 m below mean sea level and the power plant facility, Ismail *et al.* (2012) conducted a hydrodynamic assessment of the seawall under current and progressive sea conditions due to climate change. Based on the results (Figure 6), under worst case design scenarios, recommendations are given to increase the height of the seawall cap, to strengthen the beach top and back slope with a facility to drain storm water to increase coastal resilience behind the seawall. The design scenarios, which were considered to estimate wave height distributions within Abu Qir Bay and along M. Ali seawall are as follows:

- Recent morphology with the maximum yearly wave condition (H_{max} = 3.50 m, T = 7.5 s, N. direction, Depth = 14.0 m).
- Future morphology (recent bathymetry + the sea level rise within the next 50 years) with the maximum yearly wave condition. Future morphology of the study area has been predicted according to the effect of sea level rise only using Coastal Research Institute scenario as shown in Table 2.

Conclusions

- Morphological changes and observations during the last two decades on the Nile Delta coastline has shifted management decisions toward designs that follow the principles of sustainable ICZM, coupled with the use of coastal models, as demonstrated by the Egyptian government coastal authorities and Tetra Tech, CA, US in the development of the Nile Delta

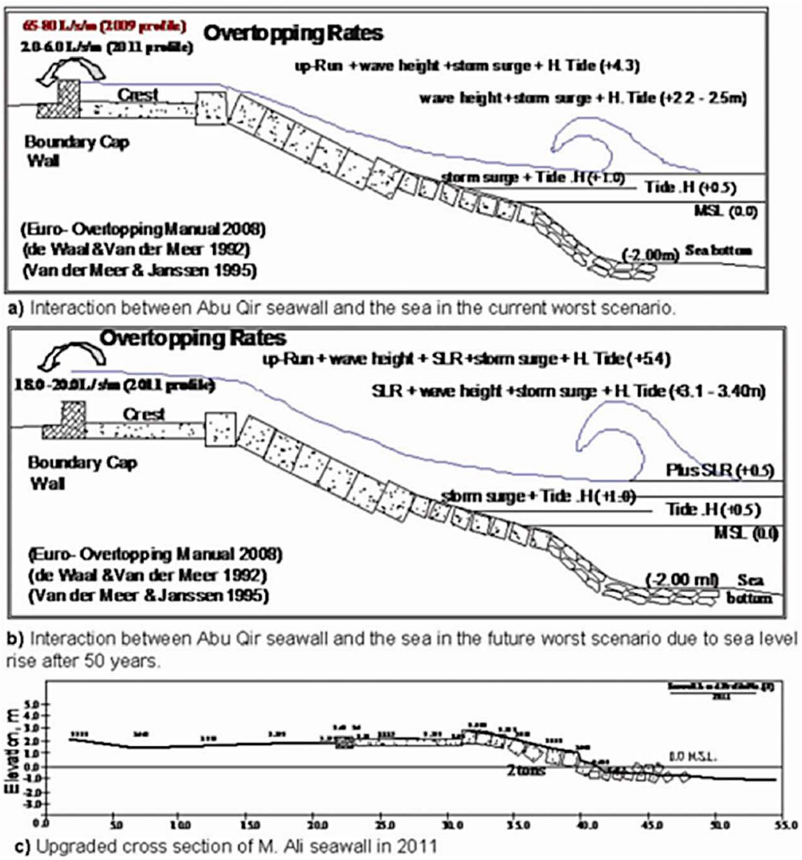

Figure 6: Impact of climate changes on subsequent wave run up and wave overtopping at M. Ali seawall, Abu Qir bay, Nile Delta coastline and upgraded design (Source: Ismail et al., 2012).

Table 2: Estimated average annual seal level rise (cm) relative to year 2000 sea level (Source: El Shinnawy et al., 2010).

City	IPCC Scenario	Year			
		2025	2050	2075	2100
Alexandria	A1F1	13.0	34.0	55.0	72.0
Burullus		14.75	37.5	60.3	79.0
Port Said		27.9	68.8	109.6	144.0

Master Plan in 1981 (Figure 7). It is evident that poorly planned coastal defenses on one part do not serve the overall protective objective as they can cause knock-on effects elsewhere of the coast. The spirit of this new approach has been translated into the initiation of the Nile Delta Master Plan II, to accommodate both anthropogenic and climatic change impacts. Such efforts on the southern Mediterranean (Figure 7) will be stimulated and inspired by the recent efforts to cope with climatic impacts in the US and Europe such as that displayed by the THESEUS Project (THESEUS). The predicted sea level rise and expected storm surge on the existing M. Ali seawall at Abu Qir bay, east of Alexandria were found to have a dramatic effect for the case of maximum storm wave condition. The wave height in front of the seawall within this area will increase by about 25 - 30 % after the next 25-50 years. The expected future events at the M. Ali seawall will not threaten the stability of the current design of armor layers but the wave overtopping will be increased extensively and therefore the boundary cap wall of the seawall needs to be increased with a facility to drain the flood water. (Ismail *et al.*, 2012)

- Global sea-level rise and probable oceanic activities, including frequent tsunamis, are occurring as a result of global climate change; however, the degree of threat can vary spatially and temporally. Adaptation and prepa-

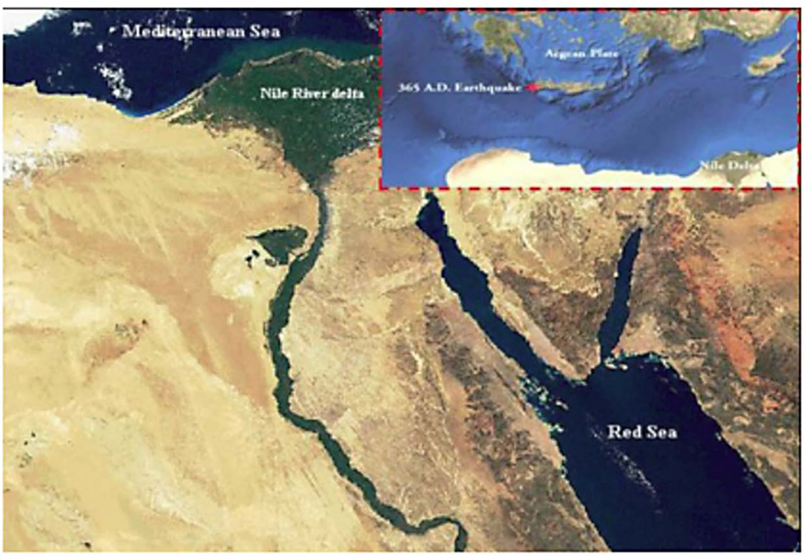

Figure 7: Egypt and Nile Delta and approximate epicenter of the great 365 AD tsunamigenic earthquake (The entire Nile Delta coastal region was probably flooded by the tsunami of 365 AD) (Source?)

ration for the impacts of climate change require regional solutions in the framework of integrated coastal and inland zones management.

- It should be highlighted that international research indicates higher rates of effective sea level rise at the Nile delta (Figure 8) than those reported by local authorities. Extrapolating contemporary rates of ESLR through 2050 reveals that 8.7 million people and 28,000 km² of deltaic area in the sample set of deltas could suffer from greater inundation and coastal erosion (Ericson, 2006). The population and area inundated rise significantly when considering increased flood risk due to storm surge.

Figure 8: Global distribution of ESLR under baseline conditions for 40 deltas. The upstream drainage basin for each delta is highlighted for presentation purposes. This figure represents contemporary combined rates of natural rate of delta subsidence, accelerated subsidence, and the contemporary rates of eustatic sea-level rise (Source: Ericson, 2006).

Recommendations

International experience in the US and Europe would indicate that management and legislative policies be adopted to achieve sustainable solutions for the Nile Delta coastal fringes and Egypt inland zones (Figure 7) as follows (Williams, 2010; Ismail and Williams, 2013):

1. Enhanced cooperation and teamwork among concerned agencies and stakeholders, at national and international levels;
2. Development and implementation of awareness programs for governmental officials, scientists, and the public to disseminate knowledge about coastal and climate risk. This knowledge is necessary to successfully integrate coastal-zone management, planning implementation, and water-resource management and conservation;
3. Development of a comprehensive coastal and climate data scientific and technical database in cooperation with all concerned parties. Flexible

information sharing and accessibility to data will help the cooperating parties achieve sustainable development;

4. Effective capacity building, such as steps to improve organizational structures and strengthen individual skills, and human resource development at local, national and international levels;
5. Adaptation of required adjustments in legislation concerned with coastal-zone management processes; and
6. Enforcement of existing laws and coordination among different local authorities to successfully implement national integrated coastal-zone management.

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PAPER

8 | Potential Impacts of Natural Hazards on the Egyptian North Western Coast

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Abstract: Coastal zones are important areas of focus in the international debate about the environment and sustainable development. Coastal zones generally consist of the interface between land and sea in a balance where marine space and resources are as important as terrestrial ones. Coastal zones have become major sites of extensive and diverse economic activities. Many coastal developing countries depend heavily on the scarce coastal resources for their economic growth. Rapid urbanization and economic development spawn complex resource-use conflicts and environmental degradation problems in the coastal zones. Since the northern coastal zone of Egypt is a highly dynamic system, most natural events show a wide range of variation through time in the use of energy and materials of environmental processes. Traditionally, natural hazards have been viewed in an ecological framework; this distinguishes between natural events and their interpretation as natural hazards (or resources). This paper provides basic spatial data covering the coastal zone extending from west Alexandria to El Sallum sector east and 60 km landward (south) along the North Western Egyptian Mediterranean Sea from 1984 to 2003. Thematic layers of relevant factual maps on a scale of 1:100,000 are provided. This study identifies causative processes and their rates to the dynamic aspects involving time-lapse, sequential coverage of spatial data and the impacts (or risk) of increasing human activities. Also, as remote sensing techniques allow for zooming-in of details, comprehensive studies of critical sites (hot-spots) and sectors at later dates would be possible. In fact, the coastal areas provide scientists with an equaled opportunity for the study of active processes. The coastal processes and the resultant movement of shoreline material up and down the beach; the socioeconomic parameters along the coast over the sea-land interaction, the development activities, e.g. tourism; and climatic conditions - all these, and many other processes, operate at a speed which renders observation, measurement and analysis a far more feasible task. In light of this, the application of the concept of dynamic equilibrium would seem to be more justified in the coastal field than in others. Coastal features such as shoreline changes, sedimentation, and even some cliff formations are without doubt the product of currently acting processes, and their forms seem to represent a changing condition of balance between several controlling factors such as, aspect, climate conditions, nearshore processes, tides, dunes movement. Yet even in coastal geomorphology, important examples of 'in-equilibrium' are often found.

Keywords: climate changes, natural hazards, hazard mitigation, Egyptian North Western Coast, sea level rise, coastal zones, sustainable development, integrated coastal zone management, satellite data, topographic maps.

1. Introduction

Climate change is one of the most significant global environmental issues facing the world today, and evidence is mounting that humans are affecting the global climate. The global warming from the greenhouse effect will raise sea level due to expanding ocean water and melting mountain glaciers causing ice sheets to thaw or slide into the oceans. Such a rise would flood deltas, coral atoll islands, and other coastal lowlands, erode beaches, aggravate coastal flooding, and threaten water quality in estuaries and aquifers (Soliman *et al.*, 2008).

The environment in coastal zones exists in a fragile balance of natural processes and human activities. But a new threat is emerging. If climate change and sea-level rise induced by global warming progress as predicted, the consequences will be serious, especially for small coral island states and people living in low-lying coastal areas. Without mitigation measures adopted specifically to tackle rising sea level, increased flooding is calculated to affect 200 million people worldwide by the 2080s. Approximately 25% of the world's coastal wetlands could be lost by this time due to sea level rise alone (Perez- Soba *et al.*, 2010)

Egypt is potentially one of the countries most at risk from the effects of climate change. It is located in an arid to semi-arid zone. The inhabited area of the country constitutes only 4% of the total area of the country (1 million km^2), and the rest is desert. The coastal zones of Egypt extend for more than 3500 km and are the home of more than 40% of the population. Most of these people live in and around a number of very important and highly populated industrial and commercial cities: Alexandria, Port Said, Damietta, Rosetta and Suez. A 50 cm sea level rise on Egypt's coastal zones would affect 2 million people and 214,000 jobs, and cause land and real estate losses worth US$ 35 billion (Agrawala *et al.*, 2004).

The North Western Coast of Egypt stretches along 525 km of the Mediterranean Sea, west of Alexandria.. This promising region has attracted many tourist-related projects with massive investments. Most of these projects are resorts, hotels, and tourist areas used for recreation and swimming purposes (El- Sharnouby *et al.*, 2011).

Disaster risks are expected to increase by 2030 due to climate change, and continued urban and tourist expansion is occurring at new sites that are exposed to natural hazards. Higher marine submersion, coastal erosion and water scarcity risks, along with an increase in seismic, land subsidence, and flooding risks will be faced. Additionally, climate change may negatively affect public health.

Determination of the critical coastal areas exposed to natural hazards that require protection along the North Western Coast of Egypt is achieved using new remote sensing techniques. A systematic method dealing with all variables is applied to assess the risks associated with a significant development at the North Western Coast. The most suitable mitigation measures are identified to reduce the risk level and to raise the manageability level, which will reduce the vulnerability of existing resources. Figure 1 shows the study area, which extends from Alexandria to El Sallum and 60 km landward (south) along the North Western Egyptian Mediterranean sea.

Multi temporal satellite data, remote sensing and Geographical Information System (GIS) techniques, as well as digitized maps and existing historical data are used. A Digital Elevation Model (DEM) covering the depths from -12.00 meters to the contour line of +3.00 meters for the coastal zone from year 1984 to year 2003 is prepared.

Depending on the model results, the shoreline retreat or advance is identified as well as the land uses up to the contour line of +3.00 meter, with special emphasis on the International Coastal Road, are shown. A sensitivity map of the study area for various natural hazards is prepared and presented which will be important for any future development of the study area.

This paper reveals many improvements in determining coastal hazards and historical development that are rooted in a better scientific understanding of how the hazards affect the development along the North West coastal zone. There is quantitative information available from this study about the development changes and anticipated hazard events that can be used for purposes of hazard mitigation and coastal development planning.

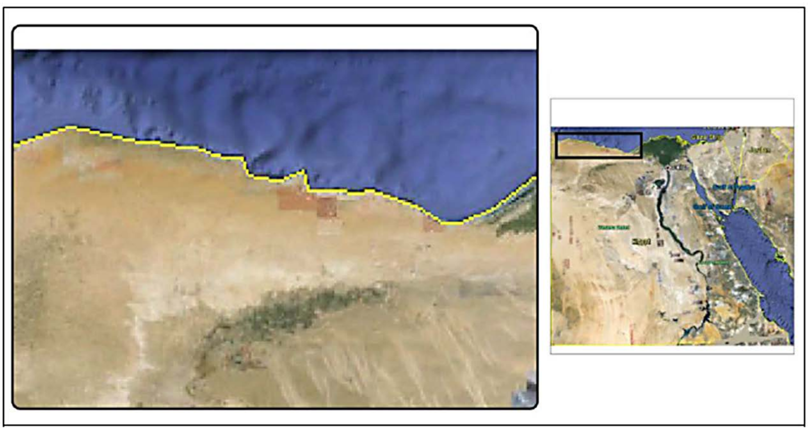

Figure 1: The study area extends from Alexandria west to El Sallum east.

2. Methodology

Preparing coastal environmental maps with scale of 1:100,000 by using satellite images, ground observations, and related ancillary data required data to be compiled and processed in different ways. These data sets have been systematically used to prepare the necessary layers to constitute an appropriate GIS for the study area covering the North Western coast. The data was integrated to establish a digital database which could be useful for site selection, coastal planning and proper management of national development projects in the coastal area.

As indicated, data available from this study is seen as primary for coastal zone management plans. It can also be used as the basis for monitoring human-induced and natural environmental change for the study area. The available data used in this study, in addition to climatic data, can be grouped into four main types: satellite data, topographic maps, bathymetric charts and fieldwork. Details of these materials are provided as follows:

I- SATELLITE DATA

As Landsat Thematic Mapper (TM) data has a ground resolution of 30 meters and seven spectral bands covering the visible, near-infrared and thermal bands of the electromagnetic spectrum, it has been used for the production of satellite image scales 1:100,000. A survey was carried out for the available Landsat scenes that cover the Egyptian North Western coast, within two time periods (1984 and 2003) as shown in Figure 2.

II- TOPOGRAPHIC DATA

Topographic maps with scale of 1:100,000 were scanned with a resolution of 250 dots per inch (DPI) as a preparation phase of the digitizing process. The digitizing process was carried out to extract general land cover features as well as shoreline, contour lines, spot heights, urban, agricultural areas, roads and canals. The list of the topographic maps that cover the North Western coast of Egypt with a scale of 1:100,000 are El Sallum, Sidi Barrani, Mersa Matruh and Alexandria.

III- BATHYMETRIC CHARTS

Recent bathymetric charts with different scales and corrected depths were scanned with a high resolution of 250 DPI as a preparation stage for the digitizing process. The digitizing process was carried out to extract bottom features of the offshore study area showing the shoreline, depth contour lines, and all sea characteristics that might be located in the study area. The list of the bathymetric charts that cover the North Western coast of Egypt start from El Sallum city and extend to west Alexandria.

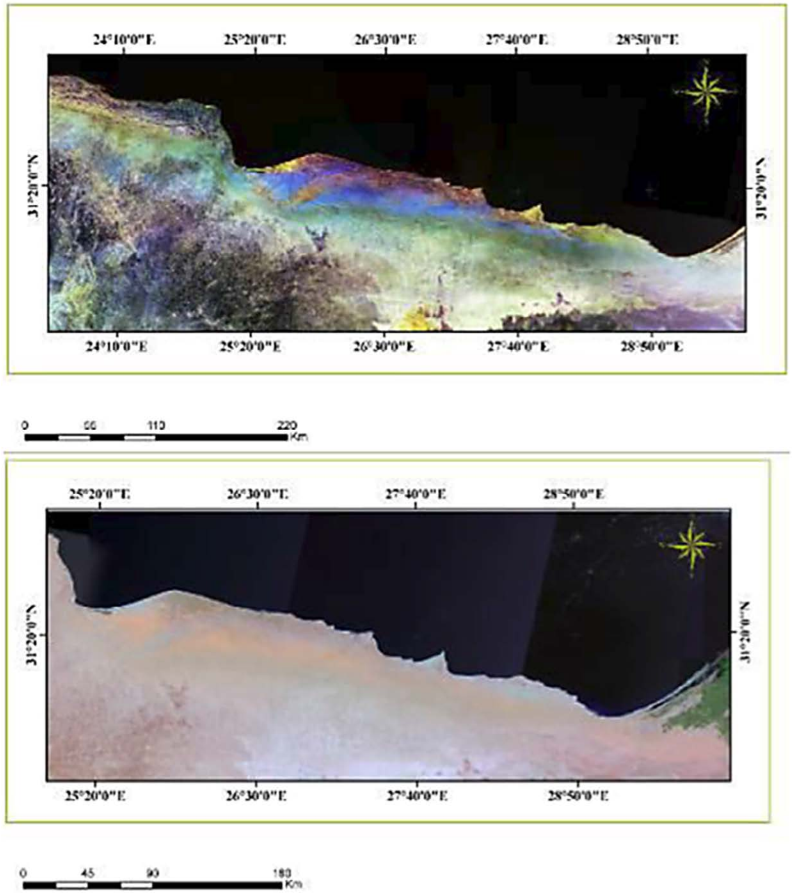

Figure 2: Landsat scenes that cover the North Western coast of Egypt for year 1984 (upper) and year 2003 (lower).

Bathymetric charts with a scale of 1:500,000 of the new system were issued by the Admiralty Office, UK. Charts were scanned in a preparation phase for the development of a three-dimensional model to present the bottom topography of the near shore water of the study area. Figure 3 shows the DEM construction off the North Western coast of Egypt.

IV- FIELDWORK

A field trip was carried out to the study area covering the route line: Cairo – Alexandria – Mersa Matruh – El Sallum along the coastal zone. Approximately 72 selected sites were visited and field observations and measurements were collected as demonstrated in Figures 4 to 8.

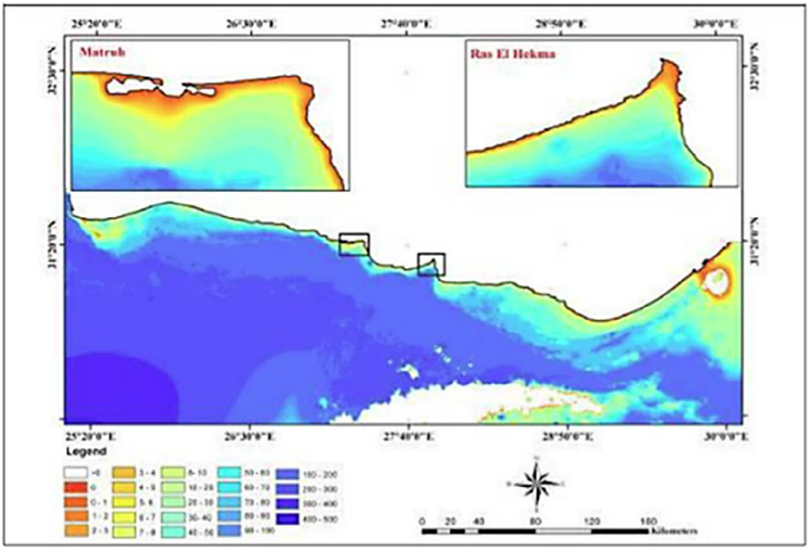

Figure 3: DEM construction of North Western coast of Egypt, Admiralty chart 2004.

Field Trip Outputs

Along the coast, one or more parallel ridges of dunes were found, separating narrow, elongated plains: south of the dunes, wind-blown soils and alluvial pans deposited by the wadis were visible. Further south, at varying distances from the coast, a rocky plateau exists. Small areas of soil suitable for agriculture were interspersed with small patches of unsuitable land.

Current development activities along the northwestern coastal plain and observations of the different natural and anthropogenic environmental features that occurred along the coast due to the coastal changes were recorded. The Global Positioning System (GPS) was used also during the verification of the produced land-use/land-cover maps.

Field trips were conducted to ground truth satellite images processed; to collect field observations regarding the most recent human developments activities; and to document the findings.

Sampling of the different natural and anthropogenic environmental features that occurred along the coast due to the coastal changes was carried out and they were photographically documented. This helped to determine the main coastal changes by considering updated land use and expected environmental risk.

Shallow soils may have to be ruled out because of potential problems of water logging and salinization, and soils with an irregular topography had to be discarded for reasons of cost.

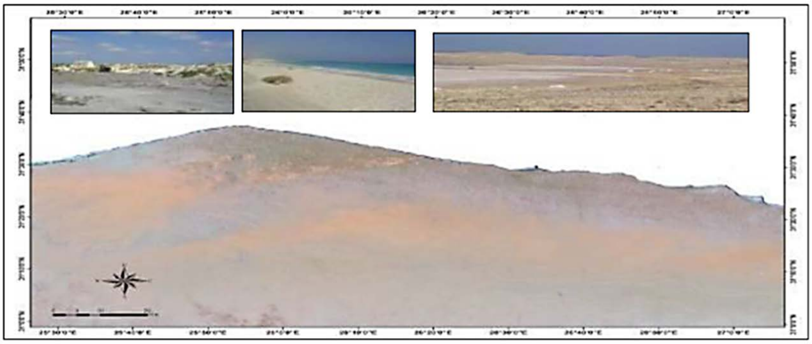

Figure 4: Thematic map of the Satellite image (2003) from Sidi Barani – Marsa Matrouh with photographs of some important visited sites.

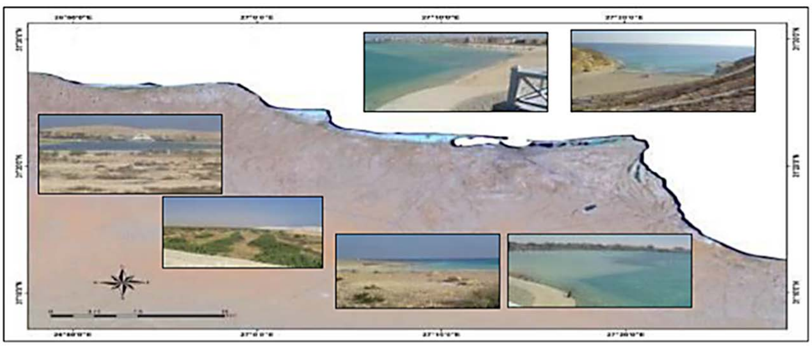

Figure 5: Thematic map of the Satellite image (2003) to Marsa Matrouh city with photographs of some important visited sites.

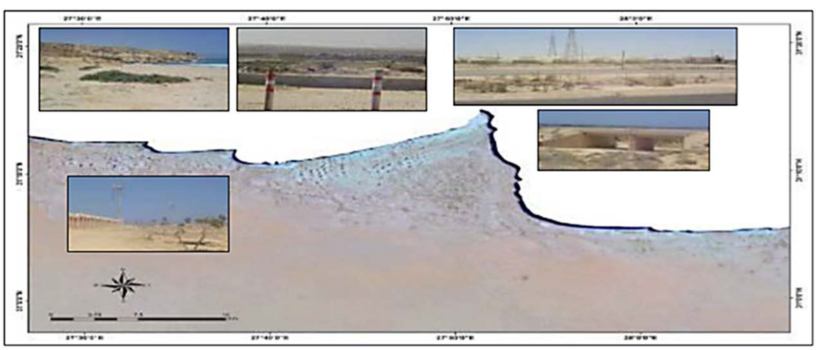

Figure 6: Thematic map of the Satellite image (2003) from Marsa Matrouh to Ras El-Hekma with photographs of some important visited sites.

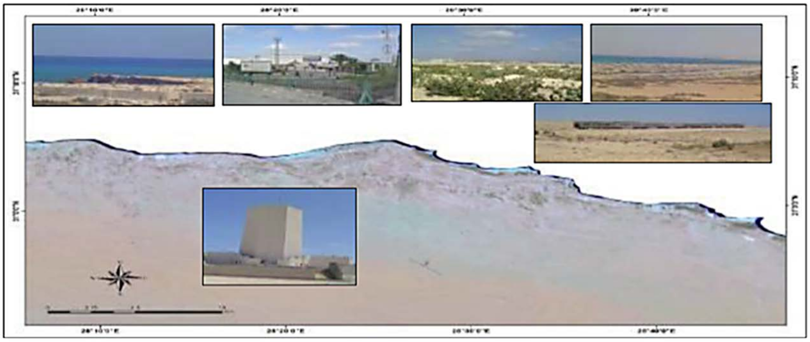

Figure 7: Thematic map of the Satellite image (2003) from Ras El-Hekma to El-Dabaa with photographs of some important visited sites.

Figure 8: Thematic map of the Satellite image (2003) from El-Dabaa to Wadi Maruit (West Alexandria city) with photographs of some important visited sites.

3. Results and Analysis

Image classification and land use charts were used to show the location of the main agricultural, urban and roads areas at a scale of 1:100,000.

I- AGRICULTURE DEVELOPMENT

Processing satellite images revealed that the total area for agriculture has been estimated at approximately 7,186.1 km in 1984 and approximately 7,535.9 km in 2003 with a total agriculture development of approximately 349.8 km. Generally, agriculture is primarily comprised of olives, figs and melon produce and sheep herding for livestock. The types of cultivation along the coastal zone determined during the field trip were as follows: fruit and vegetables in the eastern region; figs, olives, nuts, barley, melons and watermelons in the middle region; and olives, melons, dates and barley in the western regions.

Results of the thematic maps revealed that in the north west coast extending from west of Alexandria to El Sallum city in the western border of Egypt and up to a 60 km distance landward, there are practically no large cultivation areas because of a lack of water and the presence of World War II mine fields. The scattered cultivated areas are small areas (see Figures 4 to 8). According to the inhabitants, many cisterns were cut in the rock in the distant past. Geology demonstrates a double system of ridges parallel to the shore. Between the northern ridge and the shore, a lagoon is frequently filled with brackish water; it cannot be cultivated, except in a few places where it is a little dryer. Between the two ridges lies a depression, which is the most cultivated area. On the ridges the water is collected in cisterns, and in the depression there are wells often equipped with windmill pumps. In the southern areas, 10 to 15 km from the sea shore, there are yermosols which are completely inapt to cultivation even when irrigated (Sofratome, 1984).

Presently, new agricultural developments are situated south of the traditional areas but along the coastal zone. They are being cultivated in an effort to match the demographic problem. Most of the exploitations of the region are of the familial type. The livestock population, numbering only 350,000 in 1967, has increased explosively since then to 1,000,000. The resulting extermination of natural vegetation (1,500,000 hectares) is now threatening the main source of income, the employment and thus the socio-economic structure of Bedouin society.

II- ROAD NETWORK DEVELOPMENT

Output maps derived from this study indicated that road network is estimated at about 12,489.2 km in the year 1984 and about 13,438.2 km in 2003. The development average rate is about 949 km per 13 years. The low population density, low level of economic activities and thus the low purchasing power in the North Western Coast has resulted in a very modest demand for transportation services. The capacity of the present road and railway infrastructure is less in line with this level of demand for development as shown in Figure 9.

The quality of services is below standard in a number of cases. This is the result of to a nationwide shortage of rolling stock (buses, railway cars and locomotives), which also affects the North Western Coast.

The North Western Coast has a single railway line starting in El Gabary, 35 km east of the regional border and ending in El Sallum. This railway is physically characterized by steep grades and bad roadbeds with small radii, especially at the beginning; a high utilization pressure on rolling stock as is the case throughout the country; a maximum operation speed of 85 km/h, allowing a 7 hour (one-way) travel from Alexandria to Mersa Matruh; and single line operation, with a manual signaling system. It has 42 stations; 27

between El Gabary and Mersa Matruh, mostly with two sidings and 15 between Mersa Matruh and El Sallum with one siding.

Unlike roads, where the capacity increases are made in large increments (e.g. a four-lane road instead of a two-lane road), the capacity of a railway can be increased more gradually in line with the growing demand. Capacity increases depend on the type of envisaged traffic and the coordination of the measures taken. The main coastal road, running parallel to the coastline, has been developed from one narrow lane to two wide lanes. The Alexandria to Mersa Matruh stretch and the Mersa Matruh to El Sallum stretch have the highest traffic density, particularly in the summer season. The strong commercial activities between Egypt and Libya have increased the traffic density on the stretch from Mersa Matruh to El Sallum.

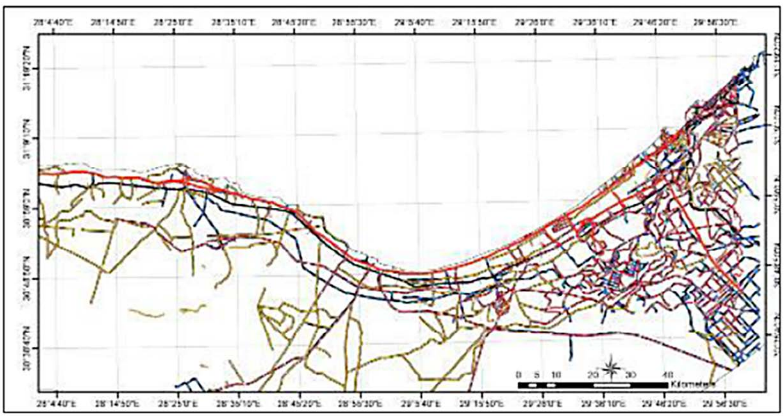

Figure 9: Roads development activities during (1984-2003) along NW coast of Egypt, Alexandria.

III- URBAN AREAS EXPANDING

The urbanized areas are identified along the North western coast: Al Hammam city, Al Dabaa city, El Alamein, Sidi Abdel Rahman, Ras El Hekma, Bagush, Mersa Matruh City, El Abyad Beach, Sidi Barani and El Sallum. The main tourist sights are: World War II graves in El Alamein and El Sallum, El Alamein Military Museum and the beaches. A combination of pure white sandy beaches and dunes, a deep blue sea, clean air and, in comparison with some competitive destinations, a favorable climate, are the prime tourism assets of the North Western Coast. The major bays are located in the Mersa Matruh area, including Bagush, Hawalah and El Abyad, and around El Sallum, Ras El Hekma and Sidi Abdel Rahman, these urbanized area were determined from image classification in the years 1984 and 2003 as shown in Figure 10.

From this point up to Alexandria the slightly curved shoreline is uninterrupted. The bays of Hawala, Bagush and Ras El Hekma compare favorably with beaches exploited for international tourism in competitive Mediterranean destinations. Historical and regional assets are found scattered over the area. Cultural heritage has primarily a traditional value.

Output maps derived from this study indicated that urban expansion in 1984 is estimated to be about 38.7 km and about 649.1 km in 2003. The average urban development rate is about 610.4 km per 19 years. Regarding smaller bays and beaches, for which the provision of access roads and development would be too costly, many investments have been carried out for development of coastal resorts. The following coastal stretches have been identified for tourism development priority: Alexandria to El Imayid, Bagush-Hawalah, Ras E1 Hekma Mersa "vlatruh, El Qasr, El Abyad, Ajiba, Sidi Abdel Rahman, Teasum remaining areas.

Hotels, mainly used for domestic tourism, are concentrated in along the Northwest coast, particularly in Mersa Matruh city. Recently many coastal resorts of international standing are constructed, such as Marina and Sidi Abdel Rahman. They are frequented by international tourists comprised of long-staying business people or embassy staff. Scattered campsites and bungalows provide lodging for domestic and regional tourists. Entertainment and night-life facilities are emerging. Transportation of larger numbers of tourists is considered, and the low to average speed makes rail transport unattractive. The road network, water supply system, and telecommunications systems are adequate and require the development of national plans. There is a need to construct new airports for civil aviation in addition to the Mersa Matruh airport. The demand for supporting facilities indicates that the area is not yet fully exploited from the point of view of coastal development for purposes such as tourism.

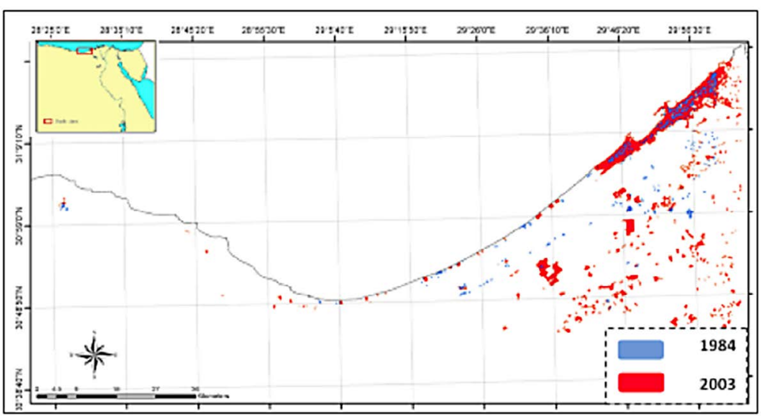

Figure 10: Urban development activities during (1984-2003) along NW coast of Egypt, Alexandria

IV- NATURAL HAZARDS

Destructive natural system events that impact coastal areas can be either episodic or chronic. Together, these types of events define what is meant by natural coastal hazards. The destructive potential of such events is often made much worse by the increasing amount of development along the nation's coastline.

A variety of natural hazards regularly threaten the North Western coast inhabitants. Severe natural system events are particularly harsh on coastal areas, often resulting in damages from sea level rise, flash floods, faults, tsunami, earthquakes and shoreline erosion.

V- COASTAL INSTABILITY

The coastal erosion/accretion phenomenon has significantly affected the coastal zone of the Mediterranean coast of Egypt, and is considered a major environmental problem. Simultaneous and continuous monitoring of coastal changes is necessary for the proper assessment of impacts of these changes and to design a viable land-use and protection strategy (Frihy *et al.*, 1990).

A variety of coastal features have been considered and erosion and accretion were specifically studied. The rates of shoreline changes were determined from satellite images from 1984 and 2003 and from a bathymetry admiralty chart from 1922 to assess the long term shoreline changes in different periods. It is worthwhile to further categorize coastal morphology in order to bring about a better understanding of the significant factors affecting coastal morphology. This has led to the development of coastal classification schemes. Coastal morphology reflects the complex imprint of the tectonic setting, modified by the combined actions of more local agents and processes. The resulting classifications have included purely descriptive schemes, as well as systems that relate to physical processes important to the morphology.

Nearshore gradient may influence coastal development on both local and regional scales. Where the sea-floor declines gently away from the shoreline, much of the energy of the approaching waves, particularly when these are large, is dissipated by friction and wave break and resultant erosion is diminished. On the other hand, a steep offshore gradient allows far more powerful wave attack, except in the case of plunging cliffs where reflection rather breaking of waves may result.

Geological structure including the coastal rock-type is arguably the most important single factor determinant for both the coastal outline in general and the detailed configuration of individual bays and headlands.

The development areas can be divided into three main groups: beaches, which are formed by breaking waves; sand-dunes, which are the result of wind transportation and deposition; and salt-marshes, produced by the settling out of fine mud held in suspension. Of these, the first is the most important, because beaches are ubiquitous, while dunes and marshes are more local in occurrence. In addition, beaches comprise a great variety of secondary forms (sand and shingle spits, bars, tombolos, cuspate forelands and so on). Figure 11 shows historical shoreline changes along the North Western Coast, Egypt.

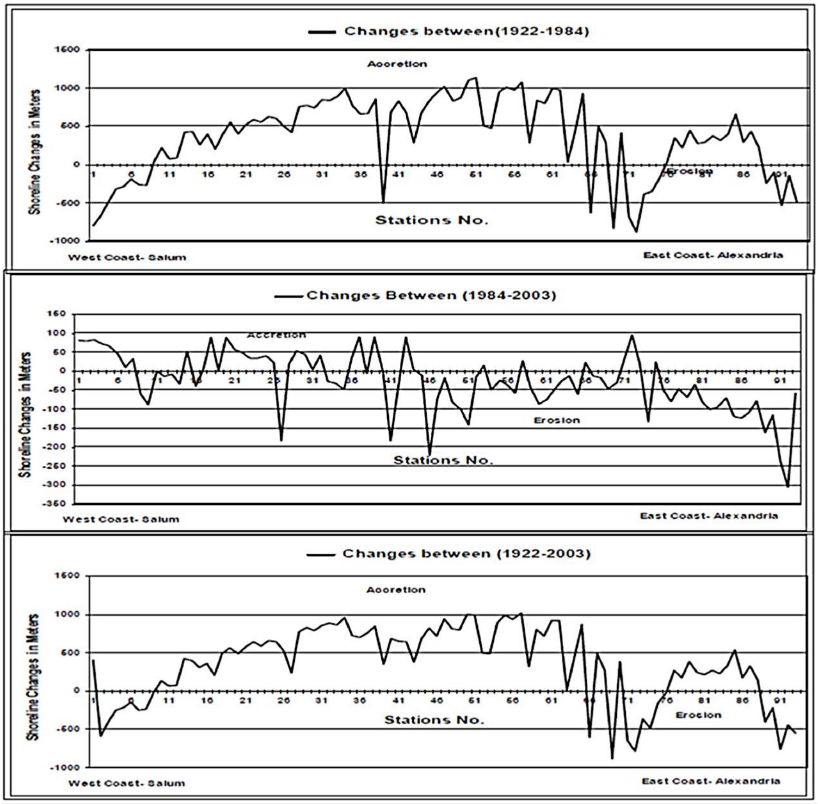

Figure 11: Historical shoreline changes along the North Western Coast, Egypt.

VI- FLOOD HAZARDS

The relief features of the North Western coastal area can exert some measure of control over coastal forms (El-Sabrouti *et al.*, 1981). For example, where the sea is eroding an upland dissected by valleys running at right angles to the coast, the resultant cliffs will be high and imposing at the terminations of interfluves and low or non-existent at the mouths of valleys. Once cliffs of various heights have been formed, rates of recession should – at least in theory – be directly affected. Other things being equal, a high cliff will retreat more slowly than a low cliff, simply because for a given amount of recession to be affected, a greater volume of debris must be removed by the waves at the foot of the high cliff. The outcome should be an embayed coastline, with bays coincident with valley mouths and headlands with interfluves. The tendency may be accentuated by the effects of stream erosion, which can materially assist in the excavation of the bays at valley mouths, and by the geological structure of the valleys which may themselves follow lines of weakness that can also be utilized by wave erosion. Figure 12 shows the flash flood distribution along the North Western Coast of Egypt.

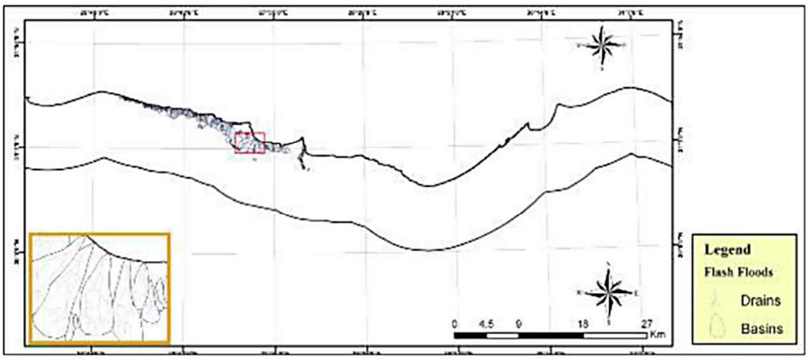

Figure 12: Flash flood distribution along the North Western Coast of Egypt

VII- SEA LEVEL RISE

All predictions involve an acceleration of sea level rise compared with the rate experienced during the last century. Peters and Darling (1985) attempted to first project the extent of greenhouse warming into the future, and then based on that prediction, estimated that sea level rises of 50 – 340 cm could be expected by the year 2100, equivalent to average rates of 5 – 30 mm/year. These are the greatest rates that have been predicted by the various studies and are large since they include the partial melting of the West Antarctic ice sheet. The IPPC Third Assessment Report estimated sea level rise of 25 – 88 cm over the next century. Taking into consideration land subsidence in the coastal zone, it is estimated that a 50 cm sea level rise should be taken into consideration for 50 year planning (McCarthy *et al.*, 2001).

The recent estimates by Van der Veen (2002) are lower, 2.8 – 6.6 mm/year by 2085 AD, rates that are still about 2 – 4 times greater than the 1 – 2 mm/year rise that has prevailed during the past 100 years.

Changes in sea level, whether of a eustatic nature, induced by isostatic depression and recovery of the earth's crust, or resulting from orogenic movements, are a vital factor – perhaps on a par with geological structure – in coastal geomorphology.

Relative rises often tend to exaggerate the intended character of a particular coastline, through the production of islands, though it must be noted that islands are not only the result of sea level rise, but can be the outcome of differential erosion and also coastal deposition. The formation of sea-cliffs and fringing platforms must begin again when the sea level rises substantially, and this will be a comparatively slow process within sheltered localities.

VIII- TECTONICS AND SEISMOLOGY

Figures 13 and 14 show the main faults and seismic data along the coastal zone. The earthquake centers recorded low and medium magnitudes over the study area. The determination of two main important hazards over the study area aims to represent the effect of the earthquakes and main faults on the development activities and future North Western planning projects.

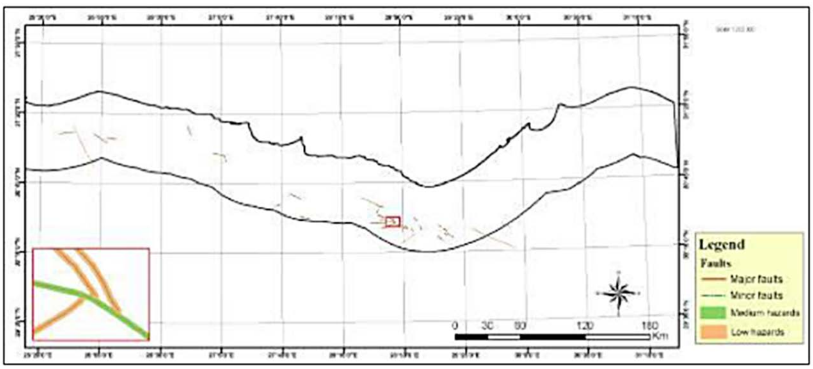

Figure 13: Major and minor faults with 50 Km buffer zone along the North Western Coast of Egypt.

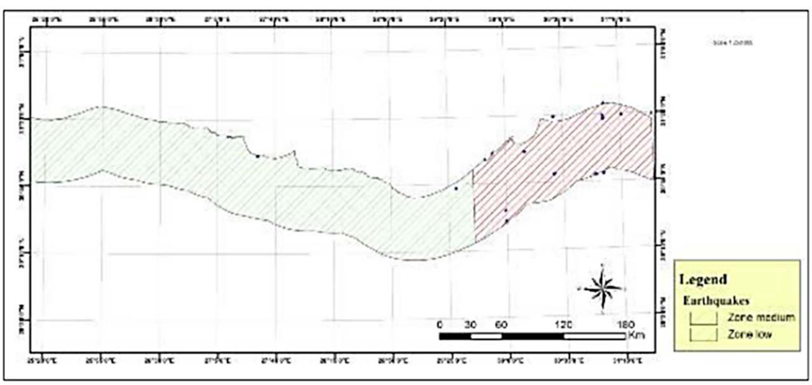

Figure 14: Distribution of seismic data of the last century along the North Western Coast of Egypt.

IX- TSUNAMI

The North Western Mediterranean Sea coasts are often subjected to the effects of tsunamis caused by earthquakes affecting the sea bed (Shuto, 1997).

Landslides may occur and create tsunamis observed along the Middle East coasts. Models of wave generation by such landslides have been calculated by Miloh and Striem (1978) offshore the Palestine coast. The wave height may reach 10 m near the source. The return period for potential tsunami generating earthquakes in this region was estimated at 350 years by Poirier and Taher (1980), with the last occurance in 1822. One observation with the intensity II at Alexandria was reported for a tsunami from the Syrian and Palestine coast (Sofratome, 1984).

The frequency of tsunamis is very rare in the Levantine Basin and along the Egyptian coasts (Ambraseys and Synolakis, 2010). Local information is not sufficient for estimating the probability distribution of maximum intensity characteristics; use of other data must be included, such as information from the entire Mediterranean Sea. The above described correlations allowed us to estimate the maximum probable height along the Egyptian coast ranging from 4 – 8 m with the return period of 200 to 250 years.

4. Natural Hazards and Development Issues

Coastal hazard events can significantly affect or even alter the natural environment, but their impacts are generally not considered to be "disastrous" unless they involve damage to human populations and infrastructure. The North Western coastal ecosystems that are particularly fragile and sensitive to the cumulative impacts of human development are also naturally fluid and generally capable of adapting to hazard impacts over time. When people and property are not present along some areas, hazards are merely natural processes that alter the environment as they have throughout the earth's history. When people and property are present, however, the impacts of hazards on the developed and natural environments are viewed quite differently (El-Raey *et al.*, 1997).

The primary focus is no longer on the natural processes associated with a major hazard event, but instead, on the disastrous results that can be measured by lost lives, property damage, and economic and environmental impacts. Hazard impacts on the natural environment become more devastating because human development has altered the ability of natural systems to recover from such events. Natural hazard events can also spawn secondary hazards such as sewage releases or hazardous materials spills that are particularly damaging to coastal environments.

The impacts of natural hazards are becoming increasingly costly and devastating. Results of this study has demonstrated that losses caused by disasters continue to rise worldwide due to a combination of factors that include a rise in the number of hazard events due to global climate change or natural cyclical trends, and an increase in human exposure in hazardous locations. Some of the increase in disaster damages worldwide could also be the result of improvements in disaster monitoring and reporting capabilities, particularly in developing cities. Disaster losses along the North Western Coast are currently estimated conservatively. Figure 15 presents the natural hazards and development activities along the North Western Coast of Egypt.

Natural hazards affecting coastal resorts and cities were sometimes devastating, but there were fewer locations to potentially be affected. As coastal populations have increased, cities have become larger and more numerous. With the growth of coastal resorts, it is no longer necessary to rely exclusively on ports and industry to fuel economic growth in even the most remote coastal areas. There are now many more coastal locations with significant populations and property resources exposed to potentially devastating impacts from natural hazards (Frihy *et al.*, 1994).

Destructive and costly ongoing flooding, faults and erosion along the North Western coast associated with higher than average levels and coastal storms have also occurred. The impacts of these large-scale events are having a profound effect on planning policy and perceptions concerning hazards.

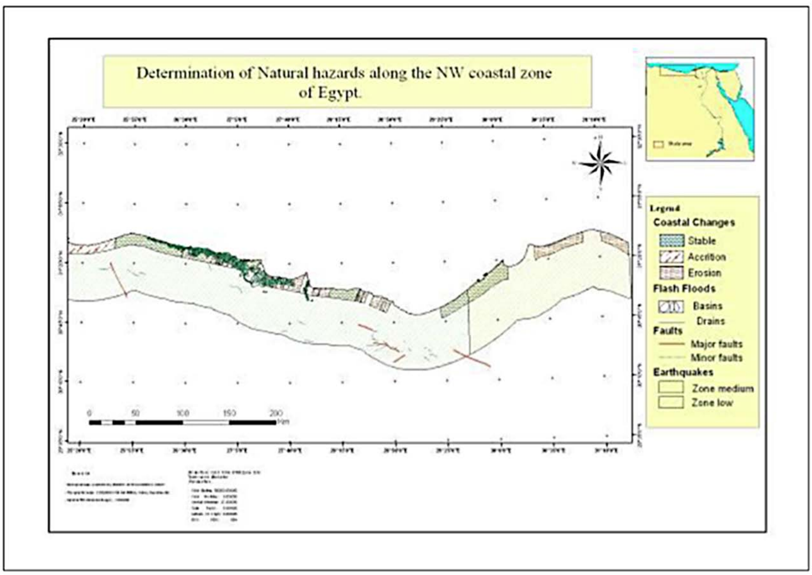

Figure 15: Natural hazards and development activities along the North Western Coast of Egypt.

5. Conclusions

There are too many demands on a community to logically and systematically establish a hazard mitigation strategy and implement mitigation activities in the immediate aftermath of a disaster. It is critical that national communities consider and plan these strategies and opportunities in their coastal planning processes. There is currently no national policy on pre-event planning for post-disaster recovery and reconstruction. Many of the most important opportunities for reducing future hazard vulnerability are lost in the early recovery process when communities rush to return to normal activities.

Considerations should be made when implementing hazard mitigation policies and initiatives in a post-disaster environment. These considerations need to be examined and weighed carefully in the coastal planning process. The technical capabilities have to be improved to predict events for coastal hazards. Moreover, improvements in monitoring, data collection, and data processing account for most of the advancements made in short-term weather-related forecasting. Better modeling capabilities, along with a more thorough understanding of variables affecting the coastal environments, such as global climate change and sea-level rise, are needed to improve long-range forecasting and planning for coastal hazard impacts.

Studying coastal issues and strategies provides a general overview of the management topics associated with efforts to minimize the impacts of natural coastal hazards. To improve these management strategies and make additional progress in all phases of disaster and hazard management, it is necessary to acknowledge the scientific and technological information requirements throughout the various hazard-related disciplines.

In this paper, significant progress has been made in the assessment of coastal development associated with natural hazards, improvements in technology used and understanding of hazards, how to mitigate them, and how to continue reducing our impact. More technological information is still needed about the interactions between hazard events such as coastal changes, and ongoing coastal processes, such as erosion, to predict future hazard impacts.

Glossary

alluvian pan: sediments deposited in a pan shape by water as it flows on to a plain or flat open valley (http://agriculture.science-dictionary.org/Soil-Dictionary/Alluvial_Pan_or_Alluvial_Cone)

atoll: a coral reef or string of coral islands that surrounds a lagoon (http://education.nationalgeographic.com/education/encyclopedia/atoll/?ar_a=1) *wadi*: the bed or valley of a stream in regions of southwestern Asia or northern Africa that is usually dry except during the rainy season and that often forms an oasis (http://www.merriam-webster.com/dictionary/wadi)

yermosols: aridic soils (http://cals.arizona.edu/oals/soils/fao.html)

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PAPER 9

Climate Change Impacts on Future Plan for Restoration of Lake Maryut, Alexandria, Egypt

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Abstract: Wetlands are some of Egypt's most important habitats in terms of biodiversity; supporting both the greatest diversity and density of bird species. Also wetlands store carbon within their plant communities and soil instead of releasing it to the atmosphere as carbon dioxide. Thus wetlands help to moderate global climate. Of the Mediterranean coastal wetlands, the most important are the six major coastal lagoons on the Mediterranean: Bardawil, Malaha, Manzala, Burullus, Idku and Maryut Lake. Maryut is an extended lake located parallel to the shoreline to the south of Alexandria City in an extended valley known as Maryut valley. The lake area used to be 250 km^2 and average depth of 90-150 cm, however, it has been continuously and gradually shrinking in area by illegal land fillings. The lake receives most of its water from agricultural drains. Primary treated wastewater has been dumped in the lake from both the eastern and western wastewater treatment plants. The lake also still receives waste water from a number of large industries in spite of the continued efforts of Environmental authorities to reduce industrial waste. These wastes have rendered Lake Maryut highly polluted and eutrophic. Climate change leads to changes in air temperature and precipitation which have direct effects on the physical, chemical, and biological characteristics of lakes. The increasing accumulation of greenhouse gases in the atmosphere as a result of human activities has begun to affect the structure, function, and stability of lake ecosystems throughout the world, and much greater impacts are likely in the future. This study aimed at preparing an integrated plan for restoration of Lake Maryut which will improve biodiversity conservation in the lake ecosystem.

Keywords: climate change, wetland restoration, Lake Maryut, biodiversity, adaptation, integrated plan

1. Introduction

Based on a variety of evidence, most scientists believe that human activities, which have increased atmospheric concentrations of carbon dioxide (CO_2) by 35% from preindustrial values of 280 parts per million (ppm) to 378 ppm over the past 150 years, are leading to an increase in global average temperatures (Dukes, 2000). Global temperatures have already risen 0.6°C (0.9°F) in the last 100 years and, according to model projections, might rise anywhere from as little as 1.8°C to as much as 7.1°C (2.7°F to 10.7°F) over the next 100 years (Sestini, 1992; IPCC, 1998).

Enormous progress has been made in increasing our understanding of climate change, and a clearer picture of current and future impacts is emerging. Research is also shedding light on actions that might be taken to limit the magnitude of climate change and adapt to its impacts (National Research Council, 2012).

Wetland water systems are very vulnerable to climate change. Changes in wetland quantity and quality of water provision through alterations in hydrological regimes will definitely affect habitat. Restoration processes will need to be realized differently on a regional level, making it important to recognize that specific restoration and management plans are required for each case (Erwin, 2009).

An integrated plan for the restoration of Lake Maryut, as one of the most important wetland in Alexandria- Egypt, will be discussed in this paper.

2. Wetlands and Global Climate Change

Wetlands are areas where water covers the soil, or is present either at or near the surface all year or at least for substantial parts of the year (Cowardin *et al.*, 1979). Wetlands are an important link between the land and water and are as productive as rain forests and coral reef ecosystems. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species (WSU, 2008). Generally, the prolonged presence of water creates conditions favoring specially adapted plants such as hydrophytes (EPA, 2012).

Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, existing vegetation, and other factors, especially human disturbance (WSU, 2008). According to the International Panel on Climate Change (IPCC) and other researchers, wetlands cover 6% of the world's land surface and contain about 12% of the global carbon pool. Due to this fact, wetlands are playing an important role in the global carbon cycle (Ferrati *et al.*, 2005, IPCC, 1998, Sahagian and Melack, 1998). In a world of global climate change, wetlands are considered one of the biggest unknowns of the near future in terms of element dynamics and matter fluxes (Paul *et al.*, 2006, IPCC, 2001).

Pressures on wetlands are likely to be mediated through changes in hydrology, direct and indirect effects of changes in temperatures, as well as land use change (Ferrati *et al.*, 2005). Examples of impacts resulting from projected changes in extreme climate events (STRP Ramsar, 2002) include: change in base flows; altered hydrology; increased heat stress in wildlife; extended range and activity of some pest and disease vectors; increased flooding, landslide, and mudslide damage; increased soil erosion; increased flood runoff resulting in a decrease in recharge of some floodplain aquifers; decreased water resource quantity and quality; increased risk of fires; and increased coastal erosion and damage to coastal buildings and infrastructure (Root *et al.*, 2003).

Climate change can be expected to act in conjunction with a range of other pressures, many of which, depending on the region, may pose far greater immediate concern for wetlands and their water resources in the short to medium term (STRP Ramsar, 2002). Wetland systems are very sensitive and particularly susceptible to changes in quantity and quality of water supply due to climate change. These changes may be noticed through alterations in hydrological regimes specifically, the nature and variability of the hydroperiod and the number and severity of extreme events (Erwin, 2009). However, other variables related to climate may play important roles in determining regional and local impacts, including increased temperature and altered evapotranspiration, altered biogeochemistry, altered amounts and patterns of suspended sediment loadings, fire, oxidation of organic sediments and the physical effects of wave energy (IPCC, 1998; Burkett and Kusler, 2000; USGCRP, 2000).

An important management strategy to ensure wetland sustainability is the prevention or reduction of additional stress that can reduce the ability of wetlands to respond to climate change. Maintaining hydrology, reducing pollution, controlling vegetation, and protecting wetland biological diversity and integrity are important activities to maintain and improve the resiliency of wetland ecosystems so that they continue to provide important services under changed climatic conditions (Kusler *et al.*, 1999; Ferrati *et al.*, 2005).

In Egypt, Lake Maryut is considered one of the main coastal wetlands that need to be restored and maintained as one of the most vulnerable ecosystems to the climate change.

3. Lake Maryut

Lake Maryut extends along the Mediterranean coast and represents the southern borders of Alexandria City. It lies between latitude 30.07°N to the north and longitude 29.57°E to the east along the Mediterranean covering an area of 65 km^2. The lake area used to be 250 km^2 and average depth of 90-150 cm, however, it has been continuously and gradually shrinking in area by illegal land fillings. The lake receives most of its water from agricultural drains. Primary treated wastewater has been dumped in the lake from both the eastern and western wastewater treatment plants (ETP, WTP). The Lake also still receives wastewater from a number of large industries. These wastes have rendered Lake Maryut highly polluted and eutrophic (ALAMIM, 2009).

The lake is divided into five basins (Figure 1), which are somewhat interconnected to each other by several breaches in the dykes of El-Umoum Drain and Nubaria Canal.

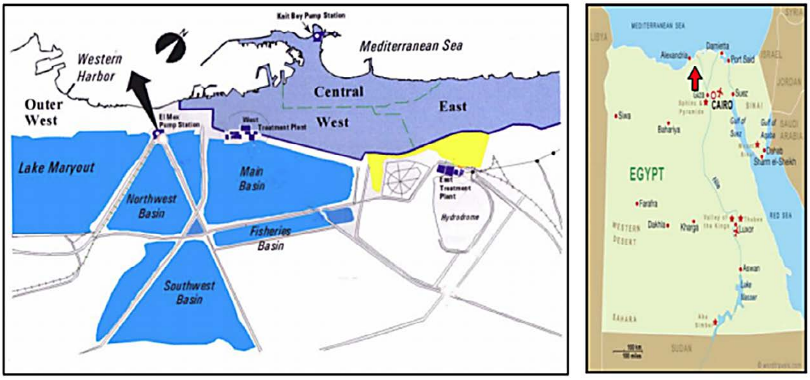

Figure 1: Lake Maryut and its basins

Since 1892 the lake has been fed by drainage canals. In order to keep the lake at level -3m, excess water is pumped into the sea by Al-Maxx Pumping Station, created for this purpose. It can be considered that currently Lake Maryut is partly a creation of Nile drainage.

Lake Maryut was formerly one of the major lakes in northern Egypt with vast biodiversity serving as a vital source of fish and salt production for the? Maryut valley and providing a high aesthetic value (Source?).

Until the 1980s, most of Alexandria's domestic sewage and much of the industrial wastewater was discharged directly into the Mediterranean Sea through a number of outfalls along the coast of Alexandria. Pollution of beaches and inshore waters resulted in severe impacts to Alexandria, and to its attraction as a summer resort. As a result, local authorities decided to divert these discharges into Lake Maryut's Main Basin. At that time, the discharge consisted of raw sewage without any treatment, mixed with industrial effluents. The lake's main basin became highly eutrophic and polluted with various chemicals. In addition to the problem of organic inputs, there were many hazardous discharges. Subsequently, two primary treatment plants were built and began operation in the 1990s. Sewage water passes through screens, sedimentation tanks and a dewatering facility to remove the sludge. However, some untreated wastewater is dumped directly into the Lake (El-Rayis *et al.*, 1994; Gamal El-din *et al.*, 1995).

Lake Maryut basins are recharged with agricultural drainage water via a number of drains, the most important of which include the Omom Drain, Nubaryia Drain, West Nubaryia Drain and Al-Qalaa Drain. These drains carry agricultural drainage water resulting from the irrigation of an area of 450,000 feddans of cultivated lands located south of Alexandria which contain high concentrations of various chemical fertilizers and pesticides, as well as sanitary and industrial water drainage as shown in Table 1 (Gaballah *et al.*, 2005; ALAMIM, 2009).

Table 1: Volume and nature of water flowing into Lake Maryut from different drains

Drain Name	Water Type	Volume m3/d (yearly average)
Public Drain	Agricultural Drainage	6 million
West Nubaryia Drain	Agricultural Drainage	1.54 Million
Al-Qalaa Drain	Sanitary, industrial and agricultural drainage	750,000 (450.000 preliminary treated sanitary drainage)
Al-Qabbary Drain	Sanitary and industrial Drainage	350,000 preliminary treated sanitary drainage
Other Drains	Untreated industrial and sanitary drainage	460,000

Lake Maryut's environmental problems of can be summarized as follows: 1) severe decrease in the concentration of dissolved oxygen in some parts of the main basin of the Lake and in the Al-Qalaa Drain due to the high increase of the organic load leading to the prevalence of non-aerobic conditions which are detrimental to the fish resources, as well as the emission of hydrogen sulphide gas of a terrible odor; 2) an increase in the density of water plant growth (green canopy) such as reeds that impede water current movement, leading to a decrease in the oxygen dissolving rates in the lake water and associated consumption. In addition, the high density of plant growth has led to the disappearance of the water body turning it gradually into land; 3) presence of organic pollutants including agricultural pesticides and industrial wastes, and inorganic pollutants, such as heavy components, in high concentrations at some parts of the lake and drains, whether in the water itself or the precipitations found in the Lake. The northeastern basin (main basin of about 5,000 feddans) is the most polluted basin particularly its eastern part; 4) unpleasant odor at the entrance of Alexandria City leaving a bad impression for visitors and adversely affecting tourism and investment in the area; 5) expected direct impact on ecosystems and biodiversity.

Pollutant load has been estimated at 122.6 tons/day for sanitary drainage, 180 tons/day from industrial sources, and up to 6 million m^3/day of agricultural wastewater. All these inputs introduce huge amounts of inorganic and organic toxic substances, from different forms of nitrogen, phosphorus, heavy metals, pesticides, and pathogens into the lake (ALAMIM, 2009).

4. Water Ecosystem in Lake Maryut

Currently Lake Maryut plays four main roles: 1) to store water from the surrounding basin, Nile and its channels network and regulate underground and surface water system in the west delta (it is currently managed through El Maxx pumping station); 2) to be the main depuration system of the industrial, agricultural and domestic waste waters from Alexandria and surroundings; 3) to facilitate drainage of the agriculture irrigation system; 4) to connect the Nile channels network with the sea through the Nubariaa navigation Channel; 5) to produce fish and plants; and 6) to provide a lagoon territory for human activities (urban development, industries, services, equipment, etc.). The four first roles determine the quality and quantity of waters entering to the lake, and also the water quality outflow to the Mediterranean Sea. The average chemical parameters and water characteristics of Lake Maryut are shown in Table 2.

The organic matter content of the lake was generally high with an annual average equivalent to 22.5 mg O_2/l, varying between 6.5 and 80.0 mg O_2/l. A large amount of the organic matter content was added to the body of the lake through sewage outfalls. The highest values were recorded in the polluted basin (the average is equivalent to 37.0 mg O_2/l). The lowest values were recorded in Omoum Drain (the average is equivalent to 12.9 mg O_2/l). The maximum values coincided with the decomposition of sewage sludge in the summer (the average is equivalent to 27.7 mg O_2/l). Minimum values, on the other hand, occurred in the winter with a mean equivalent to 20.4 mg O_2/l for the whole lake (Hassouna, 2008).

Recent results show values of dissolved oxygen ranging from 0.0 mg/l to 6.9 mg/l. The lowest values are found in the main basin and also Quala and Moheet drains in particular. This is mainly because those drains carry heavy organic loads of the untreated sewage water in addition to the numerous adjacent animal farms directly discharging their untreated effluent to these drains (Hassouna, 2008).

Dissolved ammonia occurs generally in the lake in high concentrations; the annual average of ammonia was reported to be 3.17 mg N/l, varying between 0.05 mg N/l to 12.70 mg N/l. Most of the ammonia content of the lake is a result of the decomposition of sewage and industrial wastes reaching the lake. The ammonia content of the surface water (average value of 3.07 mg N/l) was lower than that of the bottom (average value of 3.26 mg N/l). The Omoum Drain was significantly poor in ammonia and the unpolluted basin also had lower values. On the other hand, higher values occurred in the northern and southern parts in front of the sewage outfalls and the Qalaa Drain. The ammonia content reached its maximum during the autumn with an average of 4.76 mg (Hassouna, 2008).

Table 2: Water quality parameters of Lake Maryut (Source: EEAA 2008) EEAA Stations

EEAA STATIONS		DO (MG/L)	DO %	BOD	COD	NH3-N (MG/L)	NO2-N (MG/L)	NO3-N (MG/L)	TOTALN (MGN/L)	PO4-P (MG/L)
MAIN BASIN 6000 IN FRONT OF QALAA DRAIN	2004	3.8	43.7	38.0	110.0			3.6	3.6	
	2005	2.0	22.5	30.0	98.0	12.6	0.8	1.2	14.2	5.1
	2006	2.6	29.2	40.0	137.0	21.0		1.8	22.8	4.5
	2007					20.0	0.1	1.3	21.4	4.8
	2008	1.0			133.0	27.8		1.5	29.3	
	AVERAGE	**2.4**	**31.8**	**36.0**	**119.5**	**20.3**	**0.4**	**1.9**	**18.2**	**4.8**
MIDDLE OF 5000 (SOUTH BASIN)	2004	7.2	83.5	2.0	11.8	0.3	0.2	4.0	4.3	0.5
	2005	6.7	76.9	1.0	29.3	0.3	0.2	2.2	2.7	0.8
	2006	7.4	82.5	4.3	34.8	0.6	0.1	1.9	2.1	0.4
	2007					0.1	0.3	1.0	1.2	0.7
	2008	9.2		2.0	55.0	0.4	0.0	2.9	3.3	
	AVERAGE	**7.6**	**81.0**	**2.3**	**32.7**	**0.3**	**0.2**	**2.4**	**2.7**	**0.6**
MIDDLE OF 2000 BASIN	2004	5.4	63.8	6.0	99.0	0.8	0.2	5.5	5.9	3.8
	2005	7.3	84.9	2.0	49.7	0.4	0.3	2.6	2.4	0.3
	2006	6.7	73.9	4.3	84.5	0.3	0.1	2.4	2.1	0.8
	2007					0.1	0.1	0.9	1.1	1.2
	2008	7.9		5.0	81.5	0.4	0.1	1.9	2.4	
	AVERAGE	**6.8**	**74.2**	**4.3**	**78.7**	**0.4**	**0.2**	**2.7**	**2.8**	**1.6**
MIDDLE OF MAIN BASIN	2004	4.5	52.3	21.0	97.0			1.2	1.2	
	2005	3.3	36.3	44.0	99.0	6.8	0.1	1.0	7.9	4.2
	2006	3.4	38.3	29.7	136.7	15.6	0.1	4.9	18.8	3.0
	2007					9.0	0.1	3.9	13.0	4.7
	2008	7.5			67.0	16.5		0.2	16.7	
	AVERAGE	**4.7**	**42.3**	**31.6**	**99.9**	**12.0**	**0.1**	**2.2**	**11.5**	**4.0**

The annual average concentration of nitrite in the lake was 0.025 mg N/l, varying between nil and 0.490 mg N/l. The difference between surface and bottom concentrations was, on the whole, not significant. The main basin had the highest values (averaging 0.043 mg N/l) especially in its middle parts. On the other hand, lower values were recorded in Qalaa Drain due to the very low oxygen content of the drain water (Hassouna, 2008).

Phosphorus is usually higher in winter than in spring and autumn due to the decreased consumption of the element by phytoplankton. Mixed agricultural drainage water and discharge from sewage treatment plants have been identified as important sources of increased P loading. High concentrations of dissolved inorganic phosphorus (DIP) in the lake water, Qalaa and WTP outfall represented more than 53% of the Total Phosphorous (TP). The level of DIP in the main basin was reported to be at least 70 times higher than that in the neighbouring less contaminated basins. Reactive phosphate was found in Lake Maryut in larger amounts when compared to the other lakes in Egypt.

The annual average value is about 31.98 μg phosphate/l varying between nil and 160.0 μg phosphate /l. The average concentration of reactive phosphate in the surface (31.58 μg phosphate/l) was lower than that of the bottom (32.38 μg phosphate/l). Maximum values were recorded in the winter (average value of the whole lake was 39.86 μg phosphate/l). The winter maximum was attributed to the effect of sewage and industrial wastes and the low rate of mineralization due to less bacterial activity concomitant to little consumption of phosphate by plankton. Phosphorus load in Lake Maryut was estimated to be 15.6 mg P/l/year (Hassouna, 2008).

In the last four decades, the occurrence of metal contaminants in Lake Maryut has become a problem of increasing concern (ALAMIM, 2009). This situation has arisen as a result of rapid population growth and associated increase in human activities. Heavy metals may accumulate unnoticed in the aquatic environment to toxic levels. They are partitioned among the various aquatic compartments and may occur in dissolved, particulate and complex forms. The main processes governing their distribution and partition are dilution, dispersion, sedimentation and adsorption/desorption. Some heavy metals, such as Zn, Cu, Mn, and Fe, are essential for aquatic organisms, but show toxic effects when organisms are exposed to higher abnormal concentrations. Other heavy metals such as Pb, Hg, and Cd are not essential for metabolic activities and exhibit toxic properties. Heavy metals and pesticides in the Delta lakes, particularly in Lake Maryut were studied more recently than other chemical parameters. The compartments water, sediments and fish have been investigated. The occurrence and distribution of heavy metals in the heavily polluted Lake Maryut and their accumulation in the different parts of its common fish (Tilapia species) were investigated from 1978 to 1979 (El-Sharkawi *et al.,* 1999).

The variations in concentrations of metals in the lake water were mainly attributed to variations in the discharge rates of the dumped wastes. The levels of Zn, Cu, Fe, and Mn did not exceed the safe concentrations for drinking water. Cu, for instance, was below 0.2 mg/l throughout the lake. Also, chromium, presented an average value of 0.05 mg/l, which is an order of magnitude below the dangerous level (Mateo, 2009).

The most serious concern from heavy metals in Lake Maryut comes from lead. It is present in high concentrations throughout the lake, ranging from 0.7 mg/l to 4.6 mg/l, with an average value of 3.3 mg/l. This means that lead levels exceed recommended levels for drinking water by more than 200 times, in respect to EPA's directives. Lead can cause serious damage to the brain, kidneys, nervous system, and red blood cells. Lead levels, however, are not dangerous for irrigation water or fish growth (this does not mean that the fish grown in these waters is adequate for human consumption) (ALAMIM, 2009).

Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation. A concentration of 111 mg/kg and 63 mg/kg of copper in the meat of fish and crabs growing in the main basin, respectively, were obtained during WADY project (Mateo, 2009).

The bacterial population from Lake Maryut was dominated with enterobacteriaceae indicating the close relation with sewage disposal into the lake. Pesticides included fungicides, molluscicides, herbicides, rodenticides, nematicides and insecticides, with concentrations higher than those in the corresponding lake water and fish samples (Hassouna, 2008).

During the early 1970s, the annual fish production from Lake Maryut was about 7,000 tons per year, representing approximately 75% of the total fish catch in the Alexandria area. This has decreased to about 2,680 tons per year during the late 1990s. Moreover, there is evidence that the high pollution levels in the lake has led to high levels of metals in the fish, which are still being fished and sold in the market, creating a potential health hazard. During the same period, the number of fishing boats and fishermen decreased by about one-third, with the remaining fishermen having a much-reduced income. Moreover, the importance of the Lake for birds has diminished greatly over the past two to three decades, due to habitat loss, ecological changes, increased disturbance and hunting pressures.

Several projects (see Table 3) have been implemented to improve the environmental conditions of the Lake and to halt its deterioration (ALAMIM, 2009). Challenges facing the development of Lake Maryut can be described as follows:

- The absence of the owner of the lake.
- The weak financial, technical and administrative capacities for managing this zone.
- The lake has been considered for a long time as the hinterland of the city; hence all kinds of wastes are dumped into it with no protection whatsoever.
- All past efforts exerted by academic or scientific entities have focused mainly on the diagnosis of the problems with a few feasible solutions.
- The conflict of interests among stakeholders.
- The absence of a strategic policy for the utilization of the lake as a substantial natural resource.
- The prevalence of a state of despair due to the long-term deterioration of the lake, hence resulting in a lack of positive steps being taken.

Despite the evident fact that preserving Lake Maryut and its Valley achieves a natural environmental equilibrium for the north west area of the Delta, stakeholders have not yet agreed on the best scenario for developing this area. Thus they are divided into two groups; the first group believes in the necessity of drying up the Lake, while the second group calls for the immediate halt of all drying processes and restoration of the water body, moving towards the integrated and comprehensive development of the area.

5. ALAMIM Project

ALAMIM, the Alexandria Lake Maryut Integrated Management project, is focused on the sustainable development of the Coastal Zone of Alexandria. It plans to achieve this by promoting the adoption of a development action plan that addresses the needs and interest of all stakeholders while protecting the environment and economic development of the Coastal Zone. ALAMIM involved stakeholders, including the Alexandria Governorate, the Regional Bureau of the Egyptian Environmental Affairs Agency (EEAA), relevant local and national authorities, industries, local communities and NGOs, private sector, investors, and visitors. Their participation was sought when developing an integrated action plan for the Lake zone; establishing and implementing Lake Maryut Management and Monitoring units at Alexandria Governorate and the regional bureau of EEAA; and, developing creating capacity building activities and public awareness programs for local and provincial authorities and stakeholders

The ALAMIM project has defined "the Action" as their overall objective "to assist in the preparation of the integrated action plan (IAP) for the development of the LM zone in Alexandria involving all stakeholders, and in the promotion and adoption of Integrated Coastal Zone Management ICZM approaches through establishing effective and well equipped institutional structures for the integrated management and monitoring of this zone". In this sense the IAP can be considered as the central and final result of the ALAMIM project.

After the participation and debate process developed during the years 2006, 2007, 2008 and 2009, the IAP of the ALAMIM project has defined a list of actions to reach the IAP scenario. The main points of this list were summarized as follows:

1. To connect all the waste water discharges in the lake or in the drains with the sanitary system.
2. To dredge sediments from final part of the Qalaa drain zones and its outfall area into the main basin, using a new direct connection of the Qalaa with the basin.
3. To connect the Oumum drain with the east part of the main basin in order to reduce the impact of Qalaa discharge.
4. Reinforce aquatic vegetation management to reduce pollution (especially in the Qalaa drain outfall).
5. To connect directly WTP and ETP outfall with El Maxx pumping station, after secondary treatment made.

6. To study the feasibility of the reuse of treated wastewater for agriculture compatible uses.
7. To complete the industries' ecosystem knowledge around and related to the Lake Maryut system.
8. To build water quantity and quality mapping.
9. To prepare and implement training courses for industries regarding clean production and best practices in the main industrial sectors related to Lake Maryut.
10. To implement and support best practices in clean production in the industrial activities related to Lake Maryut.
11. To create the Lake Maryut Authority to achieve coordination between all the primary stakeholders.
12. To create the Lake Maryut Management Unity and define the function and structure of this authority.
13. To establish the Lake Maryut Monitoring System charged to control its water quality and associated causes, in coordination with the Lake Maryut Management Unit.

Table 3: List of projects and activities that are currently being implemented to halt the deterioration of the Lake objective Funding Body Project

Project	Funding Body	objective
To remove and rehabilitate the open garbage dump located on the southern border of the 1000 feddan basin	Alexandria Governorate	• Improve water quality • Increase fish productivity • Optimal use of lands on the environmental and economic levels • Improve environmental conditions
To rehabilitate the eastern part (600 feddans) of the main basin of the Lake and the 6000 feddans of shallow water and highly polluted precipitations	Alexandria Governorate	• To get rid of a pollution pit • Provide an optimal economic and environmental of this part • Achieve social and economic development and generate new work opportunities • Improve environmental conditions
Environmental Compatibility Project for industrial companies that discharge their non-treated industrial effluents directly or indirectly in the Lake.	World Bank (Soft loan to fund EPAP II	• Decrease industrial pollution and improve water quality • Improve environmental conditions
Repair, rehabilitate and operate air compressors (3 compressors x 30000 m3 air/hour for the Sanitary Drainage Company in Alexandria).	Ministry of Housing Company in Alexandria British Tim's Water Company	• Recover capital costs of compressors as well as civil and engineering works • Provide a suitable ventilation source to improve water quality of primary water treatment station in the Eastside treatment station • Train technical cadres on maintenance processes and operation of compressors

Table 3 (continued): List of projects and activities that are currently being implemented to halt the deterioration of the Lake objective Funding Body Project

Design and implement a system to upgrade primary treatment to secondary treatment in the western and eastern stations of wastewater	Ministry of Housing	• Improve of water quality • Increase the concentration of dissolved oxygen rates • Decrease the concentration of hydrogen sulfide gas • Improve environmental conditions
Design and establish secondary wastewater treatment networks and stations for residential communities east of Alexandria. Such communities were previously non-served and they used to discharge raw wastewater into drains that ultimately reach Al-Qalaa drain that disembogues into the main basin of the Lake	Ministry of Housing	• Improve water quality • Increase the concentration of dissolved oxygen rates • Decrease the concentration of hydrogen sulfide gas • Improve environmental conditions
Raising the water level of the 1000 feddan basin by 70 cm to mitigate the severity of pollution in Al-Qalaa drain before discharge into the main basin of the Lake.	Ministry of Water Resources and Irrigation and (Alexandria Governorate	• Improve of water quality • Increase the concentration of dissolved oxygen rates • Increase fish production
Cleaning Al-Qalaa discharge drain, building bridges, installing inner and outer protection and establishing weirs	Ministry of Water Resources and Irrigation	• Increase water speed • Water self-cleaning • Increase the concentration of dissolved oxygen rates • Decrease the concentration of hydrogen sulfide • Improve environmental conditions
Raising water level of Om Durman Basin, 2000 Feddans 70 cm of fresh water.	Ministry of Agriculture	• Increase the area of fish production basins • Improve water quality • Increase the concentration of dissolved oxygen rates • Increase fish production
Additional recharge of the 5000 feddans	Ministry of Water Resources and Irrigation	• Improve of water quality • Increase the concentration of dissolved oxygen rates • Increase fish production
Decreasing the green canopy.	Ministry of Agriculture	• Halt the shrinkage of the Lake water body • Improve of water quality • Increase the dissolved oxygen • Increase fish production • Improve environmental conditions

The strong coordination between the different public administrative bodies and stakeholders is a key aspect of successful integrated governance system. Normally, each administration has their own competences and responsibilities, but in the management of lakes or coastal systems there are many competences and processes. For this reason, it is very important to coordinate forms and unify processes in order to establish the authority in charge of coordinating all the public administrative bodies so as to produce and execute integrated decisions. Creating the Lake Maryut Authority should be the first step towards the restoration and rehabilitation of the Lake.

The Egyptian revolution in January 2011 affected the implementation of the above mentioned recommendations, however, activating the integrated action plan will be very important to adapt and minimize the climate change impacts on the lake and Alexandria region as well.

Glossary

Enterobacteriaceae: a large family of bacteria including pathogens such as *Salmonella* and *Escherichia coli* (http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Enterobacteriaceae.html)

evapotranspiration: loss of water from the soil both by evaporation and by transpiration from plants growing thereon (http://www.merriam-webster.com/dictionary/evapotranspiration)

feddan: an Egyptian unit of area equal to 1.038 acres (http://www.merriam-webster.com/dictionary/feddan)

hydroperiod: the period in which a soil area is waterlogged (http://www.merriam-webster.com/dictionary/hydroperiod)

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Chapter Two

Biodiversity

PAPER
10

Implications of Human Induced Changes on the Distribution of Important Plant Species in the Northwestern Coastal Desert of Egypt

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Abstract: The application of species distribution modeling in deserts is a useful tool for mapping species and assessing the impact of human induced changes on individual species. Such applications are still rare, and this may be attributed to the fact that much of the arid lands and deserts around the world are located in inaccessible areas. The current study is the first to conduct spatially explicit modelling of plant species distribution in Egypt. The random forest modeling approach was applied to climatic and land-surface parameters to predict the distribution of selected important plant species in an arid landscape in the northwestern coastal desert of Egypt. The impact of changes in land use and climate on the distribution of the plant species was assessed. The results indicate that the changes in land use in the area over the last 23 years have resulted in habitat loss for all the modeled species. Projected future changes in land use reveals that all the modeled species will continue to suffer habitat loss. The projected impact of modeled climate scenarios (A1B, A2A and B2A) on the distribution of the modeled species by 2040 varied. Some of the species were projected to be adversely affected by the changes in climate, while other species are expected to benefit from these changes. The combined impact of the changes in land use and climate pose serious threats to most of the modeled species. The study found that all the species are expected to suffer loss in habitat, except Gymnocarpos decanderus. The study highlights the importance of assessing the impact of land use/climate change scenarios on other species of restricted distribution in the area and can help shape policy and mitigation efforts to protect and preserve biodiversity in desert of Egypt.

Keyword: climate change scenarios, arid lands, plant species, land use change, Egypt

1. Introduction

1.1. SPECIES DISTRIBUTION MODELS (SDMS)

Species distribution models (SDMs) were founded in ecology and natural history based on gradient modeling and niche theory (Franklin 1995; Elith & Leathwick 2009; Franklin 2009). Guisan & Zimmermann (2000) defined habitat or species distribution models (SDM) as models that 'statistically relate the geographical distribution of species or communities to their present environment'. Species distribution models (SDM) are also known as: bioclimatic models; climate envelopes; ecological niche models (ENMs); habitat models; resource selection functions (RSFs); and range maps (Elith & Leathwick, 2009). These models are based on the assumption that environmental factors control the distribution of species and consequently communities (Franklin, 1995; Guisan & Zimmermann, 2000; Guisan & Thuiller, 2005). Prediction of species distribution started early on by descriptive studies conducted by ecologists interested in understanding the relationship between patterns of species in relation to geographical settings and environmental gradients (Elith & Leathwick, 2009). Later the evolution in ecology and other related fields coupled by the emergence of numerical analysis and quantitative approaches greatly influenced species distribution modeling. According to Elith & Leathwick (2009) quantitative approaches of species distribution modeling developed as a result of the convergence of two lines of research trends in ecology and geography. The first line started in ecology as field-based research that studied species-habitat relationships. These studies later adopted quantitative approaches by applying statistical analysis techniques (e.g. linear multiple regression techniques), then the advanced regression techniques (e.g. Generalized Liner Models (GLMs) and boosted regression techniques) were developed to overcome limitations of the linear paradigm. The second line emerged in geography, and specifically in physical geography, through the advancement in geographic information systems (GIS) and remote sensing techniques. The integration of GIS and remote sensing has allowed the development of methods for interpolation of global climate and modeling global surface elevation, in addition to the provision of spectral data that were employed in species prediction models. The development of the field of species distribution modeling and mapping has been driven by the need to map vegetation patterns over large areas for resource management, conservation planning, and to predict the effects of environmental changes on vegetation distribution (Franklin 1995; Guisan & Thuiller 2005).

A number of statistical and, more recently, machine-learning methods have been developed for conducting SDM over the last two decades (Elith *et al.*, 2011). A review of species distribution modeling techniques and approaches used can be found in Franklin (1995), Guisan & Zimmermann (2000), Guisan & Thuiller (2005), Elith & Leathwick (2009), and Franklin (2009). Although there are many approaches used for species distribution modeling, no rules exist to provide guidelines on which is the best modeling approach to use (Franklin 2009). It is also likely that some approaches may be better for prediction of one species over others. This is related to many factors that include: the nature of the data used (quantity & quality); the nature of the predictor variables used; the spatial scale used (resolution and the extent); and the relevance of the environmental predictors used to the ecological characteristics of the species being predicted (Guisan & Zimmermann, 2000; Segurado &

Araújo, 2004; *Elith et al.*, 2006; McPherson & Jetz, 2007; Hernandez *et al.*, 2008). The new machine learning techniques such as ensemble approaches, random forest, maximum entropy and genetic algorithms, have shown promising results in modeling rare species with few occurrence records (e.g. Pearson *et al.*, 2007; Hernandez *et al.*, 2008).

1.2. SPECIES DISTRIBUTION AND GLOBAL CHANGE

Species distribution models are now an integral part of many fields that include spatial ecology, evolution, conservation science, and biogeography (Guisan & Zimmermann, 2000; Elith *et al.*, 2006; Williams *et al.*, 2009; Elith *et al.*, 2010). The use and application of SDMs for different purposes is growing rapidly (Liu *et al.,* 2011), because SDMs provide useful tools for understanding the gaps in knowledge of species distribution. The increased awareness of environmental changes worldwide has also increased the use of species distribution mapping in conservation planning, reserve design and selection, risk assessment, ecological restoration, and regional planning. More recently it's been used in assessing potential impacts of changes in environmental and climatic conditions on the distribution of species (Wu & Smeins, 2000; Guisan & Zimmermann, 2000; Franklin, 2009; Franklin, 2010).

Projection of species distribution under different environmental change scenarios is among the most important applications of species distribution models (Elith *et al.*, 2006; Franklin, 2009). In most cases these studies deal with different land use/land cover and climatic scenarios. One of the first studies to provide projection of change in biodiversity at the global scale under different scenarios of change in climate and land use/land cover by 2100 was the study by Sala *et al.* (2000). The study provided scenarios of change in the ten widely known terrestrial biomes plus the fresh water aquatic ecosystems. They based their scenarios on how the change in some drivers (climate, vegetation, land use, and levels of carbon dioxide) will trigger changes in biodiversity.

Many general circulation models (GCMs) were developed over the last two decades. These models simulate earth processes and provide means for assessing the projected change in climate in the future. The Intergovernmental Panel on Climate Change (IPCC) compared and tested the results of many of these models in the 3rd (IPCC 2001) and 4th assessments (IPCC 2007) (Ramirez & Jarvis, 2010). The data distribution center (DDC) of the IPCC distributes a number of datasets, derived from various GCMs. These models are available on the web at: http://www.ipcc-data.org/. Due to the coarse resolution of these data, they are mostly used to assess the potential impact of change in climate at a broad scale. This coarse resolution does not suit applications aiming to assess climate change impact on agriculture and biodiversity at finer scales (Hijmans *et al.*, 2005; Ramirez & Jarvis, 2010). Therefore many attempts have been made in downscaling and disaggregating GCM outputs (e.g. Jones *et al.*, 2009; Ramirez & Jarvis, 2010).

Ramirez & Jarvis (2010) used WorldClim data (Hijmans *et al.*, 2005) as baseline climate and applied spatial disaggregation to 24 different GCMs used in the IPCC 4th assessment report for different emission scenarios and for seven different 30-year running mean periods. The data are freely available through the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) web: http://www.ccafs-climate.org/data/. The data have been used to assess the response of different species to the simulated changes in climate (e.g. Jarvis *et al.,* 2008; Bütof *et al.*, 2012; Hughes *et al.*, 2012).

Arid lands in general and deserts specifically are poorly studied areas with regard to the assessment of their biodiversity and understanding the distribution of species in their vicinity (Brito *et al.*, 2009). This is likely related to the harsh nature of these areas and the inaccessibility of parts of the desert areas. The few studies that used species distribution modeling techniques in desert ecosystems were successful in providing tools for modeling the distribution patterns of species. Yet SDM approaches have rarely been used for addressing the influence of environmental changes (climate, land use change or any other disturbances) on the distribution of species in arid lands. This may be because arid lands are some of the most poorly studied areas in the world.

Species distribution modeling techniques will be used in the current study to project the impact of environmental changes on the distribution of plant species in the northwestern coastal desert of Egypt. This region has experienced rapid change in land use/land cover recently due to coastal development projects. The area encompasses a protected area that is also recognized as a World biosphere reserve (El-Omayed biosphere reserve). Species distribution modeling techniques and available environmental predictors (bioclimatic and land-surface parameters) will be used here to: 1) predict the potential distribution of important plant species; 2) assess the potential impact of land use change on the distribution of the modeled plant species; and 3) project the potential changes in distribution of the modeled plant species under different climate/land use scenarios.

2. Materials and Methods

2.1. STUDY AREA

The study area is part of the Western Desert of Egypt. The area lies 80 km to the west of the city of Alexandria extending 40 km westward to El-Alamein town and about 65 km from the Mediterranean coast southward to Moghra Oasis. The area is part of the coastal semi-desert in the northwestern part of

Egypt (Figure 1). It covers an area of about 2600 km^2 located between 30° 10' to 30° 53' and N 28° 55' to 29° 23' E.

The area has an arid climate with mean annual precipitation of 100-150 mm/year (Bornkamm & Kehl, 1989). The area has a short rainy season, which occurs mostly during winter from November to April but may extend to May. Little precipitation occurs during the rest of the year (Ayyad & Ghabbour, 1986; Ayyad & Ghabbour, 1993). The climatic records (SUMAMAD, 2005) indicate that the total monthly evapotranspiration in the coastal area exceeds the total annual precipitation. This reflects the arid conditions and the water deficiencies that prevail in the area. A north-south climatic gradient was noticed in this region, with an increase in environmental aridity and 'thermal continentality' towards the South (Abdel Razik, 2008).

The Omayed Biosphere Reserve (OBR), otherwise known as the Elomayed Protected Area (OPA) is located in the northern part of the study area (Figure 1). The protected area is considered as one of the largest terrestrial protected areas in Egypt (Kassas *et al.*, 2002).

The vegetation of the region, particularly that of the coastal area, is described to be mostly steppe (Ayyad & Ghabbour, 1986) dominated by dwarf shrubs (Bornkamm & Kehl, 1989). Plant communities of the coastal dunes and those of the inland ridges in the area are stated to be the most diverse in the area (ROSELT/OSS, 2005). The establishment of an irrigation system in the 1990s and the release of water into the canal in 2002 have resulted in changes throughout the area that have also likely influenced species distributions.

2.2. DATA COLLECTION AND SPECIES MODELED

Field visits were conducted to survey the plant species in the area, where 827 plots were selected randomly in order to account for the major physiographic variation in the study area. In each plot plant species were recorded and identified. Floristic identifications are according to Täckholm (1974) and nomenclature of the species was updated following Täckholm (1974), Boulos (1999; 2000; 2002; 2005) and the Latin names of the species were updated following the checklist by Boulos (2009).

Species distribution modeling could be developed based on the presence-only data or presence-absence data (Philips *et al.*, 2009). In the current study both presence and absence data were employed in modeling species distribution. Mapping the distribution of all the species recorded in the study area is a lofty goal that cannot be achieved in one single study due to the insufficiency of the occurrence records and additional logistical challenges. To overcome this problem the current study sought to focus on predicting the distribution of 'important' species with sufficient occurrence records. Important species were defined as those serving crucial functions and providing important services in any ecosystem. This could include, for example, sand stabilizing and nitrogen-fixing plants. Many of the species recorded in the coastal area are considered 'multipurpose' species providing multi-use for local inhabitants (Ayyad, 1998; Heneidy & Bidak, 2004). In an endeavor to evaluate plant species' importance by accounting for all aspects of species importance; Halmy *et al.* (in review) developed an index that could be used to compare species based on different criteria. The species importance index (SII) is based on conservation status, commonness, geographic distribution, ecological, and economic importance of each species. Species importance was assessed for each species recorded in the area using the Species Importance Index (SII) method described by Halmy *et al.* (in review). The value of the index includes information related to the conservation status, commonness, biological type, and utilitarian value of each species. In this index more criteria could be included in the calculation of the SII. Each of the criteria used could be weighted differently according to the objective of the study.

$$SII = \frac{\sum_{i=1}^{n} W_i C_i}{10}$$

Where C_i is the species score for criterion i; W_i is the weighting factor for criterion i and it is calculated using the formula below;

Where wf_i is the weight factor assigned for each criterion. In the current study the criterion of conservation status was given a weight factor $wf_i = 2$ and the rest of the criteria were given the same weight factor $wf_i = 1$; n; is the number of criteria used in assessing the species importance. The value of the species importance index (SII) are in the range from 0 to 1, with values approaching 1 indicating species with high importance value and those approaching 0 in-

$$W_i = \frac{wf_i}{\sum_{i=1}^{n} wf_i}$$

dicating species with a low importance value. The current study focused on important species based on their importance values as indicated by the species importance index (SII) and the number of occurrence records for each species. The species with SII value of 0.55 or more and sufficient number of occurrence records (> 100) were modeled.

2.3. ENVIRONMENTAL PREDICTORS

The accuracy and the predictive power of any habitat distribution model depends on the quality and the accuracy of the field data employed and the choice of the environmental variables used to build the model (Peterson & Nakazawa, 2008). A conceptual framework for the environmental factors to be included in plant species distribution models was provided by Austin & Van Niel (2011). In the current study a number of land-surface parameters and bioclimatic variables were used to build the plant species distribution models (Table 1). Ecological land-surface parameters derived from DEMs are considered important for mapping vegetation especially if combined with other parameters including spectral indices derived from satellite imagery (Jelaska, 2009). The land-surface parameters used in the current study were derived using SRTM digital elevation data (DEM) V4.1 (Jarvis *et al.*, 2008). The land-surface parameters employed in the study (Table 1) included slope; a terrain roughness index (TRI) that provides an quantification of the level of undulation and the complexity of the surface (Olaya, 2009); topographic wetness index (TWI) which provides a relative measure of moisture availability of any point in the landscape (Moore *et al.*, 1993); and a slope length and steepness (LS) factor. All the land-surface parameters were derived using the Automated System Geoscientific Analyses version 2.0.7 (SAGA, 2011).

Climatic conditions are recognized as the most important environmental variables responsible for the patterns of species distribution at broad scales (Zimmermann & Kienast, 1999). However the availability of climatic data layers of appropriate resolution has been rare for researchers intending to do species distribution mapping, especially in understudied areas (Franklin, 2009). Recently, interpolated global climatic data layers that represent the previous and current climatic conditions were made available to the public (e.g. 'WorldClim' of Hijmans *et al.*, (2005) and 'CliMond' of Kriticos (2012). WorldClim is available with global coverage at a spatial resolution of 1 km^2 and can be downloaded from http://www.worldclim.org. The WorldClim data include monthly mean total precipitation and mean, minimum, and maximum temperature in addition to nineteen other bioclimatic variables. The current study used thirty environmental variables (Table 1) representing factors important for plant survival, including bioclimatic variables, topographic variables and light controlling factors. The inclusion of light controlling factors in modeling plant species distribution was recommended by Austin and Van Niel (2011), especially for studies that involve assessment of the impact of climate change on plant distribution. Light can be used in SDM studies expressed as approximate solar radiation indices calculated using elevation, slope and aspect (Franklin, 2009). Using the digital elevation data, solar insolation indices were calculated and included in the analysis. To account for maritime influences due to proximity to the Mediterranean Sea, the distance to the coast was also included as a factor in modeling plant species. All the layers representing the variables employed in the analysis were resampled to match the spatial resolution of the DEM used.

2.4. MODELING TECHNIQUE

The data used in the current study was collected systematically using field surveys through which the presence/ absence observations were recorded for each species. Generalized linear models (GLMs) or ensembles of regression trees such as random forests (RF) or boosted regression trees (BRT) are recommended in cases where presence/absence data are available (Franklin, 2009; Elith *et al.*, 2010; Elith *et al.*, 2011). The current study applied the machine learning ensemble method random forest (RF), to predict the distribution of the selected species using climatological and topographical factors. The collected presence/absence data were divided randomly to two sets; 70% for calibrating the models and 30% for testing and evaluating the models. All the analyses were conducted within the framework of the open source statistical computing environment of R 2.13.1 (R Development Core Team 2011). The 'RandomForest' package (Liaw & Wiener, 2002) was used for carrying out the random forest analyses.

Random Forest (RF) has been used in some studies for modeling species and predicting changes in species distribution under different climate scenarios (e.g. Prasad *et al.*, 2006; Cutler *et al.*, 2007; Hernandez *et al.*, 2008; Evans & Cushman, 2009; Williams *et al.*, 2009). It is one of the 'ensemble modeling' techniques that have recently been used successfully in ecological modeling (Franklin, 2009). It is composed of an ensemble of Breiman *et al.* (1984) Classification and Regression Trees (CART) (Benediktsson *et al.*, 2007). The RF approach has the advantage of being a non-parametric approach that can produce a highly accurate classification results and can process a larger number of independent variables (Breiman, 2001). It has been recommended for being robust to outliers and noise (Breiman, 2001; Gislason *et al.*, 2004; Gislason *et al.*, 2006; Benediktsson *et al.*, 2007; Horning, 2010; Rodriguez-Galiano *et al.*, 2011).

In Random Forest, an ensemble of Classification and Regression Tree (CART) models is created by training each model on a bootstrap sample of the original training data set. The output from each CART model is then subjected to a voting process whereby the most common vote is selected for producing the final results of a classification and the average of all the tree results is obtained by performing regression. The size of the random forest model (i.e. the number of trees) and the number of variables to be used for splitting nodes at each tree in the random forest model need to be specified by the analyst depending on the study. The selection of these parameters is based on the combination that minimizes the out-of-bag (oob) error. Out-of-bag error estimation is used as an assessment of the accuracy of the model. It is estimated by keeping out (out-of-bag) one third of each bootstrap replica generated from the original training data and using it to test the tree models. The use of oob error for evaluating the performance of the RF models is considered a robust unbiased method (Breiman, 2001). In the current study, trials were conducted to determine the optimum combination for the number of trees to fit the random forest model and the number of variables to be used for splitting nodes. The trials showed that models with a size of 750 trees and four splitting variables at each node minimized the error rates. All the variables were used first to fit a general model for predicting each species, whereby an assessment of the importance of each variable in fitting the each species model was also estimated. The selection of variables to create a reduced model was based on the percent of increase in mean square error (MSE) caused when a variable is randomly permuted and introduced to the model. Following this approach, the most parsimonious model with the least MSE value was selected for predicting each species.

2.5. MODELS EVALUATION AND ACCURACY ASSESSMENT

The accuracy and credibility of habitat distribution models should be considered in the context of the intended applications (Guisan & Zimmermann, 2000). Accuracy assessment and uncertainty about the data used in developing these models should be reflected in, and accounted for, by any further analysis that might use the products of these models (Roloff *et al.*, 2009). An account of the most commonly used measures for accuracy assessment of the species distribution models can be found in Franklin (2009) and Liu *et al.* (2011). The most commonly used threshold-dependent method for assessing accuracy of habitat distribution models is the Kappa statistic; however Kappa has been criticized for producing a biased accuracy assessment. Allouche *et al.* (2006) described the bias encountered when using Kappa statistic (Cohen, 1960) and suggested using the true skill statistic (TSS) (Peirce, 1884) as an alternative method for assessing the accuracy of habitat distribution models. In the current study both Cohen's Kappa and the TSS are used as threshold-dependent measures in assessing the accuracy of the produced models along with the overall accuracy, sensitivity (the proportion of the correctly predicted presence observations), and specificity (the proportion of the correctly predicted absence observations). The area under the receiver operating curve (AUROC) (Mason & Graham, 2002) is also used as a threshold independent measure.

2.6. ASSESSING THE POTENTIAL IMPACT OF CHANGE IN LAND USE AND CLIMATE

Species distribution modeling is used frequently to predict the potential changes in species distribution under different change scenarios (Elith *et al.*, 2010; Austin & Van Niel, 2011). Prediction of the potential shift in plant distribution under different climate change scenarios is considered as one of the important applications of the species distribution models (Wisz *et al.*, 2008; Austin & Van Niel, 2011). Most of the studies that project the impact of climate change on species distributions have been applied on global or regional scales (e.g. Sala *et al.*, 2000; Skov & Svenning, 2004). However there is a need for applying the same principles at the landscape level which will be of great help to conservation efforts at this scale (Trivedi *et al.*, 2008). The information provided by such tools is considered crucial for decision making related to land management and conservation planning (Margules & Austin, 1994; Guisan & Zimmermann, 2000). Most of the studies that have predicted the potential change in plant species under climate change scenarios have focused on temperate regions (e.g. Zimmermann & Kienast, 1999; Dirnböck *et al.*, 2003; Trivedi *et al.*, 2008). The current study provides an assessment of the potential impact of climate change on the distribution of plant species in a desert ecosystem.

In order to assess the impact of change on the distribution of the modeled plant species, both the change in climate and land use were evaluated. Land use/land cover (LULC) maps for the years 1988, 2011 and projected 2023 were developed for assessing the impact of land use change on the distribution of the modeled plant species. The LULC map for the year 1988 represented the most natural stage for the landscape, while the one for the year 2011 represents the current condition. The simulated LULC map for the year 2023 represents the condition of the landscape in the future assuming the same trend of change that has been occurring in the period 1999-2011. These maps of land use/land cover were reclassified into two categories only representing natural and artificial areas. Natural areas represent all the areas that have not been transformed by human activities. Artificial areas include areas such as urban, roads, orchards and croplands. A digital Boolean map was created for each year where the artificial areas were given values of zero and the natural areas were given value of 1. By multiplying the Boolean map for each year by the maps of the potential distribution of each species, maps of the distribution of each species in the year 1988, 2011 and 2023 were obtained. Gains and losses in area occupied by each species under each land use scenario were estimated.

To predict the potential distribution of the modeled species under different climatic scenarios, predicted climate changes according to the CSIRO Mk 2.0 & Mk3.0 GCM (Gordon *et al.*, 2002) were used. These models were used because they predicted a higher increase in the mean annual temperature than other models over the same time period and provided different emission scenarios for the study area. The scenarios used in this study represent different emission scenarios according to IPCC 4^{th} assessments. Both A2A and B2A are high greenhouse emission scenarios, while A1B is a medium green house emission scenario that assumes balance between all sources of energy (fossil & non-fossil). The data used for the analysis represent the average for the period 2010–2040 according to the SRES-A1B, A2A, and B2A scenario. The data was obtained from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) website: http://www.ccafs-climate.org/data/. The same 'bioclimatic' variables used for predicting the potential distribution of species under the baseline climate were also used for projecting the species distribution under the different climate scenarios (see Table 1).

These scenarios were used to project the change in distribution of plant species according to changes in climate in the study area at 2010-2040 and compare it to the potential distribution under the baseline climate. To assess the change in species habitats under the combined effect of land use and climate change, twelve scenarios were developed for each species (Table 2). The scenarios are based on three land use scenarios and three climate change scenarios. The land use scenarios include no land use (theoretically natural landscape); the current land use scenario represented by the land use/land cover map of 2011; and a future land use scenario simulated for the year 2023. The gain or loss in habitat area for each species under each of these scenarios was estimated.

3. Results and Discussion

3.1. SPECIES DISTRIBUTION AND CONTROLLING FACTORS

A total of 244 species were recorded in the study area, out of which 57% are perennials, 38% are annuals and the remaining are biennials or short lived perennials. Species recorded in the study area belong to fifty taxonomic families. Compositae (Asteraceae), Gramineae, Leguminosae (Fabaceae) and Chenopodiaceae are contributing the most to the flora of the region; this is in accordance with Shaltout (2002). The use of Species Important Index (SII) facilitated the selection of the species based on their importance. The distribution of 10 species out of the 244 recorded in the study area was modeled (Table 3). Eight models out of the ten attained an AUC value over 0.7 which indicates that these models are of moderate performance (Manel *et al.*, 2001). Astragalus spinosus and Stipagrostis obtuse models attained AUC values exceeding 0.65 which indicates that the models are better than random. Based on kappa values, Astragalus spinosus, Echinops spinosus, and Stipagrostis obtuse models are considered of poor performance as they had kappa values less than 0.4 (Table 3). The models of seven species out of the ten performed fairly well as indicated by all the used measures of accuracy assessment. Both models of Haloxylon salicornicum and Noaea mucronata exhibited good performance with kappa and TSS exceeding 0.5, AUC above 0.8, and overall accuracy above 81%.

The accuracy and the predictive power of any species distribution model depends on the quality and the accuracy of the field data employed and the choice of the environmental variables to be used in the model (Peterson & Nakazawa, 2008). Taking into account the limitation of the resolution of the environmental data employed in the study particularly, the climatic variables used for predicting the distribution of species in the study area, the results obtained are considered acceptable. The availability of high resolution environmental predictors is important for modeling the distribution of species at landscape scales (Newbold, 2010; Austin & Van Niel, 2011). Such high resolution environmental data is difficult to obtain for the poorly studied areas. The deficiency in geographic databases (e.g. topographic and climatic databases) representing areas in developing countries and underdeveloped areas was and still is one of the major problems that face researchers.

The pattern of species distribution is often related to the number of environmental variables. Predictive models of species distribution could include variables selected based on a theoretical basis following conceptual model (Vaughan & Ormerod, 2003). The conceptual framework for modeling plant species suggested by Franklin (1995) was revisited by Austin & Van Niel (2011). They emphasized including environmental predictors that are considered direct factors influencing plant growth and distribution. This included light, temperature, nutrients, water, carbon dioxide and biotic interaction. Although it is important to include the variables that correlate to the species distribution and also show meaningful biological relationships (Vaughan & Ormerod 2003), some studies fail to include some factors of importance. Austin & Van Niel (2011) highlighted the need for inclusion of light as a predictor in models predicting distribution of plant species, which has been overlooked by many studies. They argued that light as a predictor has an important influence on distribution of plant species. In the current study light was included in modeling species of the study area expressed as total insolation, direct insolation, diffusion insolation, and direct/diffusion insolation ratios. Each of these factors was found to be important for modeling plant species in the study area. Diffusion insolation was found to be important for predicting all the species except for Echinops spinosus, for which direct insolation was found to be important (Table 4). Austin & Van Niel (2011) maintain that the difference in light regime between north and south-facing aspects can result in differences in temperature equal to that resulting from a shift of 200 km in latitude.

In the current study generally seventeen out of the original thirty environmental variables contributed to the modeling of the species in the study area. Of the climatic variables, the mean of temperature diurnal range, temperature seasonality, annual precipitation and precipitation of the wettest quarter were the common climatic factors in controlling the distribution of most the modeled species (Table 4). Climatic variables representing annual cycle (e.g. annual mean temperature and annual precipitation) seem to control the general vegetation cover over the broad scale. Bornkamm & Kehl (1989) divided the western desert into five zones characterized by different vegetation cover and plant communities based on the mean annual rainfall. The study area falls within Zone I and Zone II of this classification. The vegetation cover of Zone I (semi-desert with mean annual rainfall > 20 mm) is composed of dwarf shrubs dominated by Thymelaea hirsuta. Zones II and III are full-desert (with mean annual rainfall 10-20 mm) with communities dominated by Asphodelus microcarpus and Plantago albicans. Climatic factors that represent seasonality (e.g. mean of temperature diurnal range, temperature seasonality and precipitation of the wettest quarter) are more important for the distribution of the species at local scales as is suggested by the results of the current study.

The results indicate that the land-surface parameters are of influence on the distribution of species. Topographic factors such as elevation, diffusion insolation, direct insolation, and topographic wetness index were found to be important in predicting most of the modeled species (Table 4). Hammouda (1988) in a study focusing on the Omayed area (part of the study area) found that species distribution and plant community composition are influenced by topography, the nature and origin of the parent material, in addition to the land use and degree of human intervention. Other studies that focused on assessing the quantitative relationships between environmental variables and vegetation in the northwestern desert (e.g. Ayyad, 1973; Ayyad & Ammar, 1973; Ayyad & El-Ghareeb, 1972; Ayyad & El-Ghareeb, 1982) also found that the land-surface parameter controlling moisture availability are of importance for species distribution. Ayyad and Ammar (1973) found that abundance and the distribution of the perennials more affected by factors controlling moisture availability through run-off; such as slope and curvature. Ayyad and Ammar (1974) also found factors controlling moisture availability (e.g. slope inclination, topographic position, nature of surface, soil depth and soil texture) the most important in controlling vegetation composition in the area. Ayyad and El-Ghareeb (1982) found the micro-variations in the soil were attributed to variations in topography and the nature of parent materials on the distribution of species in the area. The results of the current study showed also, that the proximity to sea is of the common factors important for predicting all the modeled species.

Communities of the coastal dunes dominated by Echinops spinosus and Thymelea hirsuta and those of the inland ridges dominated Gymnocarpos decanderus and Deverra tortuosa are stated to be the most diverse in the area (ROSELT/OSS, 2005). However these communities are stated to be threatened due to the establishment of summer resorts on the coastal dunes and the establishment of the irrigation network on the non-saline depressions (Salem, 2003).

3.2. POTENTIAL IMPACT OF CHANGE IN LAND USE AND CLIMATE ON SPECIES DISTRIBUTION

3.2.1. Land Use Change Impact

Species distribution models are increasingly used for prediction of the potential distribution of the species in response to disturbance or changes resulting from human intervention. Predictive habitat distribution models are used as important tools for assessing the impact of land use change and other forms of human interference on different species. Habitat distribution models have proven to be useful for modeling both commonly distributed species (e.g. Franklin, 1998) as well as rare species (e.g. Wu & Smeins, 2000; Williams *et al.*, 2009). Some studies used models with AUC values greater than 0.6 for projecting the impact of climate change on plant distribution (e.g. Trivedi *et al.*, 2008). However, the intention of this study was to be more conservative and use only the models that showed reasonable performance according to all the accuracy assessment measures to assess the impact of both land use and climate change. As a result only seven species were mapped to assess the impact of change in land use on their distribution. Assessment was done by comparing the area occupied by each species under no land use change in the area (theoretically natural landscape) to that in the years 1988 and 2011. The results show that all species face reduction in their habitats (Figure 2). The results show also that all the species are at risk for increased reduction of their habitats under the projected land use change by the year 2023.

Noaea mucronata attained the maximum loss in habitat area in 1988 (7.47% of the potential area; Figure 2), this increased five folds by 2011 (37.74%) and six folds by 2023 (44.79%). The major loss for this species occurs between the year 1988 and 2011. This trend is noticed for all the modeled species. Halmy *et al.* (in review) assessed the change in the landscape between the years 1988 and 2011 and found that the landscape has experienced changes by which many natural areas were transformed to new uses. The study concluded that the landscape is trending towards being more artificial. This explains the dramatic increase in loss of areas occupied by each species between the year 1988 and 2011. The projected loss in the species' area between the year 2011 and 2023 was shown to be lower than that of 1988 and 2011. Noaea mucronata, Asphodelus aestivus, and Deverra tortuosa (Figure 2) are most affected by the changes in land use in the period 1988-2011 and will continue to be at risk of habitat loss by the year 2023. The distribution of these three species is concentrated in the northern part of the landscape. This part of the landscape has been the most modified by human activities, and will continue to face more modifications pressures in the future.

Urban sprawl, agricultural activities and other activities occurring in the area have resulted in habitat loss. These recent changes in the region place the plant species and their habitats under threat. In the late 1980s, establishment of summer resorts on the coastal dunes started to reshape the landscape of the area. Quarrying activities increased as a result of the establishment of these resorts. Mining and cutting of the limestone ridges in the area provide building materials necessary for the establishment of the resorts. This may have contributed to the fragmentation, destruction and loss of habitats. Species inhabiting the coastal dunes and the non-saline depression habitats are stated to be threatened due to the establishment of summer resorts on the coastal dunes and the establishment of the irrigation network on the non-saline depression (Salem, 2003). Factors such as habitat size reduction or habitat fragmentation represent the most serious causes of species loss. However arrangement and connectivity of habitat patches are also of great importance. Habitat fragmentation makes it difficult for wildlife to maintain stable populations (Akçakaya *et al.*, 1995; Akçakaya, 2001). The current study did not assess the fragmentation in the habitat of each species or estimated the degree of connectivity among patches. This will be part of future work planned to include more species with restricted distribution in the area.

3.2.2. Climate Change Impact

Many studies have focused on projecting the impact of climate change on the distribution of plant species (e.g. Zimmermann & Kienast, 1999; Guisan & Theurillat, 2000; Sala *et al.*, 2000; Dirnböck *et al.*, 2003; Peppler-Lisbach & Schröder, 2004; Thomas *et al.*, 2004; Trivedi *et al.*, 2008). Most of these studies have been applied on global or regional scale. The current study attempts to assess the potential impact that climate change might have on the distribution of some plant species at the landscape scale within a desert ecosystem.

Under the CSIRO GCM models, the different emission scenarios used in the current study are predicted to lead to changes in the temperature and precipitation of the area (Table 2 & Figure 3). The study area is expected to experience an increase in annual mean temperature under the three applied scenarios, with B2A expected to result in the highest increase in temperature. Not all the scenarios predict a reduction in the annual mean precipitation of the area. The area is expected to experience an increase in the annual mean precipitation by 3.11mm as compared to the average over the period 1950-2000 under the A2A scenario. Climate has an influence on species distribution at broad scale (Zimmermann & Kienast, 1999; McMahon *et al.*, 2011). The results show that at the landscape level the change in climate under the different emission scenarios have resulted in changes in the modeled species distribution. Although the differences among the climate scenarios developed by the different models up to 2050 are stated to be minor (Jones & Thornton, 2009; Jones & Thornton, 2013), the current results show that the expected impact of each of the climate scenarios used on the modeled species is different (Figure 4).

Noaea mucronata, *Asphodelus aestivus*, and *Anabasis articulataare* are expected to be at risk of loss of habitat under all the employed scenarios. The high emission scenarios B2A and A2A cause higher impact on these species compared to the low emission scenario (A1B). For example, under B2A *Noaea mucronata*, *Asphodelus aestivus*, and *Anabasis articulata* are expected to lose about 96%, 58% and 17% of their potential area respectively, while under A1B each are expected to lose 85%, 29%, and 13% of their potential area respectively

(Figure 4). The scenario A1B, on contrary, is expected to cause more loss in area for *Asphodelus aestivus*, and *Deverra tortuosa* (29% and 7%, respectively) compared to the A2A scenario (23% and 2%, respectively). For *Gymnocarpos decanderus*, and *Haloxylon salicornicum* the A1B scenario is expected to cause loss in area of their habitat (1.2% and 2.2%, respectively), while these species are expected to gain habitat under the other two high emission scenarios (20.5 and 5.8% under A2A scenario and B2A scenario, respectively). Under the A1B scenario there will be an expected reduction in the annual precipitation and precipitation of the wettest quarter compared to the average observed for the period 1950-2000 (see Figure 3). On the contrary, under the A2A and B2A scenarios, the area is expected to experience increase in both annual precipitation and precipitation of wettest quarter compared to the average observed for the period 1950-2000. These factors were found to be important for the occurrence of *Asphodelus aestivus, Deverra tortuosa, Gymnocarpos decanderus, and Haloxylon salicornicum* (Table 4).

Thymelaea hirsute seems to favor the change in climate under the three different scenarios. The species is expected to gain habitat under these scenarios. The decrease in temperature seasonality and the increase in annual precipitation, precipitation of wettest month, precipitation of wettest quarter, and precipitation of coldest quarter under A2A and B2A compared to the average for the period 1950-2000 may explain this expected gain in habitat for Thymelaea hirsute under these scenarios. *Noea mucronata* is expected to be the most adversely affected of the modeled species by the change in climate under the employed scenarios. *Noea mucronata* seems to be sensitive to the increase in temperature seasonality that is expected to increase under the three scenarios.

3.2.3. Land Use and Climate Change Scenarios

The results show that while the change in land use in the study area resulted in loss of the area of the potential habitat for all species, the change in the climate under the employed scenarios may result in gain in area for some species. The expected loss in the area of *Noaea mucronata, Asphodelus aestivus, and Anabasis articulata* (96%, 58%, and 17%, respectively) under the high emission climate change scenario B2A is higher than the expected loss under the projected change in land use by the year 2023 (44%, 32%, and 15%, respectively). Under the scenarios of combined change in climate and land use either under the current land use or that projected by 2023, all the species are expected to suffer loss in area (Figure 4). An exception to that is *Gymnocarpos decanderus*, which is expected to gain area under the combined scenario of A2A emission and each of the current land use scenarios and the projected land use by 2023. However this increase is less than 5% the potential area suitable for the species under the A2A/2011 scenario and less than 1% under the A2A/2023 scenario.

The results reveal the serious fate that plant species might face under scenarios of climate and land use change. Immediate actions are needed to ensure that species such as *Asphodelus aestivus* (Figure 5) and *Noaea mucronata* (Figure 6) are not declining in other places across the northwestern coast. The current study modeled the distribution of the species in part of the phytogeographical region, the status of these species need to be known over the whole phytogeographical region. Future studies to assess the status of the species in the area, especially those of restricted distribution, are still needed. Based on the findings of these results, measures should be taken to maintain these species in the flora of the region.

4. Conclusions

The application of Random Forest to the employed climatic and land-surface parameter data proved to be successful in predicting the distribution of the plant species in the arid land landscape. The performance of the species distribution models in the current study could be attributed to the resolution of the environmental predictors used. At the landscape level the use of finer scale environmental predictors, especially climatic factors, may increase the prediction power of distribution models. The inclusion of environmental predictors that represent light proved to be of importance for the prediction of some of the modeled species in the study area.

The study found that the expected impact of the A1B, A2A and B2A scenarios on the distribution of the modeled species is variable. In arid lands some species might be adversely affected by the change in climate under certain scenarios, while others might benefit from these changes. Land use change poses more risk on most of the species modeled compared to climate change. The impact of land use is not differential while that of climate change is. Change in land use in the area resulted in habitat loss for all the modeled species. Land use change impact could be faster and more substantial in reducing the size of plant species habitat. If the current trend in land use change continues, all species will continue to suffer habitat loss.

The combined impact of land use and climate change pose serious threats to most of the species modeled. Under combined scenarios of change in land use as projected by 2023 and change in climate, all the species are expected to suffer loss in habitat, except Gymnocarpos decanderus. The results show that some species such as Noaea mucronata and Asphodelus aestivus may suffer serious threats in the area under the combined land use climate change scenarios. So, actions are needed to ensure that these species are not threatened across the northwestern coast and in Egypt. This also highlights the importance of assessing the impact of land use/climate change scenarios on other species of restricted distribution in the area.

The application of species distribution modeling in desert and arid lands can provide a useful tool for mapping species and assessing the impact of human induced changes on different species. Such applications are still rare, and this may be attributed to the fact that most of the arid lands and deserts are located in inaccessible or lightly populated areas. Most of these areas are also located in less developed areas where the systematic surveys of the natural resources are not conducted on a regular basis. The lack of environmental predictors of appropriate landscape resolution to be used for modeling species in such areas is another factor to be considered. The current study is the first to conduct spatially explicit modeling of plant species distribution in the area. It will encourage more studies that map plant species distribution and assess the risk to important species from human interference. Future studies are needed to assess the magnitude of fragmentation in each species habitat and to estimate the degree of connectivity among patches.

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PAPER 11

Restoration of the Ecological Process in Alexandria, Egypt

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Abstract: In recent years, the impacts of human activities and urbanization on the environment and the surrounding native landscape have become apparent. One of the resultant damages is the problem of degradation, which can be defined as human-induced or derived by natural processes. It negatively affects the capacity of the land to function effectively within an ecosystem by accepting, storing and recycling water, energy, and nutrients. 'Ecological restoration', which is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed provides a solution to the problem. The aim of eco-restoration is to protect, enhance and conserve ecosystems and to protect its biodiversity from loss. Ecological restoration differs from other approaches to restoration; in fact, its focus is to restore the original biodiversity and ecosystem processes that existed before the degradation or disturbance occurred. The aim of this paper is to demonstrate the severity of the issue of degradation as an environmental problem and to introduce ecological restoration as a guideline to reduce degradation and eventually eliminate it.

Keywords: degradation, ecosystem, ecological restoration, biodiversity, degraded landscape.

1. Introduction

Parks and green spaces are essential components of ecosystems; they can be thought of as representing the breathing lungs of the city, to minimize the impacts of pollution, and provide a habitat for many different types of species.

The Foundation of Ecological Security (2008) found that:

> In recent years, the impact of humans has caused a number of dramatic changes to a variety of ecosystems found on the Earth. Humans use and modify natural ecosystems through agriculture, forestry, recreation, urbanization, and industry. The most obvious impact of humans on ecosystems is the loss of biodiversity. The number of extinctions caused by human domination of ecosystems has been steadily increasing since the start of the Industrial Revolution. The frequency of species extinctions is correlated to the size of human population on Earth, which is directly related to resource consumption, land-use change, and environmental degradation. Other human impacts to ecosystems include species invasions to new habitats, changes to the abundance and dominance of species in communities, modification of biogeochemical and hydrological cycles, pollution, and climatic change. (p. 76)

This paper begins by providing a broad overview of biodiversity and ecological processes in ecosystems and defines the term degradation and its severity by degrees and types. It then examines analytical examples to achieve a set of principles that can be applied to a case study in Alexandria, Egypt. Finally, the paper provides a conclusion which discusses a framework for the restoration of ecological processes, recommendations and associated guidelines.

The aim of the research includes reconstructing the biotic communities that have been lost from the landscape; repairing damaged communities; conserving genetic variation of native plants and animals; providing an educational opportunity/scientific study; and providing recreational benefits that may extend in certain circumstances to nature tourism.

The research hypothesis assumes that ecological restoration can be maintained when the degree of land degradation to be restored is known and accordingly the suitable restoration method for the type of degradation can be applied.

2. Definitions

Ecosystem

An ecosystem is defined as a dynamic entity composed of a biological community and its associated abiotic environment. Ecosystems are always undergoing alterations of their components. Some of these alterations begin first with a change in the state of one component of the ecosystem, which then cascades and sometimes amplifies into other components because of relationships (Makhzoumi and Pungetti, 1999).

Biodiversity

The 1992 United Nations Earth Summit in Rio de Janeiro defined "biodiversity" as "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". The term biodiversity refers to the totality of genes, species, and ecosystems of a region (Makhzoumi and Pungetti, 1999). Biological diversity includes the following three hierarchical levels:

- genetic diversity, the total genetic information contained in the genes of all the species;
- species diversity, the variety of species on earth; and
- community and ecosystem diversity, the variety of habitats, natural communities and ecological processes in the biosphere.

These levels of biodiversity are interrelated, yet distinct enough to be studied separately to understand the interconnections that support life on earth. This paper largely focuses on community and ecosystem diversity of vegetation and plants (Nachtergaele *et al.*, 2009).

Land Degradation

Land degradation, whether caused by man or natural processes, prevents the land from effectively accept, store and recycle water, energy, and nutrients. Severe land degradation affects a significant portion of the earth's arable lands, thus decreasing the wealth and economic development of nations. Land degradation cancels out gains advanced by improved crop yields and reduced population growth. The causes of land degradation are mainly anthropogenic and agriculture related. It is basically credited to: increasing biotic pressure, land clearing, high rate of population growth and high incidence poverty in rural areas, agricultural depletion of soil nutrients, urban conversion, irrigation, pollution (especially inadequate use of fertilizers, non-sustainable use of natural resources and improper land use practices) (Foundation for Ecological Security, 2008).

Degradation types include soil degradation, biological degradation and water degradation. This research focuses on biological degradation which is concerned with the loss of vegetation and loss of habitat.

3. Biological Indicators of a Degraded Eco-System

The biological indicators of a degraded ecosystem include a decrease in vegetative cover, a decrease in above-ground biomass and a decrease in yield. Indicators may also include the alteration of key species distribution and frequency and failure of species to successfully reproduce. In the degradation process, some land can still have potential for vegetative cover, while some cannot bear green cover. The land, which can be brought under vegetative cover with reasonable efforts, is wasteland. No land is waste and any land can be converted into productive land if appropriate techniques are used at the appropriate time and space.

The following four levels of land degradation are recognized based on soil quality (F. Nachtergaele, 2009):

- ***light,*** the terrain has somewhat reduced agricultural suitability, but is suitable for use in local agricultural systems. Restoration to full productivity is possible through modification of the management system. Original biotic functions are still largely intact;
- ***moderate,*** the terrain has greatly reduced agricultural productivity, but is still suitable for use in local agricultural systems. Major improvements

are required to restore productivity. Original biotic functions are partially destroyed;

- ***strong,*** the terrain is non-reclaimable at farm level. Major engineering works are required for terrain restoration. Original biotic functions are largely destroyed; and
- ***extreme,*** the terrain is irreclaimable and beyond restoration. Original biotic functions are fully destroyed.

4. Ecological Restoration

According to the Society for Ecological Restoration (2004), "the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed is called ecological restoration or eco-restoration". Eco-restoration involves bringing back original normalcy of function, structure, potential, service and process of eco system (Landscape restoration, 2003). Attributes of an ecosystem are mainly its structure and functions. It may be possible, perhaps to restore the functions fairly completely, but achieving the original structure may be more difficult (Martin R. Perrow *et al.*, 2002)

4.1 LEVELS OF RESTORATION

There are four levels of restoration: full or complete restoration, restoration of only certain attributes, rehabilitation, or reclamation. Figure 1 represents the different options for the improvement of a degraded ecosystem which can be expressed in terms of the two major characteristics of structure and function.

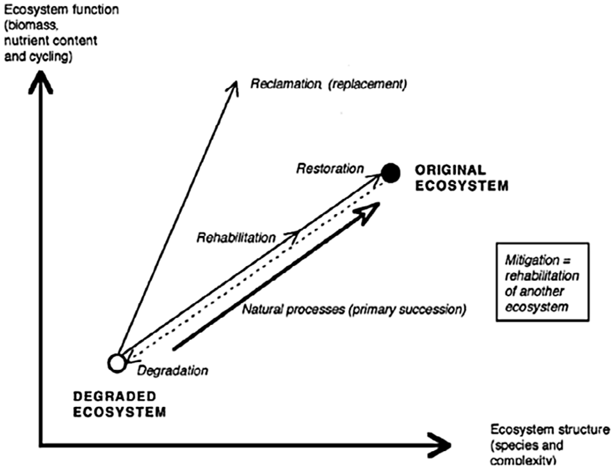

Figure 1: Different options for the improvement of a degraded eco-system (types of restoration and their closeness to the original ecosystem)

When degradation occurs both characteristics are usually reduced, although not necessarily equally. Used in its narrow sense, restoration implies bringing back the ecosystem to its original or previous state in terms of both structure and function. There are then a number of other alternatives, including rehabilitation in which full restoration is not totally achieved and involves the replacement of the original by something different. All of these alternatives are covered by many people by the general term reclamation. Mitigation is a different consideration (Martin R. Perrow *et al.*, 2002).

4.2 COMPONENTS OF AN ECOSYSTEM

Eco-restoration focuses on following four basic components of the ecosystem (Martin R.perrow *et al.*):

- ***water cycle,*** the constant process of precipitation, transpiration, evaporation, and surface and ground water flow;
- ***mineral cycle,*** also referred to as the nutrient cycle. Nutrients follow cyclical patterns as they are used and re-used by all living organisms;
- ***succession,*** the process of change is the only constant in all ecosystems. Populations of plants and animals change continually in response to all sorts of environmental pressures; and
- ***energy flow,*** sometimes referred to as the carbon cycle because carbon is involved in all energy storage and transfer. Energy flow is closely related to the previously mentioned cycles where it makes them possible.

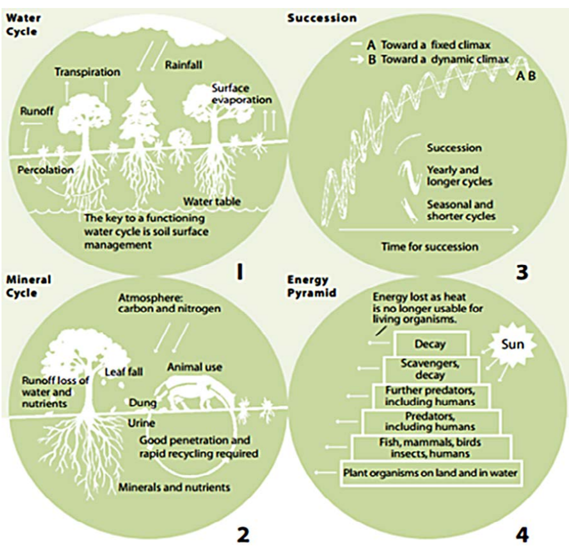

Figure 2: The four basic components of ecological restoration (ecological source book of restoration, source author, year?)

4.3 FACTORS AFFECTING ECOLOGICAL RESTORATION

Physical Factors

- Climatic factors: temperature, wind velocity, and storm condition.
- Edaphic factors: type, texture and structure of soil, pH of soil and soil profile, soil minerals and salinity, depth of water table and presence of impervious rocks or nutritional deficiency in soil.
- Topographic factors: Nature of slope, aspect and exposure, altitude and configuration of land surface.

Biotic Factors

These represent the biological spectrum of the area, like vegetation composition and animal communities (e.g. parasites, weeds, exotics, fire, insects, influence and impact of wild animals…).

Other Factors

These include the type of forests, type of grasslands, state of plant secession, climate vegetation of the area, corridor problems of the area, ecological signification of the area (criticality), threatened species, presence of new species and protected area in and around targeted area.

4.4 DEGRADATION AND ECOLOGICAL RESTORATION

Figure 3 represents the status and trends in global land degradation according to recent statistics measured globally. The four types of degradation of ecosystem benefits and the corresponding intervention options for each are listed in Table 1.

Table 1: Showing the typology of degradation of ecosystem benefits and the intervention options (F. Nachtergaele, 2009)

Typology of degradation of ecosystem benefits	Intervention options
Type 1 – High degradation trend or highly degraded lands	Rehabilitate if economically feasible; mitigate where degrading trends are high
Type 2 – Moderate degradation trend in slightly or moderately degraded land	Introduce measure to mitigate degradation
Type 3 – Stable land, slightly or moderately degraded	Preventive interventions
Type 4 – Improving lands	Reinforcement of enabling conditions which foster SLM

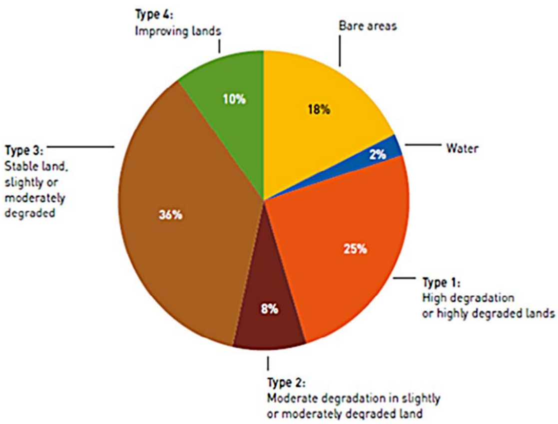

Figure 3: Status and trends in global land degradation (F. Nachtergaele, 2009)

5. Applications of Ecological Restoration

5.1 CONSTRUCTED WETLAND

Wetland restoration attempts to re-establish ecological processes in damaged or destroyed natural wetlands, while wetland construction attempts to initiate wetland processes, typically on a non-wetland site, often for such purposes as improving water quality. Wetlands restoration and construction have been used frequently as mitigation to compensate for wetlands lost, typically due to construction projects. Wetlands can be designed to provide specific functions lost from the landscape. These functions may include development of wetland plant communities that can provide valuable habitats for invertebrates, fish, and wildlife. They also include surface water storage, which provides for the absorption of storm water flows, and retention, transformation, and removal of nutrients, sediments, and contaminants.

5.2 RAIN GARDENS AND INFILTRATION BIO-SWALES (VEGETATED INFILTRATION BASIN, BIORETENTION, BIOFILTRATION)

Rain gardens are landscaped areas that collect and treat stormwater runoff using bioretention. Bioretention systems collect and filter stormwater through layers of mulch, soil and plant root systems, where pollutants such as bacteria, nitrogen, phosphorus, heavy metals, oil and grease are retained, degraded and absorbed. Treated stormwater is then infiltrated into the ground as groundwater or, if infiltration is not appropriate, discharged into a traditional stormwater drainage system. Rain gardens may look similar to traditional landscaped areas, but they differ in design and function. They can be planted with a variety of perennials, grasses, shrubs and small trees, with native plants typically preferred. Rain gardens are a valuable addition to both residential and commercial sites. Rain gardens also treat the quality of rainfall runoff whilst providing habitat for native species.

5.3 XERISCAPING

Xeriscaping protects one of the most important natural resources – water. Xeri comes from the Greek word xeros, which means dry. Xeriscaping typically uses plants that need or tolerate dry (xeric) conditions. It also emphasizes minimal use of fertilizers and pesticides. Because Xeriscape landscapes do not require a great deal of care, considerable money and time can be saved. Xeriscaping will enable the establishment and maintenance of an environmentally healthy and attractive landscape. When properly planned, xeriscaping is a cost-effective method of landscaping to conserve fossil fuel energy and water on a residential- and community-wide level. Xeriscaping is an old concept with a new name that addresses water shortages.

5.4 USE OF NATIVE VEGETATION AND DIRECT SEEDING

The use of native vegetation is considered a sustainable aspect of ecological restoration and a cost effective approach in landscape. Direct seeding is the use of plants in seed form rather than potted stock. The use of seed is a cost-effective way to introduce a large number and wide variety of species into a site.

5.5 CULTURAL AND HERITAGE CONSERVATION

Part of the ecological restoration process may include restoration or conservation of heritage parks or historical monuments which is considered important in providing multifunctional landscapes. This allows a green space not only to be restored from the vegetation and landscape aspect but to also become an attraction point to visitors and will give value to the space. Consequently, pedestrian movement and activities should be considered in design plans and development restoration strategies. Also the presence of supporting elements like galleries, green houses and outdoor exhibitions related to the site theme, enhances the restoration of a specific park or green space and keeps it lively.

5.6 SOD MATS

Sod mats are used where vegetated areas are slated for removal and project timing allows for harvest and relocation of blocks of vegetated soil (sod) containing the roots and seed bank of existing plants. This application has been used for stabilization and has proven to be very successful.

5.7 SOIL SEED BANK SALVAGE

This technique is a wetland restoration/creation strategy used where an existing wetland is to be removed. The existing topsoil of a wetland is stripped and then re-spread on a recipient site; the root fragments and seeds within the stripped top soil provide a 'ready-made' wetland seed mix for the new site. This technique has proved to be highly successful, provided that the recipient site has appropriate substrate and hydrology.

6. Principles of Ecological Restoration

6.1 APPLYING LANDSCAPE ECOLOGY THEORIES.

Landscape ecology is a field that assists in analyzing structure, function, and changes in a landscape. It helps to manage a restored floodplain in an ecological and sustainable way by considering the context of regional landscape.

6.2 DESIGNING FOR FUNCTION, NOT STRUCTURE

Hydrological function governs wetland ecosystem development. The wetland structure, including soil, vegetation, wildlife communities, and the abiotic environment, is determined directly and indirectly by wetland function. As a result, the success of a restoration attempt should be based on restoring wetland function rather than the form of a wetland structure.

6.3 ALLOWING SELF DESIGN

Self-design is an innovative concept in ecosystem restoration processes. Restoration by means of self-design relies on the self-organizing ability of an ecosystem, in which natural processes (wind, rivers, biotic inputs, etc.) contribute to species introduction and selection. In self-design, the presence and survival of species due to their continuous introduction is the essence of the succession and functional development of an ecosystem. Ultimately, sustaining natural energy is the best way to maintain ecological integrity with capacities to adapt to disturbance and changes.

6.4 MINIMIZING ENGINEERING TECHNIQUES

To minimize artificial input in a restoration plan, it is critical to minimize the need for maintenance and avoid over-engineering to reduce the interference of artificial mechanisms and materials involved in wetland ecosystem natural succession. High maintenance approaches not only increase the costs, both in construction and management, but also make restored systems dependent on human and financial resources that may not always be available.

6.5 PLANNING WITH TIME

Time is an important factor in natural processes and dynamics. A wooded bottomland swamp may take longer to re-establish in terms of structure and function than a shallow-water, sedge-meadow wetland. Boggs and Weaver (1994) pointed out that the pattern of change in riparian vegetation and nutrient pools likely developed over more than a century of succession. Therefore, sufficient time should be allowed for natural succession to restore floodplain wetland structure and function. Consequently, time should be considered fully when establishing stages of goals and objectives in a restoration plan.

6.6 DESIGNING FOR CULTURAL-NATURAL SUSTAINABILITY

Political, economic and cultural issues are not discussed in most wetland restoration literature reviews. A sustainable restoration plan, however, should include these perspectives. Since humans manipulate the land greatly, focusing solely on the ecological aspect of restoration and not accounting for regional anthropogenic influences will likely result in failure of the restoration.

7. The Design Process and Steps towards Ecological Restoration

Since humans guide restoration, a design process has been developed in order to organize a restoration plan. The design of an effective restoration project should include clear goals and objectives, sufficient baseline data and historical information, integrated planning and comprehensive design, and long-term monitoring.

7.1 GOALS

Ecological restoration is defined by restoring an ecosystem's functions; as a result, restoration of specific functions becomes the goal. Subject to the influence of various human values, a restoration may be planned to achieve multiple goals in terms of wetland function and values. Mixed goals, however, may be difficult to achieve and difficult to quantify for monitoring. Therefore, one primary goal must be identified for the project.

7.2 SITE SELECTION

Criteria for site selection should be established based on restoration principles and project goals and objectives. According to the principle of establishing a self-sustaining ecosystem, a restoration with natural succession potential is better than newly created wetlands. As a result, criteria for selecting an adequate site include several elements: (1) historical wetlands or grasslands with important features with value, (2) potential to reconnect the natural hydrological regime, (3) hydric soils, and (4) possible wetland species or seedbank.

Other components related to planning within a regional scale and designing for sustainability include existing and future land use, land availability, geomorphic setting (e.g. steepness of river channel and topography gradients), climate, and regulations (e.g. Clean Water Act and Endangered Species Act).

7.3 SITE ANALYSIS

Site Inventory: Onsite and offsite inventories provide a baseline for the restoration plan. Onsite inventory includes investigating local hydrology, soil properties, native and non-native flora and fauna communities, accessibility, land use and human activities. Other data requirements include water quantity and quality, flood frequency and duration, climatic and geomorphic data, natural and cultural history, land use and development pattern, regulations, and financial and stewardship support.

Site Evaluation: Site evaluation is a process used to assess the suitability of a selected site and the feasibility of restoration according to information collected from the site inventory. Criteria for evaluation include the ability to reconnect the original hydrologic regime, soil properties for water capacity and wetland vegetation, control of invasive species, potential seed bank, availability of land acquisition, appropriateness of landscape and land use setting, accessibility to the site, wetland restoration and land use development regulations.

7.4 SITE PLAN

Based on the result of the site analysis, an effective site plan should amplify opportunities and minimize the constraints onsite in order to achieve the project goals.

7.5 SITE DESIGN

Specific design should be addressed after the site plan is developed. Details include hydrologic engineering, topographic grading details, planting design, construction details, and facilities to accommodate specific human needs.

7.6 MANAGEMENT

A restoration project should have a long-term management plan to ensure that the ecosystem functions are restored and the goals are achieved. A management plan includes monitoring and evaluation programs to investigate the conditions of the restored wetland and evaluate the successfulness of the restoration plan through a set of assessment procedures. Figure 4 explains the design process for ecological restoration.

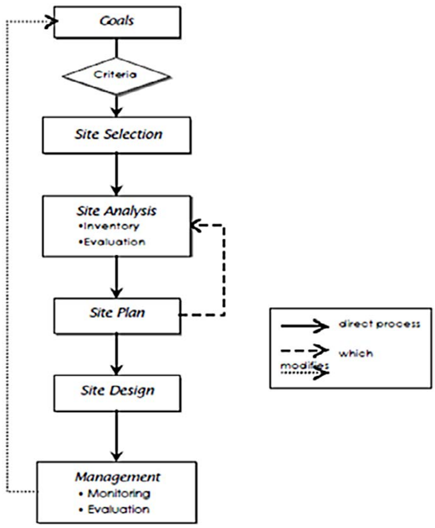

Figure 4: The design process diagram

The design process is not always straightforward or linear. Site evaluation and site planning is a systematic, iterative process of collecting and analyzing information followed by modifying the plans, then repeating the cycle until the initial concept is polished into a preliminary plan that becomes the basis for the design. The process provides a baseline for evaluating alternative sites, choosing compatible designs, assessing important components, drafting concept drawings, and outlining construction details. Once the plan and design are accomplished, a monitoring and evaluation program should be conducted to ensure that the restored wetlands are functional and the goals are achieved. Assessment of the success of the restoration project and recommendations for the next restoration plan are parts of the management plan.

8. Analytical Examples

8.1 ORANGE COUNTY GREAT PARK, CALIFORNIA, USA

The Orange County Great Park will transform the former El Toro Marine Corps Air Station into one of America's largest metropolitan parks, spanning more than 1,300 acres (nearly twice the size of New York's Central Park). The Great Park's award-winning master plan embraces environmental sustainability, preserves Orange County's agricultural heritage, and honors the military history of the former air base, setting a new standard for sustainable park design and urban planning. Upon completion, the Orange County Great Park will join

Figure 5: Illustrations of the proposed Orange County Great Park, California, USA. *(a) Master plan, (b) Aerial view, ©Internal view of the park, with vegetation and wetlands, (d) The visitors cente*r

America's inventory of national treasures and set a new standard for great metropolitan parks around the world.

8.2 BROOKLYN BRIDGE PARK: ECOLOGICAL DESIGN AND HABITAT RESTORATION TO CREATE AN ICONIC PUBLIC SPACE IN NEW YORK, USA

Designed by the Michael Van Valkenburgh Associates, Inc. Team, Brooklyn Bridge Park is the largest urban park created in New York City since 1875. The project concept involves the conversion of East River industrial piers into recreational areas which provide public access to restored native coastal and intertidal habitats. The designers contributed to the planning and design of the freshwater wetlands, tidal wetlands and tidal pool features of the Park as well as the stormwater management system, all of which serve as a "living classroom" for visitors. The winner of multiple design awards, the Park represents one of the most important interfaces between ecology and urban public space in the United States, and is currently one of the City's most spectacular public spaces.

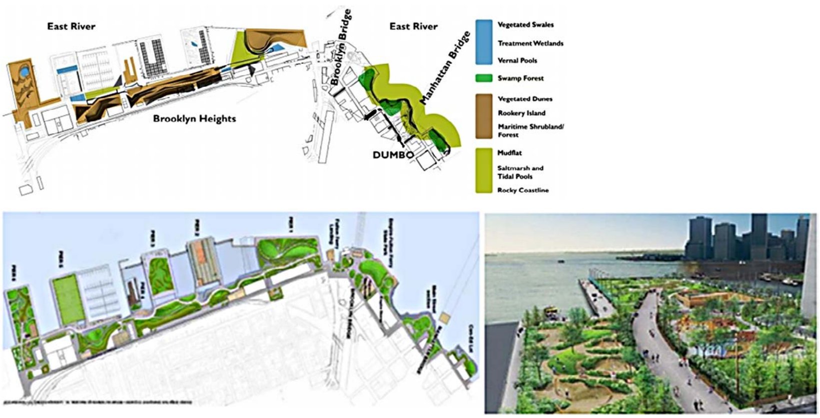

Figure 6: Illustrations of the proposed Brooklyn Bridge Park, New York, USA. *(a) Master plan and analysis, (b) Master plan of the park zones, (c) Aerial view of the park landscape*

8.3 THE XIAN EXPO - 'FLOWING GARDENS'

The Expo embodies the idea of transformation as the site was formerly a sandpit where the water was severely degraded during the 1980s. Efforts over the past two decades have restored the ecosystem and now the Expo is able to demonstrate what can be accomplished through the use of the most advanced technology, ideas, and materials. The 37 ha park is a proposal comprising of a 5000 m^2 exhibition hall, a 4000 m^2 greenhouse and a 3500 m^2 gate building. Flowing Gardens creates a consonant functionality of water, planting, circulation, and architecture as one seamless system.

Figure 7: Illustrations of the Xian Expo, China. *(a) Site plan, (b) The three main expo buildings, © Aerial view of the Park plaza and open spaces, (d) Aerial view of the green house, (e) Aerial view of the park and various vegetation and wetlands*

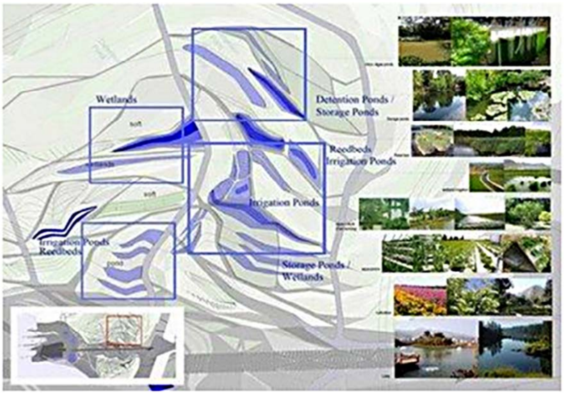

Figure 7 (continued): Illustrations of the Xian Expo, China. *(f)Master plan analysis of the park showing locations of wetlands, retention ponds and irrigation ponds*

9. Case Study: 'The Shallalat Park'

9.1 LOCATION AND HISTORY

The Shallalat Park is located in Alexandria, Egypt. It is considered the third largest park in Alexandria and is located in the Shatby area along Sultan Hussein Street. The location of the Shallalat gardens now replaces the northern fortress created at the years of Mohamed Ali around the early 20th century, which "modernized" the medieval city walls of Alexandria. The park follows the curve North East of the Rosetta Gate (one of the old fortress gates).

Figure 8: Historic photos and illustrations of the Shallalat Park, Alexandria. *(a) Site plan (Source: Google maps), (b) and (c) The old park in 1938 (Source: Alex. maps)*

The park borders Hourryea Avenue and Sultan Hussein Street Square, this is known as the 'Greek Quarter' not only because this section of town dates back to the Greek period, but also because rich Greek merchants inhabited the area during the 19th century. The Park is populated with various shrubs and trees. It was originally designed by Nubar Pacha, one of Mohamed Ali family's prime ministers and the design was based on the ideas of the American landscaper Fredrick Almstead.

9.2 CURRENT CONDITION

At the present time, the park is in bad condition; the winding paths of the park are now littered with garbage and canals that once had water running through them are today dry, home only to plastic bags and old tires. Moreover, in the past years the area of the park began to shrink because of several road expansions which used part of the park's area along with the construction of the natural gas pipe storage area; not only is the park in poor condition but it is also shrinking (Al Ahram, 2005).

Figure 9: Current photos of the Shallalat Park, Alexandria. *(a) The Arab tower at the northeastern corner, (b) Fountain in the pond, © View across the artificial pond*

10. Discussion

In light of the aforementioned information in the literature review, the design process for ecological restoration of the park can be explained as follows:

10.1 GOALS

The goal of this ecorestoration is to create an ecological park that enhances biodiversity and provides a new iconic green space that is beneficial for the existence of both humans and nature.

10.2 SITE SELECTION

Table 2: Site selection evaluation of the ecoresoration of the Shallalat Park

criteria	Availability in site	Form
Historical wetlands	✓	The lake
Potential to connect hydrological regime	✓	
Hydric soils	✓	
Possible wetland species or seed bank	rare none	
Endangered species	✓	Plant species
Land availability	✓	

10.3 SITE ANALYSIS ELEMENTS

Elements

- Soil properties → moderate conditions
- Accessibility and land use
- Species present
- Nature and cultural history

Accessibility Map

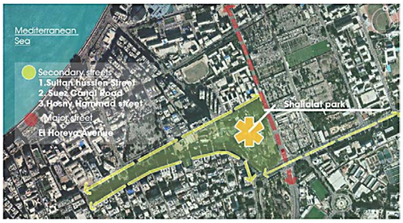

Figure 10: Site plan of the park showing the accessibility and surrounding streets.

Land Use

Figure 11: Land use map of the near surroundings

Species (Plant Species)

The Park is home to various plants and trees of different types and shapes that give the park its character and shape its environment.

Nature and cultural history

The Park is of cultural and natural value and was once an important historical site in the years of Mohamed Ali (as mentioned previously in the historical background).

Figure 12 : Plants and trees found in Shallalat Park. *(a) Jacaranda mimosifolia, (b) Salix Babylonica, © Mulberry tree, (d)Poinciana Regia (in autumn) red flowering tree, (e) tall thin palm: Washingtonia Robusta, short palm: Washingtonia Filifera, (f) Pentas Athena , Petite Scarlet(shrub)*

10.4 SITE PLAN

Table3: Opportunities and threats identified at the site plan stage for the ecorestoration of the Shallalat Park

opportunities	threats
The lake	Some Endangered species
The waterfall	Safety
The ancient fortress remains	Shrinkage of the park
The old cafeteria building	Pollution in water elements
The outdoor stage	

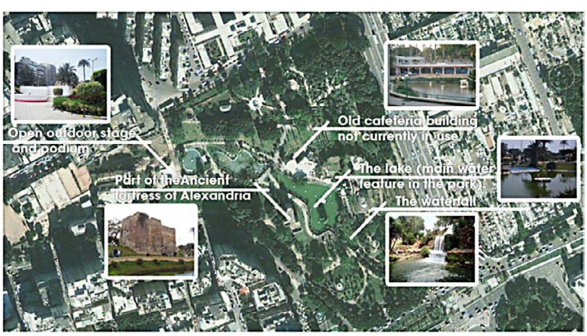

Figure 13: Opportunities in features present in the park

The lake represents a major opportunity aesthetic-wise, climatic enhancement-wise and most importantly is available for future use in rain collection systems, as a habitat for certain species or as an irrigation source and many other suggestions. The waterfall is an iconic feature in the park and an attraction. The fortress exemplifies the opportunity for the historical or cultural uses of the park. The cafeteria building can be reused as well as the outdoor stage which can assist in any events that might occur in the future use of the park. Since the park is abandoned with no maintenance work or public focus, it has become home to theft.

10.5 SITE DESIGN

In reviewing the three analytical examples, many of their applications were found to be suitable for application on this case study in addition to the features mentioned earlier. They include the following:

Proposed Features

Figure 14: Design proposal features

- Rain gardens/detention or retention ponds/infiltration swales → the lake
- Treatment wetlands → the lake and its adjacent extensions
- Irrigation ponds making use of water elements present in the site for irrigation purposes through irrigation pipes.
- Green house/expo building: Plant species that require a greenhouse environment or new species that will be introduced can be placed in a greenhouse that will also act as a visitor attraction in the site.
- Cultural and heritage conservation: The park includes potential cultural and historical features like the ancient fortress and the park's history which makes the park a historical place worth visiting and also the outdoor stage

space can be used in events or outdoor lectures related to the site history or plant species.

- Use of native plants or direct seeding which is more economical and beneficial for the park and future protection of species
- Cleansing biotope: It is an area planted with selected native wetland species. During a storm, rainwater runs off the roofs of the building and terrace and other impermeable surfaces into the Cleansing Biotope. The water filters through the plant root systems, where contaminants are removed and treated by bacterial activity on the root surface. The cleansed water is then stored in an underground tank.

Vision in Sketches

Figure 15: Vision Sketch 1 (by author Rana Sameeh)

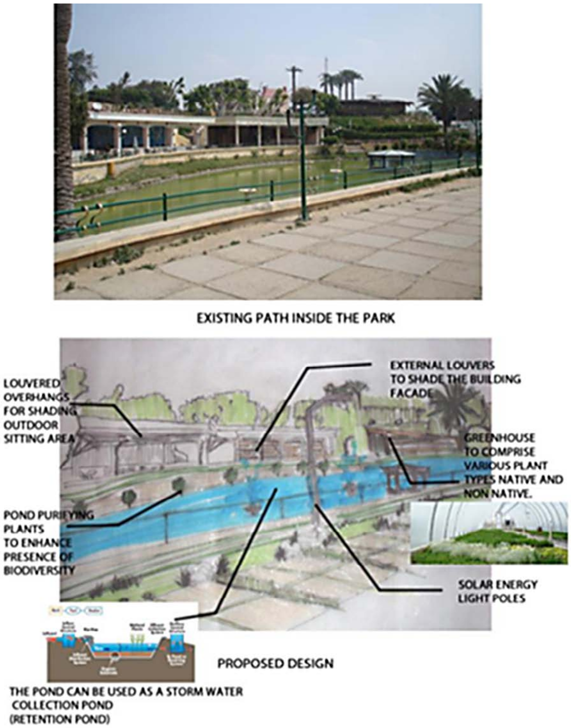

Figure 16: Vision Sketch 2 (by author Rana Sameeh)

11. Conclusions

The need for effective habitat restoration is growing, but landscapers and biologists should move beyond simply drawing lines on maps and calling the spaces "restored habitat". Greater consideration should be given to how these spaces are filled. The Shallalat Park is an urban green space with great features and the potential to become an iconic space in the center of Alexandria. With the proposed design plans and strategies for ecological restoration and management, the park can transform and the ecological processes in the park can be restored and conserved.

This paper can be considered a beginning of an approach towards solving the degradation problem in native vegetation or at least a start to understanding it and acknowledging the nature of the ecosystem and how it can be easily affected by any changes surrounding it. This paper also can be used as preliminary reference for any researchers who seek to understand the same topic.

In summary, some general guidelines for ecological restoration include:

- Planning on a regional scale.
- Establishing a self-sustained ecosystem.
- Designing for cultural-natural sustainability.
- Allowing nature to play its role.
- Design for coexistence of man and nature.
- Full restoration may not always be achieved but partial restoration assures the potential of reaching a full restoration in the long run.
- The type of degradation and type of land to restore affect the ecological restoration process.
- Ecological restoration aims to achieve the most convenient systems and environment for both man and nature that can enhance their co-existence and allow natural processes to occur normally.
- Restoration actions should be based on explicitly stated hypotheses.
- Initial restoration projects should be designed as experiments to address information needs.
- Project implementation should be preceded by restoration planning.
- Restoration must consider "ecological succession."
- Project proponents should recognize ecosystem potential constraints and limits of irreversible changes.
- Restoration projects should be based on carefully developed goals and objectives.

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Case study: site visits, references from other professors, Alexandria maps, landscape and agriculture surveys reports.

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PAPER 12

South Mediterranean Coastal Landscape; Lush Lawns versus Native Species—A Case Study of the North Western Coast of Alexandria, Egypt

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Abstract: Planting in arid climates demands special considerations, as plants must withstand hardships of scarcity of water, high temperature and high soil salinity. Selecting suitable plants that can thrive in such conditions presents a challenge for landscape designers. There are many factors affecting the sustainable growth of plants; of utmost importance is matching the plant with the site conditions, as plants vary in their tolerance and ability to adapt. Current practices in the South Mediterranean coastal area are more focused on beautifying and creating resort landscape images with large expanses of green lawns and golf courses, ignoring the area's ecology. These practices exhaust natural resources and are fraught with failure as introduced plant species might not match the arid environment, wilt and needlessly consume natural and financial resources. The purpose of this paper is to provide a case study on the north-western coast of Egypt to demonstrate current landscaping practices, and to provide sustainable alternatives based on a set of landscape criteria developed for arid coastal landscapes.

Keywords: arid climates, sustainable planting, sustainable landscape, native species.

Introduction

Plant materials are important elements in landscape design and in the management of the environment. They not only serve practical purposes as structure, control or screening elements, but also have a specific role in balancing the ecological system and supporting the psychological well-being of humans (Dunnett and Clayden, 2007; Dunnett and Qasim, 2000). Booth (1989) considers plants as structural, environmental and aesthetic elements and Robinette (1972) classifies the uses of plants to architectural, engineering, climate control and aesthetic uses. Both classifications are very similar. Booth's structural elements coincide with the architectural uses of plants to organize space and as walls, ceilings and floors in the landscape; Robinette's engineering and climate control uses coincide with environmental qualities of plants and their role in controlling issues such as glare, erosion and noise.

The use of plants in an environmental capacity is quite pivotal in arid climates due to harsh weather conditions, limited resources and the tight loop of species' dependency. Plants improve, control and provide a more favourable microclimate. Plants as organic elements are best suited for this task as they depend on their context and coevolve over time to the specifics of this context (Motloch, 2000).

The discipline of landscape design and planting has a long standing history and the visual characteristics of plants in terms of form, size, colour and texture and the employment of plants to suit uses is well established (Booth, 1989; Motloch, 2000). However, choice of plants suitable to the arid climate, knowledge of the array of native species and means of achieving visually pleasant landscapes using these species is less applied.

This research aims to determine a set of criteria to identify the most appropriate native plant species for the north-western coast of Egypt -,an area located in an arid, Mediterranean climate - according to factors affecting planting design in this region. The first part of the paper reviews sustainable planting design in arid regions, reflecting on the ecology and plant selection. Factors affecting planting design are then discussed, forming along with planting design criteria, an evaluative framework. The second part of this paper introduces the case study area, its recent development and landscaping experiences and assesses their suitability against the evaluative framework developed in Part 1. The paper concludes with evaluating the sustainability of the planting approach in the north-western case study area, highlighting achievements and failures, and suggesting some solutions which may be considered for future improvement.

PART 1:
Factors Affecting Sustainable Planting Design in Arid Regions

Plants are crucial to ecological functioning and the promotion of natural processes. It is through planting that environmental qualities such as enhancement of air and water quality, biodiversity and soil stability (more so in arid climates where sand storms and soils of thin crusts threaten areas of plantation) are achieved. Plants are therefore central to achieving environmental sustainability (Dunnett and Clayden, 2007). A plant that is suited to its environment will fully utilise natural resources, exists in harmony with the natural environment and can survive for many years with minimal impact on the environment. Introduced plants can enhance landscape design and aesthetics but will often require specific treatments requiring additional effort and financial resources. Plants that are poorly suited to their environment will not thrive despite the application of best practices (Harris *et al.*, 2004). Despite this knowledge, standard landscape planting practices result in the use of large numbers of relatively few species in simple compositions which make little reference to local character and ecology, and are maintained to produce a static effect that may require considerable resource inputs (Dunnett and Clayden, 2007).

Considering that 38 percent of the earth's land surface is hyper-arid, arid or semi-arid land (Science Daily, 2010), more attention should be given to appropriate planting in arid regions (Gomaa and Picó, 2011). Eight natural areas have been assessed as at risk of desertification. These include coastal areas, the Prairies, the Mediterranean region, the savannah, the temperate Steppes, the temperate deserts, tropical and subtropical Steppes, and the tropical and subtropical deserts; with the Mediterranean region second at risk (Núñez et al., 2010). Hyper arid zones have low, infrequent and irregular rainfall, rarely exceeding 100 mm, comprised of dry land with no vegetation, except scattered shrubs. Grazing is frequently practiced. Arid zones have high rainfall variability, ranging between 100 to 200 mm annually, and are characterised by grazing and irrigated farming, with sparse native vegetation of annual and perennial grass, herbaceous vegetation, shrubs and small trees. Semi-arid zones support rain-fed agriculture and native vegetation of grass, fortes, shrubs and trees, and have variable seasonal annual precipitation between 300 to 800 mm (FAO, 1993).

As mentioned, plants have different uses - structural, environmental and aesthetic - but in arid climates, perhaps the environmental use is most important. Available plants can be native plants, adaptive plants or cultivated plants depending on the surrounding environment. Native plants evolve in response to the physical and biotic processes of a region, making them uniquely adapted to local conditions. They seldom need interfering and can be considered as a practical and ecologically valuable alternative for landscaping, conservation and restoration projects (DCR, 2012). They are vital components of ecosystems, providing aesthetic qualities of cultivated plants yet surpassing them in ruggedness and resistance to drought, insects and diseases (Gill, 2000). On the other hand, adaptive species arrive from other areas via a carrier and adapt to the environment through genetic modification. This is important to identify (Salt *et al.*, 2008) as crops around the world could be affected negatively by climate change and mechanisms would be needed to adapt plants to drought, higher temperatures or changes in soil nutrition (Science Daily, 2011). Adaptive plants add to the diversity, creating a more visually attractive array for landscaping as well as providing a food source and shelter for wildlife (Knops *et al.*, 1999). Cultivated plants are introduced to the site, requiring land modification, special treatment and additional water (Gabr, 1990). They are mainly grown for their produce, but others add aesthetic qualities. Examples of the three categories found in Egypt are provided in Figure 1.

Whether native or not, suitability of plants to the site is of prime importance. Limited resources and precarious conditions of arid regions and environmental changes experienced should compel landscape designers to choose an array of plants, which require minimal interference. Yet a lack of knowledge of native plants leads to the common practice of importing introduced plants. A change from traditional to sustainable horticultural practices; a sound understanding of ecological site conditions and knowledge of plant species and associated maintenance considerations best suited to specific sites are factors that can impact the sustainability of planting in arid regions.

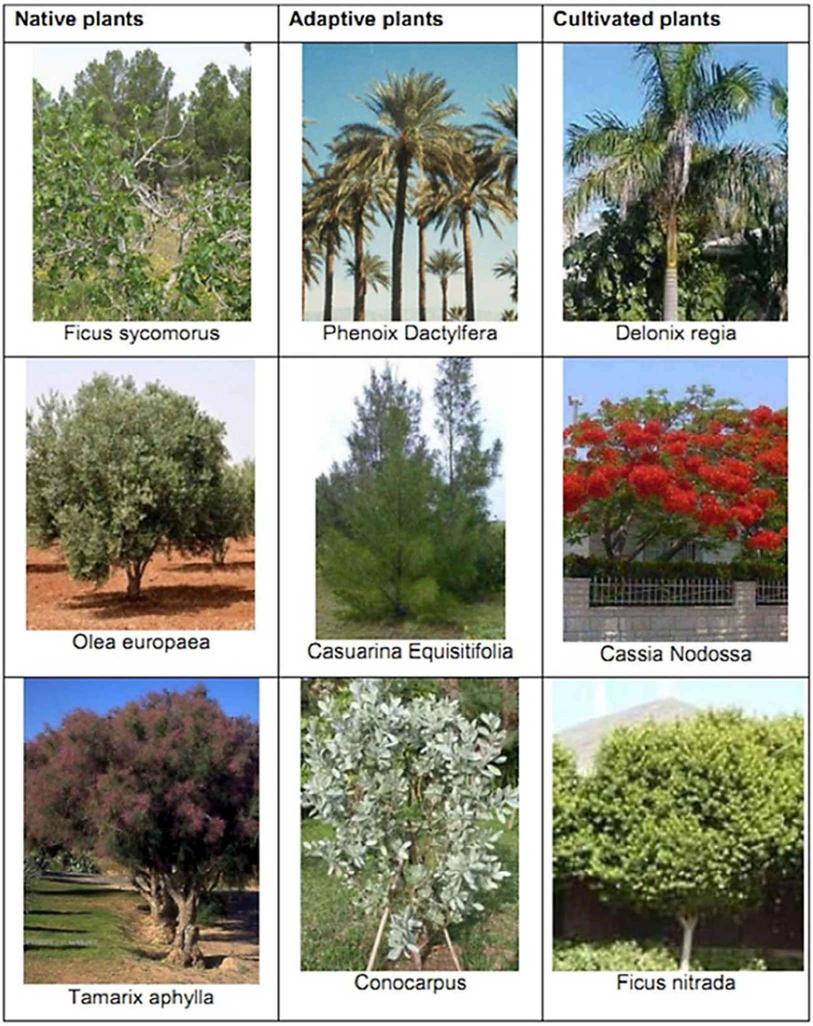

Figure 1: Examples of different plant types in Egypt (Salama, 2012).

The following paragraphs focus on elements that contribute to a sound ecological understanding of a site's abiotic and biotic factors. To inform this case study, the focus will be on the Mediterranean arid region.

Abiotic Factors are physical factors that affect planting design that include climatic conditions, landform, soil conditions, water sources and irrigation techniques.

1. **Climatic factors** of radiation, temperature, rainfall, humidity and wind force, interact shaping planting and the community structure of an arid region. In terms of solar radiation, most is formed between latitudes 15° north and 35° south and the lack of clouds contribute to the receipt of very high levels of radiation and sunshine, often over 85% of the theoretical maximum, double than that received in humid zones of comparable latitude (Hafez, 2000; Konya, 1980). In terms of temperature, early stages of plant growth are greatly affected by large variations between day and night surface temperatures (Konya, 1980). In terms of rainfall, it is marginal in the Mediterranean arid areas, mostly occurring in autumn and winter months, with annual rainfall in coastal areas of approximately 100mm to 150mm (Hafez, 2000). In terms of relative humidity, mean monthly values in the region increase eastwards, with the highest values registered during July and August and the lowest values registered in February and March. Wind affects temperature, evaporation, the rate of moisture loss and transpiration from vegetation. Evaporation and transpiration rates are extremely high in arid regions, particularly where high winds and low humidity combine (Brain, 1994; Cochrane, 1978). In the Mediterranean region, prevailing winds are north/northwest in summer and autumn, associated with early morning fog. In winter south/southwest winds prevail known as 'Khamasin', characterised by hot and dry winds increasing aridity, creating sand storms, increasing heat and causing plants to wilt (EEAA, 2009).
2. **Landform** and plant material define landscapes and their variety adds diversity to spaces (Motloch, 2000). Arid regions are covered by drifting or semi-stabilised sand dunes of various shapes; parabolic, coalesced parabolic, longitudinal, transverse, barchan, obstacles and shrub coppice, some up to 100 m high (Singh, 1977). Active dunes are a menace to inhabitants and infrastructure. Crests and flanks of semi-stabilised dunes remain active because of cultivation and mismanagement. Dunes can be managed by protection against biotic interference, creating micro-wind breaks in parallel or checker board and use of appropriate plant species (Kar, 2005).
3. **Soils** associated with arid regions vary considerably in depth, texture, composition and water permeability. They are also characterised by the upward movement of soluble salts in the soil profile when evapotranspiration exceeds rainfall, a difficulty for species not adapted to saline soils (Brian, 1994). 25 percent of Egyptian soil is limestone, characterised by weathered, thin crusts (Abdin, 1982) thus alkali soil is predominant, par-

ticularly on the coastal area. It is essential to know soil content in order to determine the pH value and ratio of calcium to sodium to magnesium. Also, knowledge of the soil's texture and structure is required to determine the amount of water penetration, absorption and drainage. It is important to maintain soil moisture to minimise stress on plants. If irrigation systems are used, the maximum capacity required should be determined.

4. **Water sources,** whether provided through natural hydrological processes or irrigation technologies, should be complementary, as water is the most critical factor when evaluating planting development options. Water sources vary: surface water, which tends to be saline; groundwater, which affects the concentration of salts if recharge of the water table is slow; rainfall, a significant source in less arid regions; processed water, which can be recycled water from sewage effluent; and desalinated water or collected water from dew (Brian, 1994; Shata, 1979). Processed water is a viable source in coastal areas and is supplementary to natural sources. Depletion of natural resources cannot be allowed thus water quantity and associated fluctuations should be calculated. Also, measurement of the depth of water will inform the type of wells to be dug and whether certain species in need of initial intensive irrigation can survive eventually with minimal water. Irrigation systems vary in cost, level of automation and feasibility: surface systems tend to waste water, are mildly efficient and cause salinization and clogging where drainage is poor; sprinkler systems use one third of the water that surface systems use, can cover large areas but cannot cater to diverse plant requirements; trickle systems use 1/10 of the water that surface systems use, cater to individual plants and leach salts out of the root; and managed water tables and hydroponics through processed water explained above.

Biotic factors represent living creatures that directly or indirectly affect the habitat of plants, including plants themselves. Types of plants and wildlife interaction with plants will be explored below.

1. **Plant** growth is accelerated in warm areas because of prolonged sunlight, provided the availability of water. Native desert plants adapt to drought conditions and can be categorised into three main groups showing morphological and physiological change, namely Xerophytes, Halophytes and Hydrophytes. *Xerophytes* are protected from drought by heavy leaf cuticles (e.g. Ficus spp), small leaves (e.g. Acacia spp), or in the case of cacti, water storage in tissues such as thorns (e.g. cavenia and A. nilotica). Yet other plant species, mainly ornamental species, lose leaves or die back in response to hot periods (e.g. Haloxylon spp, Lantana and Bauhinia spp). *Halophytes* are protected from salt damage by high osmotic values

of cell sap and low transpiration rates (e.g. Suaeda, Arthrocnemum and Nitraria spp). *Hydrophytes* are protected from possible flooding in high water table areas by comparatively low osmotic values and high transpiration rates (e.g. Atriplex, Tamarix and Prosopis spp) (Brian, 1994). It is essential to understand the local ecology and to assess the viability of introducing plants from equivalent environments elsewhere. For example, although Eucalyptus spp transplant successfully, the transpiration rates of this plant species are so high that their viability is precluded in areas of low water availability. Where irrigation is too expensive, a strategy of planting of succulent cacti and indigenous trees and shrubs, highlighted with a few drought tolerant specimen trees could work best. It may be necessary to limit grass and groundcover plants and to concentrate on interesting and sheltered hard surfaces with spaces for attractive plant groups.

2. **Wildlife** plays an essential role in planting in arid areas. The process of natural nutrient production and vector seed allows for regeneration and reproduction. On the other hand, plants provide an essential source of moisture through succulent and internal water absorption features. Grazing is considered a mutually beneficial activity, completing the ecosystem food chain; however, illegal practices and overexploitation can cause overgrazing. The ability of a plant to survive and to recover from grazing depends on how much material is lost and when plants are defoliated. If it occurs right after a plant had seeded for the season, plants are at risk. How palatable a plant is also affects its survival. Generally, plants tend to become less palatable as they grow and mature. Overgrazing adversely affects soil properties which results in reduced infiltration, accelerated runoff and soil erosion. The degradation of the planting process may be a short-term phenomenon and recovery is possible after grazing pressures have been greatly reduced.

To summarize, factors affecting planting design in arid regions are abiotic and biotic. The above review has shown that the climate in arid coastal areas of the Mediterranean is characterised by high radiation, absence of cloud cover, high temperature, precipitation ranging between 100-150 mm per year and high relative humidity. Soil salinity and soil moisture affected by high evaporation and low precipitation as well as landforms characterised by shifting dunes affect the choice of plants. Native and adaptive plants are diverse and can withstand precarious conditions of arid regions. Wildlife plays an important role in the regeneration of ecosystems.

Table 1: Evaluative Framework adapted from Salama (2012)

Sustainable Planting Design Evaluative Framework	Criteria of evaluation		Evaluation and description		
	Planting Design considerations	Planting main concept	Low		
			Medium		
			High		
		Plant selection	Low		
			Medium		
			High		
		Planting process	Low		
			Medium		
			High		
	Factors affecting planting design	Water sources & Irrigation techniques	Low		
			Medium		
			High		
		Soil Conditions	Low		
			Medium		
			High		
		Landform	Low		
			Medium		
			High		
		Climatic factors	Low		
			Medium		
			High		
		Biotic	Low		
			Medium		
			High		
Project	Marina El Alamein Touristic Region			Evaluation	Description

The process is also challenged by attitudes from conventional horticulture practice resorting to a few known species probably imported from other environments and their approach would not necessarily use plants for all their uses: environmental, architectural and aesthetic. A sound ecological understanding of sites as well as knowledge of best-suited plant species for site conditions and maintenance considerations is needed. These aspects have influenced the selection of criteria forming the evaluative framework applied to the case study.

Table 1 shows the evaluative framework of sustainable planting design. It consists of two categories derived from the previous discussion. The first addresses the abiotic and biotic factors. The second addresses the design consideration criteria of plant selection and planting concepts. Each category is evaluated on a scale measurement of high, medium and low. The next section of this paper will present an analysis of the case study according to the framework's criteria.

PART 2:
Case Study of Marina El Alamein Touristic Area, the North Western Coast of Alexandria, Egypt

The north-western coast of Egypt is situated in the arid zone of the Mediterranean region. It comprises a great variety of native trees and shrubs, which can grow in diverse habitats within the region. According to Boulos (1995), of the 2088 species of flowering plants in Egypt, nearly 1000 are recorded in the coastal strip stretching between Alexandria and Matrouh. The north-western coastal region holds much development potential. In the past two decades, this coastline has undergone resort type development with lush lawns and cultivated, introduced species.

This research study aims to determine the most appropriate native species for the north-western coast case study area of Marina El Alamein touristic region, based on an analysis of abiotic and biotic factors, sustainable planting design and plant selection. It intends to explain how much has been achieved, what failure has taken place in planting in Marina El Alamein, and to suggest solutions for future improvement.

Figure 2: Marina El- Alamein touristic region based on Google Earth, 2012

Marina El Alamein is a large recreation tourist center located 94 km from Alexandria city. It extends about 12 km along the coast and is expected to extend a further 3 km in the future, and its width is approximately 1.6 km inland. It has an area of about 20 km² (Figure 2) planned with a clear master plan and landscape design concept.

CATEGORY 1: FACTORS AFFECTING PLANTING DESIGN IN THE CASE STUDY AREA

1. Abiotic factors:

a. **Climatic factors:** Like most of the lands in the Mediterranean Basin, Marina El Alamein has an arid Mediterranean climate characterized by warm to hot dry summers with a high of 34 ˚C with steady breezes from the sea that keep temperatures moderate in summer and mild to cool wet winters. Strong radiation prevails from March until the end of September, with a peak in June and July. November, December and January are relatively cloudy months. Precipitation is approximately 120mm per year, with rainfall characterised by significant annual fluctuation in distribution and intensity (EEAA, 2009). Relative humidity is high in the summer, reaching 65 percent in July, with a sea breeze rendering the climate comfortable. In the winter, relative humidity is average, at 55 percent in January. and low in autumn a 45 percent due to heat waves (EEAA, 2009). The prevailing wind direction is from the north and northwest with an average speed of 13 km/h (Windfinder, 2012), and moisture content decreases in the summer (W. Underground, 2012).

b. **Landform:** Many physiographic units may be distinguished in the Marina El Alamein area. Besides these features, biotic factors, including human impacts, help to characterize landscape units. The main features of the various physiographic units lead to the distinction of three major physiographic systems (Ayyad M.G, 1983): coastal, ridges and depressions, and inland plateau system. The coastal system covers a small part composed mainly of calcareous rocks overlain by dunes. The ridges and depression system constitutes the main part of the territory, including gentle slopes and relatively large depressions. The inland plateau system is close to the inland desert characterized by extensive flat rocky surface and shallow soil (Selim, 2002). The coastal system prevails in the touristic area.

c. **Soil conditions:** The soil types closest to the beach are calcareous ridges of recent marine origin alternating with sandy depressions followed by a thick and very hard slab formed by deposits of mixed Aeolian and Colluvial origin. The coastal plain is sandy soil characterised by moderate depth, sand, saline, and excessively calcareous with significant gypsum accumulation. On the other side of the North coastal main road, soil is low in organic matter, deep, non-saline (salinity increasing with depth), calcareous with or without a zone of slightly defined lime accumulation (Ayad, 1983; Faculty of Science, 2005). The soil is relatively dry due to drought-like conditions in the summer and occasional heavy rain in the autumn. Soils are sandy loam to sandy clay loam and often at least 1m deep; salinity problems are frequent in the lowest lying areas. The chemical analysis of these soils indicates that they are characterized by low salt content. Calcium carbonate is generally very high in the coastal areas (Boshra, 2007).

d. **Water sources:** The surface water in the area is very limited as precipitation is 120mm per year as indicated. In the inland plateau, rainfall water is partially lost to evaporation and the rest infiltrates to the shallow soil to be used by native species or eventually lost to evaporation. Northwards, the landscape shows some valley catchment areas (Shalabi, 2000). Relatively large quantities of groundwater are found at depth in rocks, but the quality of the water is brackish to highly saline and is not suitable for most cultivation. The depth of the water table varies from less than 1m to more than 50m (Shalabi, 2000). Fresh water is pumped from the Alexandria distribution network into two pipelines running parallel at an average capacity of about 8000 m^3 in autumn to 10600 m^3 in summer (IDSC, 1998). Grey water from the Nile is the main source of irrigation, arriving through El-Nasr canal till Al-Hammam ending at El-Sheikh Zayed canal which turns into pipelines at Marina El Alamein region (Shalabi, 2000).

The main sources of water in Marina El Alamein touristic region are the pumped fresh water suitable for drinking and the grey water for agriculture and irrigation. There are two main irrigation techniques which are drip system and sprinkler system, where the drip system is used to irrigate trees and the sprinkler system to spread grass areas.

2. Biotic factors:

a. **Plants:** Native fruit trees, such as olives, dates and figs, grow well in the area, where 51 percent of Egypt's production of olives are in the north-western coast. Other crops, such as barley, are grown (Selim, 2002). Despite having 120 species that grow in the area, Marina El Alamein touristic region depends on cultivated plants such as Ficus spp, Cassia Nodossa, Delonix regia and Oreodoxa regia, in addition to the use of extended grass areas on a large scale (see Figure 3). These cultivated plants do not match soil conditions and require a significant amount of fertilizer, necessitate continuous maintenance and, as water loving plants, need a large amount of water. Native desert plants would require almost no water after their first year (Gabr, 1990).

Figure 3: The use of cultivated plants and extended grass concepts (Salama, 2012)

b. **Wildlife:** Marina El Alamein touristic region is considered as a closed residential resort, so grazing is not permitted in this location. Only birds are found. In El Alamein area south of the road, the natural vegetation includes many species of annuals, mostly herbs and a few grasses, perennial herbs, and shrubs, which provide a good pasture for grazing and animal husbandry (Selim, 2002).

To summarize, the important issues in the biotic and abiotic factors associated with planting design are soil, water and the planting concept. Marina El Alamein region's soil contains remarkable levels of carbonates, characterised by high salinity in the lowest areas and relatively dry soil in the hot season. Water sources are readily available, but it is not conserved by current planting design that favours plants and a wide range of extended grass concepts with high water use. It must be noted that there will be a serious water shortage facing Egypt in the next period (Cunningham, 2012), making water conservation practices in planting design in this region an important opportunity.

Table 2 shows a summary of the analysis of abiotic and biotic factors of the study area.

The second category in the evaluative framework is planting design considerations, which consider plant selection, whether native, adaptive or cultivated; planting process; and main planting concept with an environmental, aesthetic or architectural imperative.

CATEGORY 2: PLANTING DESIGN CONSIDERATIONS

1. **Planting main concept:** The planting concept of Marina El Alamein consists of aesthetic design conventions, thought of as decorative elements, applied almost an afterthought after the completion of building construction. Plants represented are imported from non-arid regions such as Europe.

Grass is the most prevalent planting material as shown in Figure 2, whether in public or private spaces. Abiotic and economic factors suggest that grass areas are to be used sparingly as they require soil, water and heavy maintenance.

Table 2: Factors affecting planting design in Marina El Alamein touristic area

	NO	FACTORS	DESCRIPTION	PROBLEMS	PROBLEMS SOLVING POSSIBILITIES
Abiotic Factors	1	**Climatic Conditions**			
		Climate zone	arid Mediterranean	- Hot dry seasonal climate - One rainy season	
		Solar radiation	Very sunny climate		
		Temperature	Hot summer, about 34'C Mild winter, about 20'C		
		Rainfall	One rainy season during the period between October and February.		
		Humidity	High most of the year Lower values in autumn		
		Wind	From the North West or from the North East		
	2	**Landform**			
			Northern coastal plain		
	3	**Soil Conditions**			
		Soil Types	elongated calcareous ridges of recent marine origin alternating with sandy depressions	- Remarkable increase in carbonates - Soil salinity - Relatively dry soil	
		Soil Analysis	Carbonates is moderate to high		
		Soil Fertility	Salinity problems in lowest areas. Calcium carbonate is very high in the coastal areas		
		Soil Moisture	Relatively dry		
	4	**Water Sources and Irrigation Techniques**			
		Sources and Quality	Surface water and Ground Water and Grey water	- Limited sources due to one rainy season and groundwater salinity - One main source for irrigation.	
		Water Analysis	Fresh water pipes from Alex. Saline ground water		
		Irrigation Systems	Main source is irrigation canal from Nile using drip and sprinkler systems.		
Biotic Factors	1	**Plants**			
		Plants type	Native Plants :No native plants Cultivated Plants: Ficus spp, Cassia Nodossa, Delonix regia. Oreodoxa regia, etc.and using extended grass areas.	- Extended grass concept and Cultivated plants which need great amount of water and fertilizers	
	2	**Wildlife**			
			There is no grazing in the touristic area boundary.		

On the other side of the road, Golf Porto Marina has an area of about 600,000 m^2 planted with grass (see Figure 3). In order to achieve this concept, thousands of tons of top soil has been brought from the Nile Valley to cover desert soil with about 30-50cm of clay. The irrigation system follows surface techniques. The soil draws salts due to evaporation, which creates problems and depletes grass areas. Aesthetic and architectural considerations prevail in the design concept and selection of plants. A static form dominates the landscape, with mowed grass and shaped trees. Natural desert planting concepts are almost completely absent. It is possible to achieve aesthetically pleasing effects by using of native plants with road formation and gravel of various colours, which would provide ground surface texture (see Figure 4).

Figure 4: The natural desert plant concept (Salama, 2012).

2. **Plant selection:** Limited knowledge of indigenous plants has contributed to the import of foreign plant species. Most plants in the study area were chosen according to experiences in the Nile Valley as a plant taxonomist in the area of study pointed out. Further, an agriculture engineer working in the area explained that designers choose the species they are familiar with. The introduced plants in the area do not satisfy environmental desert conditions. For example. Oreodoxa regia (Royal palms), Delonx rega (Poinciana) and Ficus nitida are introduced plants in this area. It was observed that most non-adapted species die within a few months of planting and less adapted ones require large amounts of irrigated water

to survive. Native plants are undervalued because of a lack of cultural appreciation and hence are not found in Marina El Alamein touristic area, despite aesthetic and economic values as well as water conservation benefits and ready soil conditions.

3. **Planting process:** On a large scale, the natural desert planting should start by creating an overall framework with fast-growing pioneer species that are adapted to arid conditions. This will create shelter, shade and screening for the intermediate phase plants which will ultimately replace the pioneers. The final phase will concentrate on slow-growing shade tolerant species which will be long-lived. This new microclimate will afford some protection to more sensitive plant species, encouraging them to grow (Gabr, 1990). This process is known as the succession process.

   The next part of this paper applies the evaluative framework to the case study area. It provides conclusions regarding the factors that affect planting design in the area and suggests planting design considerations necessary to resolve challenges associated with sustainable planting design in coastal areas.

PART 3: Application of the Evaluative Framework

The analysis and evaluation demonstrates that criteria achieving a medium score are planting design concept and water sources. Aesthetic uses and architectural uses were well considered; however, they were achieved at the expense of environmental uses. Other plant concepts could have arrived at similar aesthetic and architectural functions whilst scoring high on environmental grounds. Water sources used are diverse, hence scoring a medium score, however, malpractice exists and current sources are definite. Less successful criteria have shown disregard to the hot climate, soil problems, native plants and succession planting process.

In order to achieve sustainable planting design in the Marina El Alamein touristic area, designers should consider using native plants in planting design to suit the hot climate, soil salinity, and water conservation, in addition to their aesthetic value.

They should also consider using the natural planting concept which suits the environment of the arid regions and desert areas, instead of the extended grass concept which mainly depends on heavy irrigation and soil modifications. Also, the use of a succession process is considered the suitable way for the growth of adaptive plants which can survive in this microclimate.

Table 3: Evaluation of Marina El Alamein Planting Design.

Sustainable Planting Design Evaluative Framework	Criteria of evaluation		Evaluation and description		
	Planting Design considerations	Planting main concept	Low		Use of extended grass concept Aesthetic use dominates, Architectural use considered
			Medium	√	
			High		
		Plant selection	Low	√	Dominant use of cultivated plants Little to none use of adaptive and native plants
			Medium		
			High		
		Planting process	Low	√	Top soil, seed spread, transplant and surface irrigation practices from the Nile Valley
			Medium		
			High		
	Factors affecting planting design	Water sources & Irrigation techniques	Low		Use of drip irrigation in some areas Disregard of limited sources
			Medium	√	
			High		
		Soil Conditions	Low	√	Disregard of salinity, high carbonate content and dry soil
			Medium		
			High		
		Landform	Low	√	Solutions to soil stabilisation not used, instead use of grass as ground cover
			Medium		
			High		
		Climatic factors	Low	√	Disregard to the hot humid climate most of the year
			Medium		
			High		
		Biotic	Low	√	Complete change of habitat
			Medium		
			High		
Project	Marina El Alamein Touristic Region			Evaluation	Description

Conclusions

Plant materials are important physical elements in landscape design and the management of the environment. The environmental uses of plant materials, rather than architecture and aesthetic uses, are of great importance in arid regions which have precarious environmental conditions. Notwithstanding the significance of aesthetics in landscape design, the visual characteristics of native plants qualify them for aesthetic purposes and are directly related with the surrounding environment allowing them to adapt and survive their environment by having a special size, form, colour, and texture.

The arid region is characterized by high temperature, and relatively high humidity. The soil is characterized by its salinity and drought. Water shortage and salinity are due to high evaporation and low precipitation, which affect the plant growth. The key to sustainable planting is matching the plant with the conditions of the environment, preventing needless exhaustion of natural and financial resources. A plant that is poorly suited for the site will not succeed even if best planting procedures are available. The use of the succession process in planting new reclaimed areas provides short-lived species with the suitable microclimate they need to survive in the harsh environment.

Finally, natural desert planting is not widely practiced because of a limitation in suitable plant species but also due to a lack of knowledge in best-suited plant species and maintenance considerations. A sound ecological understanding of a site as well as knowledge of available native species and their planting process is sorely needed.

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PAPER 13

Vulnerability Assessment of Bivalves Due to Climate Change and Coastal Pollution in Nile Delta Coastal Region

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Abstract: Egypt is faced with two major environmental problems on its coastal zone and they will have a direct and critical impact on Egypt's entire economy. The first problem is climate change and its impact on the coastal environment; the second is coastal pollution. Successful environmental management and governance can be realized through maximum dissemination of information. The aim of this work is to assess the bivalves' vulnerability to climate change and coastal pollution using its hard structure (shells). Comparison between the growth rate and calcium carbonate contents of ***Cardium edulis*** and ***Mactra corallina*** shells collected from Nile Delta coast in 1999 with the recent shells collected during 2011 from the same place was carried out to assess the different environmental effects of climate change and coastal pollution in the 12 year interval on the shells. Al, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, V, Zn and U were measured using ICP for the shells under investigation. The investigation of the differences of Cardium shell thicknesses revealed that the shells collected during 1999 were thicker than shells collected during 2011. It means that the availability of calcium carbonate, which is critical for the organism to build its shells, has decreased in the Nile Delta coastal environment since 1999; this indicated that more CO_2 converted to carbonic acid thus resulting in more acidification. The influence of water temperature increase on shells was also studied.

Keywords: costal pollution, bivalves, acidification, biomonitoring

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Introduction

The coastal system is a dynamic environment with complex interactions between climate and non-climate drivers of change (Ramieri *et al.*, 2011). The consequences of climate change and marine pollution on the Nile Delta coastal zone are considered as they can affect the Egyptian way of life and their economics. Environmental indicators are powerful and cost-effective tools for tracking environmental progress, providing policy feedback and measuring environmental performance. Therefore, recognition of an environmental indicator for climate change and marine pollution at the Nile Delta coastal ecosystem is highly valuable and useful.

Many marine ecosystems are sensitive to climate change. According to IPCC (2001), "global climate change will affect the physical, biological and biogeochemical characteristics of the oceans and coasts, modifying their ecological structure and their functions." A useful approach to consider six primary climate drivers and their respective impact on 13 secondary or process variables was presented by Nicholls *et al.* (2007). The six primary drivers of coastal climate change impacts are sea level, wave, temperature, CO_2 concentration (acidification), runoff and storms.

Long-term changes in Alexandria air temperature have been observed; historical data indicated acceleration of the increasing of air temperature with time (NOAA, 2011). Increasing global and regional air temperature brings about increases in water temperature, which is likely to adversely impact water quality (Gleick, 2000). Increasing water temperature at Nile Delta coastal region was confirmed by the Egyptian Environmental Affairs Agency (EEAA and EIMP, 2012) and by El-Gamal and El-Shinnawy (2012) and that slight increase of water temperature along the Nile Delta coastal area through 10 years was monitored.

Ocean acidification occurs when atmospheric CO_2 is absorbed into the ocean, where it converts into carbonic acid. Therefore, pH is considered the best way to measure acidification. As CO_2 globally levels increased from 1998 to 2010 (NOAA, 2011), the oceans have gradually grown more acidic. The investigation of the time series of the surface seawater pH revealed that gradual increase of acidification (decrease of pH values) was observed at Nile Delta coastal stations (El-Gamal and El-Shinnawy, 2012). Increasing CO_2 levels and the resultant lower pH of seawater decreases the saturation state of calcium carbonate ($CaCO_3$). Therefore, increases in surface ocean CO_2 levels could have severe consequences for organisms that make external $CaCO_3$ shells. The layers of mollusc shells are comprised of either all aragonite or inter-layered aragonite and calcite (Royal Society, 2005). To make these calcareous structures, seawater has to be supersaturated with calcium (Ca^{2+}) and carbonate ions (CO_3^{2-}) to ensure that once formed, the $CaCO_3$ does not dissolve. Lower pH reduces the carbonate saturation of the seawater, making calcification more difficult and also weakening any structures that have been formed (Royal Society, 2005; Carre *et al.*, 2006). Therefore, the potential consequences of ocean acidification are concerns that structures made of calcium carbonate may become vulnerable to dissolution, affecting the ability of shellfish to form shells. Another concern is the sensitivity of aragonite to acidic conditions. In lower pH conditions, aragonite, which binds the Ca^{2+} and CO_3^{2-}, will dissolve, thus causing the shell will dissolve. Duarte *et al.* (2013) mentioned that in coastal ecosystems, the detection of trends towards acidification is not trivial and the attribution of these changes to anthropogenic CO_2 emissions is even more problematic.

Biomonitoring of environmental change, including pollution, has received increasing interest in recent years (Dick *et al.*, 2007). Biomonitoring offers an appealing tool for the assessment of metal pollution in aquatic ecosystem (Zhou *et al.*, 2008). Heavy metal accumulation in bivalve soft tissues has received increasing interest in recent years with respect to biomonitoring of environmental change, including pollution. To a lesser extent, accretion of elements from the environment into bivalve hard structures (shells) has been investigated and acknowledged (Dick *et al.*, 2007). Environmental archives are useful tools for describing past and current climate variations and they provide an opportunity to assess the anthropogenic contribution in coastal ecological changes (Halfar *et al.*, 2008; Jones *et al.*, 2009; Rosenheim *et al.*, 2009).

Shells of bivalve mollusks are now increasingly used for climate reconstructions. Mollusks combine virtually all the requirements for being a perfect environmental indicator and climate recorder. Bivalves sensitively record changes of ambient environmental conditions, in particular temperature (Henderson, 1929; Kennish and Olsson, 1975), food availability (Page and Hubbarrd, 1987; Sato, 1997), salinity (Davis and Calabrese, 1964; Marsden and Pilkington, 1995) and pollution (Mutvei *et al.*, 1996; Dunca *et al.*, 2005). Environmental variables are recorded in the shells in multiple ways, i.e., as variable growth rates (Koike, 1980; Kennish and Olsson, 1975) and variable geochemical properties (Jones *et al.*, 1986; Wefer and Berger, 1991; Owen *et al.*, 2002). Bivalve shells also function as calendars. Periodic accretion of calcium carbonate is controlled by biological clocks (Clark, 1975; Thompson, 1975; Richardson *et al.*, 1979; Kim *et al.*, 1999) and divides the growth pattern into time slices of approximately equal duration, i.e., growth lines and growth increments. Aside from annual growth patterns (Jones, 1980; Ropes *et al.*, 1983), bivalves form daily growth increments and lines (Berry and Barker, 1968; Pannella and MacClintock, 1968). Bivalves exhibit an extremely broad biogeographic distribution (Schöne *et al.*, 2005).

The aim of this work is to assess the vulnerability of mollusk bivalves to the consequences of coastal pollution and climate change on the coastal water quality. This aim will be achieve through different ways. Bivalve growth rate will be measured, by studying the variation of shell growth increment between the 1999 shells and 2011 shells, to indicate the historical variation of water temperature due to climate change. Also, the difference in shell thickness will be measured to inidicate the slight increase of acidification and decrease of the availability of calcium carbonate. Moreover, geochemical data (variation of elemental concentrations) can be extracted to indicate the coastal pollution through the bivalve life proxies archived in its shells.

Materials and Methods

Study Area

The area of study is the Nile Delta coastal region and the bivalve shell samples were collected from El-Gamil outlet (at the outlet of Elmanzalah Lake) near Port Said and from El-Burullus Lake outlet as shown in Figure 1. Control shells were collected from Ras Elhekam (unpolluted area) at the northern Egyptian coast. The Nile Delta is located in the North of Egypt; it's the area where the Nile flows into the Mediterranean Sea. In fact, the delta contains near the two thirds of the Egyptian population, and 45% of the agricultural production of the country. Most big cities in Egypt are located in this region, because climate is more pleasant for the population and ground is fertile. The high density has consequences on nature. These described conditions are inducing water pollution. The Intergovernmental Panel on Climate Change declared the Nile Delta one of three sites on earth that are most vulnerable to sea level rise as consequence of climate change (IDRC, 2011). Consequently, any rise of the sea level will have a major impact in Egypt (Huguet, *et al.*, 2012).

Representative bivalve species samples were collected from the area under investigation. Two bivalve species were studied in this work: the edible cockle *Cardium* (*Cardium edulis*) and the Rayed trough shell *Mactra corallina* (Figure 2). On the tidal flat, Cardium and Mactra were collected by hand, by digging out with a plastic fork. These two species were compared with the same species collected during 1999. These coastal areas are generally rich in bivalves.

The work and activities will be divided into two main branches. The first is to investigate the vulnerability of the bivalve shells to coastal pollution and the second is to investigate the vulnerability of bivalve shells to the consequences of climate change (i.e. water temperature and acidification).

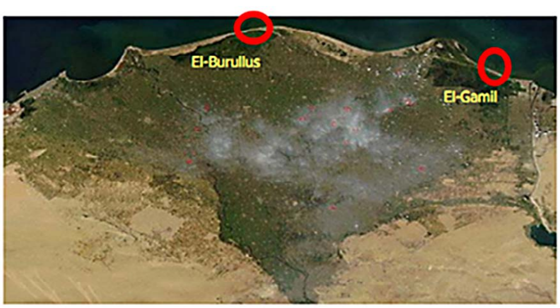

Figure 1: Map of the Nile Delta sampling sites.

Figure 2: Two bivalve species were studied. *a) Cardium edulis, b) Mactra corallina*

Checked Bivalve Species

Biomonitoring of acidification has been carried out using Cardium shells. It was investigated by comparing features of Cardium shells collected from El-Gamil during 1999 with those recently collected during 2011. Shells were cut through the umbo with a diamond saw and wet polished with sandpaper (400 and 600 grain size as described by Philipp *et al.*, 2005). The age determination has been carried out by studying annual deposited rings within the shell umbo (Brey and Mackensen, 1997). Dimension measurements of Cardium shells have been carried out using vernier calipers. The growth patterns of the etched cross-section were then viewed under JEOL JSM-5300 Scanning Microscope after coating of the shell slights by JFC-1100E Ion Sputtering Device.

Heavy Metal Analyses

Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) with radial torch equipped with argon saturation assembly was used for the determination of lead and cadmium. High purity (99.99%) argon was used as plasma, auxiliary and nebulizer gas. The gas flows were kept at 15.0 l/min for plasma, 1.50 l/min for auxiliary and 0.56 l/min for nebulizer. Radio frequency (RF) power of the plasma generator was 1.35 kW. Vertical height of the plasma was fixed at 7 mm. Sample uptake time of 30.0 sec, delay time of 5 sec, rinse time of 10 sec, initial stabilization time of 10 sec and time between replicate analyses of 5 sec was maintained throughout the studies for ICP-OES. All the observation of emission were recorded corresponds to the most sensitive emission wave length of Al, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, V, Zn and U. The instrument was calibrated for various parameters before the studies.

Quality Control

To ensure the reliability of the test results, quality control was carried out. Sample collection was replicated from selected bivalve shells having the same stage of growth and collected from the same site. These samples were tested on a batch basis, with each batch including blank and duplicates. The reagent blank included all of the reagents used in both the analytical digestion process and went through the entire process (digestion). Duplicates of 10% of the samples were with every batch. Two unknown routine samples were analyzed for every tenth sample of the selected shells. The final solution was analyzed in the same manner. Analysts in prepared solutions from the actual samples were analyzed in a randomized order in the most repeatable way possible (same day, same equipment and same person). Duplicate samples were used to calculate the precision of the analytical results.

Table 1: Lower limits of detection (LLD) of the elements under investigation using ICP-OES.

Element	LLD	Element	LLD
Al (ppm)	0.032	Mo (ppm)	0
Cd (ppb)	0	Ni (ppm)	0.007
Co (ppb)	0	Pb (ppm)	0.001
Cr (ppm)	0.002	V (ppm)	0.0004
Cu (ppm)	0	Zn (ppm)	0.03
Fe (ppm)	0.044	U (ppm)	0.003
Mn (ppm)	0.001		

Results and Discussion

Time series distribution of the ambient sea surface temperature and its pH were measured during the period from October 1998 to September 2011. Figure 3 shows the trend of the average values of sea surface temperature and pH at Nile Delta coast (Rashid, Elburullus and Damietta). The average values of sea surface temperature have a slightly increasing trend with time while pH has a slightly decreasing trend with time indicating more acidification.

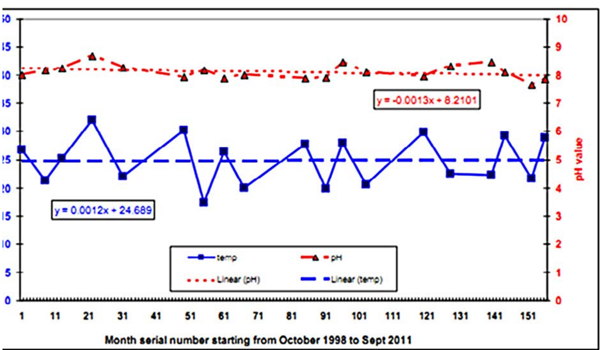

Figure 3: Linear trends of the average sea surface temperature and pH values at Nile Delta region during the period from October 1998 to September 2011.

Mollusk Shell Vulnerability to Climate Change

A pilot study was done to compare the Cardium shells collected during 1999 with the recent shells collected during 2011. The shells under investigation were around 4-5 years old. Cardium shells have been investigated for the two main key drivers: acidification and surface seawater temperature. The first investigation is the study of the difference in thickness between shells collected recently in 2011 as indicator of the climate change and acidification and compared with relatively old shells collected during 1999. The second investigation studies the distance corresponding to growth at a specific year and compare this distance between shells collected recently in 2011 and with relatively old shells collected during 1999. The wider distance is indicative of the relatively higher ambient temperature of the shells' environment during their lives.

1. BIOMONITORING OF ACIDIFICATION

Mollusk shells are considered as natural archives or natural recorders of changing environmental conditions because the accretion or growth rate of the natural archive is influenced by the prevailing climatic conditions. Two different techniques have been used to study the difference in shell thickness.

The first technique was carried out by taking vertical slices starting from the shells umbo for comparison of shell thickness between of the growth lines during the different years as shown in Figures 4 and 5. The thickness of the annual growth lines of first, second and third years were measured as 1.75, 2.7 and 2.85 mm, respectively, of the Cardium slices collected during 1999 and 1.35, 1.85 and 1.9 mm, respectively, of the slices collected during 2011.

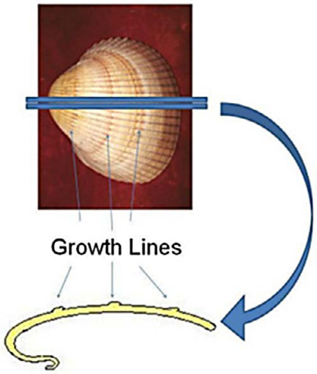

Figure 4: Vertical slice of Cardium shell

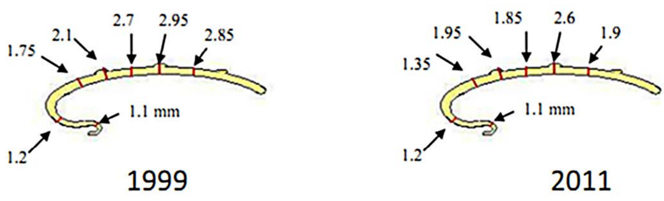

Figure 5: Differences of Cardium shell thicknesses during 1999 and 2011.

Moreover, higher thickness at the position of the annual growth lines was observed as 2.1 and 2.95 mm for the first and second annual growth lines for 1999 Cardium compared with 1.95 and 2.6 mm, respectively, at the same growth lines for the 2011 shells as shown in Figure 5. The investigation of the differences of Cardium shell thickness during 1999 and 2011 revealed that shells collected during 1999 was thicker than shells collected during 2011 at different parts within the life period of the bivalve. It means that the calcium become less available in the marine environment within the area under investigation in 2011 than in 1999. This indicated a decrease in the availability of calcium that was required to build its shells; this decrease is a result of increasing amounts of CO_2 due to climate change and the resulting acidification. Detailed growth lines investigations have been done using scanning microscope as shown in Figure 6.

This result is in agreement with the finding of Gazeau *et al.*, (2007) that shellfish are unable to produce thick shells in low pH conditions because of the dissolution of aragonite and the low abundance of CO_3^{2-} in the water (due to CO_2 increase). Bibby *et al.* (2007) also observed that the intertidal snail *Littorina littorea* (the common periwinkle), in normal pH conditions, produces thicker-than-normal shells, but was unable to do so in low pH conditions. Shell dissolution and decreasing rates of calcification cause an increased susceptibility to predation and altered behavior. Consequently, shellfish (extinction of some species) provide food for man and a refuge for some species of fish. Without shellfish, these fish species may not be able to find food or become more susceptible to their predators, which in turn can cause declines in their populations and possibly lead to extinction and changes to entire ecosystems.

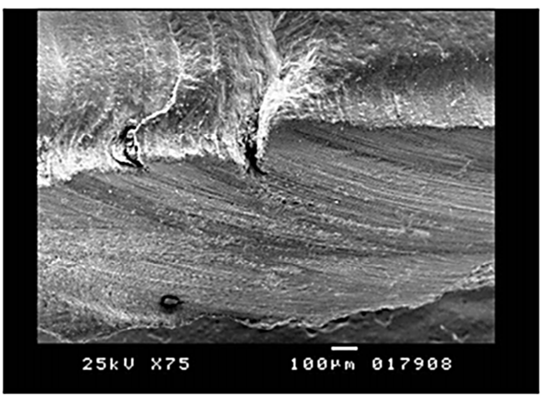

Figure 6: Cardium shell slice under scanning microscope showing the growth lines during 2011.

The second technique was carried out for another group of Cardium shells which have approximately the same age and collected during 1999 and 2011. The shell samples under investigation were examined for their total length and width. The recent shells were found wider and longer than the 1999 shells as shown in Figure 8. In the middle of growth distance of the second year (between annual growth line 1 and 2), horizontal slices were taken as shown in Figure 7. In spite of the recent shells being wider and longer, they were determined to be thinner at the lower lines but they compensate this lowering of thickness by elongating (increasing the heights) their ribs as shown in Figure 9. This is another confirmation of the decrease of the amount of calcium due to the increase of CO_2 in seawater. Finally, the results revealed that Cardium species are vulnerable to climate changes and its consequences to the coastal marine environment such as acidification.

2. BIOMONITORING OF WATER TEMPERATURE INCREASE

The investigation of bivalve shells against water temperature as a measure of climate change was carried out for group of Cardium shells. They were approximately the same age and collected during 1999 and 2011. The shell distance within the growth lines during the second year has been investigated at specific position of the shells between annual growth line 1 and 2 years using vernier calipers. The increase in the 2nd year growth distance of shells collected in 2011 compared with the others collected in 1999 revealed that shell size is one of the consequences of increasing water temperature as shown in Figure 8.

The higher water temperature means higher rate of growth which leads finally to higher in size. This is another biological confirmation of increasing of seawater temperature.

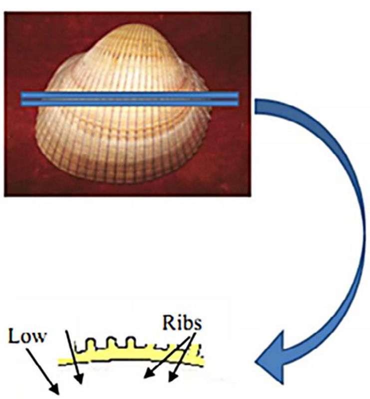

Figure 7: Horizontal slices of Cardium shell showing the thickness of the ribs and at the lower lines.

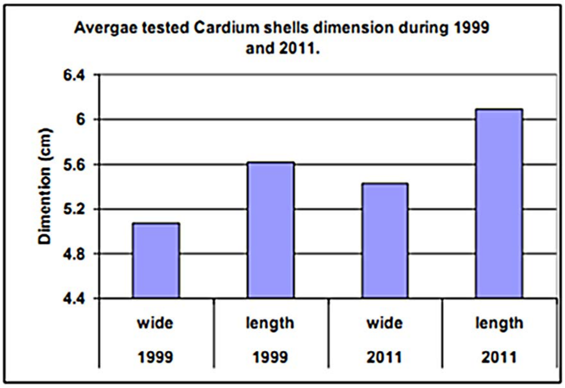

Figure 8: Average dimension of the Cardium shells under investigation.

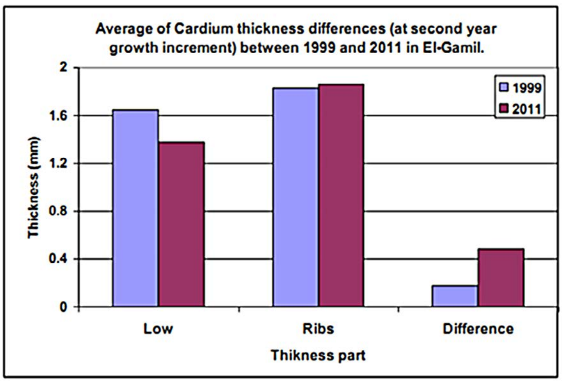

Figure 9: Average thickness of the second year growth increment of Cardium shells under investigation.

Mollusk shell vulnerability to coastal pollution

Two mollusk species have been investigated for coastal pollution; *Cardium* and *Mactra* collected during 1999 were compared to the recent ones collected in 2011. Both species were investigated by ICP-OES that can measure Al, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, V, Zn and U. The comparison between the two species with the control species has been represented in Figures 10 and 11. The majority of heavy metal under investigation was found at higher concentrations in shells collected in 1999 than in 2011. Significant higher concentrations of Co, Ni and Fe were detected in *Mactra* shells collected from El-Burullus during 1999. Figure 12 shows the accumulation of all the measured heavy metals in groups according to the species and the year. In general, 1999 shells, either *Cardium* or *Mactra*, were found to have higher concentrations of the detected elements than the same species collected in 2011. Also, shells collected from the less polluted control area contain relatively small amount of any of the heavy metals under investigation. Figure 12 shows that *Mactra* 1999 has been recognized as the most polluted species (450 ppm). At 2011, the pollution monitored biologically through the bivalve shell indicated that the coastal pollution has retreated gradually. This may be due to the government's efforts to reduce pollution in all forms and the implementation of the Ministry of State for Environmental Affairs and the Egyptian Environmental Affairs Agency with the Environmental Laws starting with #4 for 1994 and the new version 9 for 2009. This is a confirmation that bivalve shells can be used as indicator for heavy metals and pollution detection. It confirmed by many authors such as Sadikaj *et al.*, (2010), Brown *et al.*, (2005) and Fischer (1988).

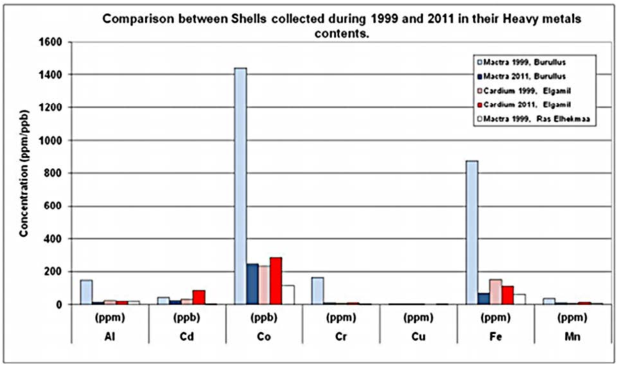

Figure 10: Comparison between mollusk shells in their Al, Cd, Co, Cr, Cu, Fe, and Mn content.

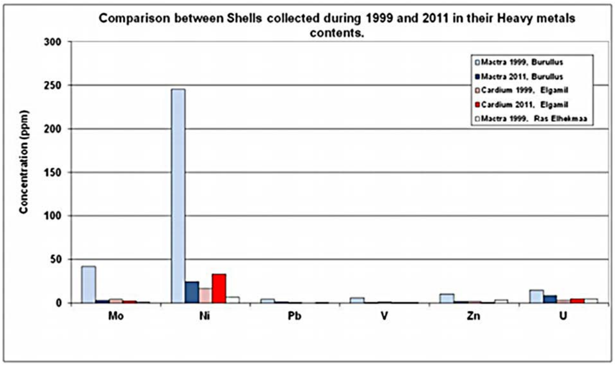

Figure 11: Comparison between mollusk shells in their Mo, Ni, Pb,V, Zn and U content.

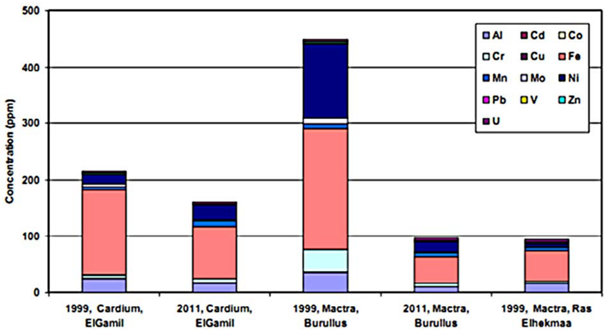

Figure 12: Heavy metals concentrations of shells under investigation

Conclusions

- The potential use of bivalve shell as a bioindicator for climate change and coastal pollution was discussed and tested.
- Both increasing temperature and the acidification of ocean waters will have profound effects on near coastal ecosystems, affecting the biota and potentially in the long-term, the generation of calcareous sediment supply by marine organisms.
- Regarding the increase of acidification due to an increase of CO_2 as a consequence of climate change in the marine environment, shellfish form its shells from calcium carbonate was categorized as vulnerable species.
- The thickness of the shells collected during 2011 is thinner than those collected in 1999 and the organism compensates this effect by enlarging its ribs.
- Different water pollutants can be detected in the bivalve shells.
- The biomonitoring of coastal pollution revealed that the pollution load is retreating due to the efforts of EEAA and other environmental affairs stakeholders.

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Chapter Three

Water

PAPER 14

Towards a Water Based Regional Development Model for Siwa Oasis in the Western Desert-Egypt

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Abstract: Siwa Oasis is a depression which uses groundwater as the only source for everyday use as well as all development and economic activities. For thousands of years, the Siwa natural system was well preserved by the local community, ensuring sustainability and minimum environmental risks and threats. With emerging pressure from development, coupled with challenges posed by climate change consequences and threats, a future regional development model focused on the issue of water management on Siwa became an urgent issue. Since the 1960s, the Oasis experienced a significant change in activity patterns having great impact on land use and ultimately and seriously on water balance and management. Changes included expansion of agricultural activities, tourism, urban development, ground water mining, and food industries. These activities significantly affected factors such as land cover, water demand, waste water types and amount, economic stability and, last but not least, social structure and cultural habits. Appreciating the urgent need for development and the continuous pressure on natural resources, this paper tries to draw a conclusion on the various aspects, forces and impacts of regional development. From this, a model is built to integrate important and significant forces and impacts for use in projecting and understanding the future of Siwa and its region. The paper starts with a brief review of the status of environmental and economic conditions in Siwa Oasis and its regional sphere. It then discusses the changes that occurred during the last 50 years, trying to identify the main factors affecting the balance in the environmental, social and economic system of the Oasis.

Keywords: Siwa, regional development, water management, arid zone, oasis.

1. Introduction

This paper evolves from previous research (Salheen, 2011) in which an environment-led approach for the development of Siwa Oasis, Egypt, was explored. In Salheen's paper, it was clear that water management is the main consideration associated with the development of the Oasis, which is located in the Western Desert in Egypt. The current research is an attempt to give a further review on the issue of water management in the Oasis, with a focus on environmental and economic conditions. This attempt is a first step towards next research steps aiming to build a regional development model that takes into account the various aspects, forces and impacts related to the future development of the Oasis. This model is meant to support the previous and current governmental efforts to develop a comprehensive plan for the Oasis as well as a strategic plan for Siwa in particular.

Siwa is the largest oasis in Egypt with an approximate area of 1175 km2. It is located about 800 km west of Cairo and 300 kilometers inland from the Mediterranean Sea. It is situated in a depression of 20 m below sea level. Connected to the other oasis and urban centers through roads and trails, Siwa is the gate to the many Safari trips to the Western Desert and provides the main link between Egypt and Libya. Historically, Siwa was on the main trade line between North Africa and Egypt, providing the route for annual pilgrimages and seasonal trips. The main road leading to Siwa is now Matrouh–Siwa which extends a length of 306 km (as shown in Figure 1).

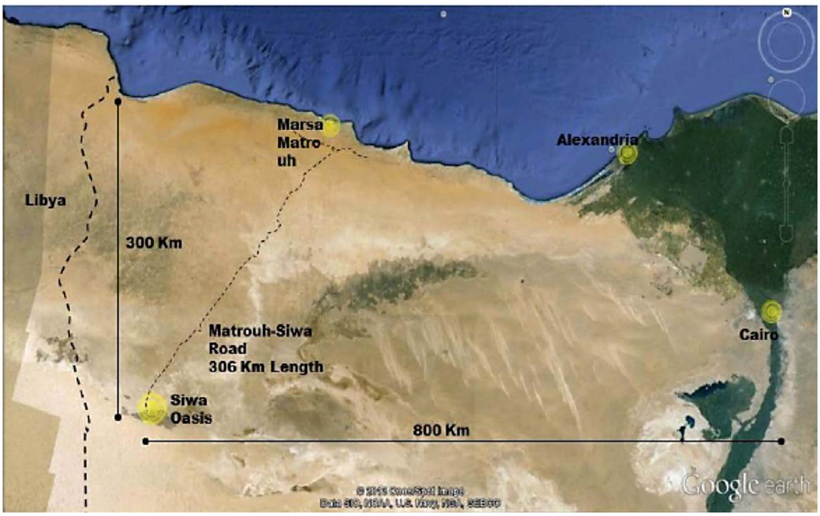

Figure 1: Location of Siwa oasis (Source: Google Earth modified by the author)

Siwa Oasis is an elongated depression, with a length of about 75 km (east to west) and a width of 5 to 10 km (north to south). It is bounded in the north by escarpments rising about 100 m above its oasis ground level and it is bounded in the south by several belts of sand dunes stretching west, north-west, and south-east. Siwa is part of the great depression in which it lies; it extends from Zeitouna in the east to Bahi-edeen and Maraghe in the west – a distance of over 48 km in length. West of Maraghe extends a regular chain of small oases along the same valley or its offshoots reaching inside the Libyan borders, such are Girbe, Um Ghazlan, and Shiata (Figure 3) but there is no cultivation in these oases, despite water and excellent grazing for camels. important resource.

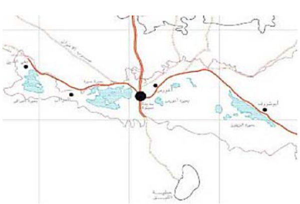

Figure 2: Main Roads to Siwa (Source: GOPP, 2007)

Groundwater is the most valuable resource in the oasis as it is the only source of water in the oasis. It is extracted from the Nubian Sandstone Aquifer System, which is considered to be a non-renewable source of water in the North Africa area. There is an essential need for optimal management of this

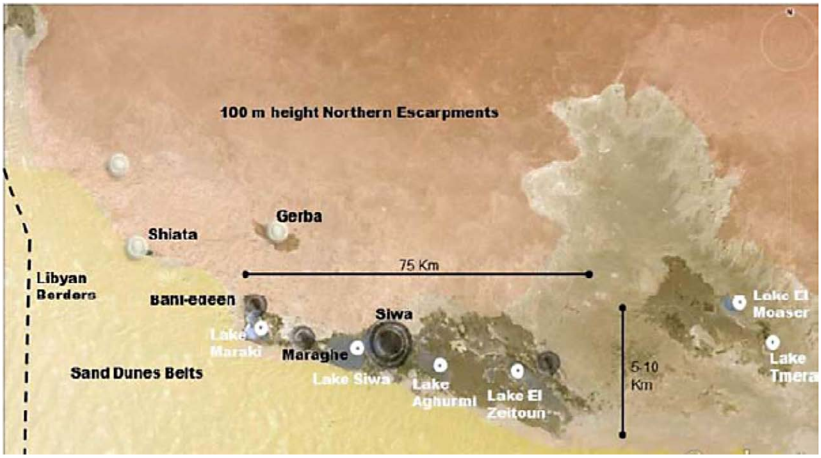

Figure 3: Siwa Oasis (Source: Google Earth modified by the author)

2. Methodology

This paper relies on the preliminary findings of a previous publication by Salheen, 2012, as a desktop research which highlighted the importance of water management, in particular for the future of Siwa. This was followed by an investigation field trip in November 2012 where various stakeholders met and interviews were conducted on the issue of water management in the Oasis (see Figure 4). The interviews focused mainly on discovering knowledge within the society and identifying points or milestones when water balance within the oasis is interrupted. Finally, solutions for the future development which acknowledged the specificity and sensitivity of the Oasis was also investigated. In a subsequent visit to the Oasis during December 2012/January 2013, parallel to a more general excursion, the author discussed and confirmed the findings that came out of the first visit (November 2012) and compared them to literature with technical staff and local authorities as well as local community members and natural leaders.

In this paper, two issues are further analyzed as the two poles of the envisaged development model. The first is the issue of water representing the supply side in the model and the second is the issue of land use representing the demand side. Potential future scenarios for development are also presented and evaluated in terms of advantages and disadvantages. Finally, the paper concludes with points from the main findings of this step of research and to the next steps towards the regional development model of Siwa, as a representative of other remote water-sensitive communities within arid zones.

3. Water Sources in Siwa

The Siwa Oasis suffers many environmental problems related to water use, management and water balance: water logging, soil salinization, increase in the surface area of the saltwater lakes and marshes and the rise of water table levels by 4.5 cm/year (Abo-Ragab, 2008). As a result, land productivity deteriorates, which in turn lowers agriculture income (Abo-Ragab, 2008). In this section, sources of water in the Oasis are being described and discussed.

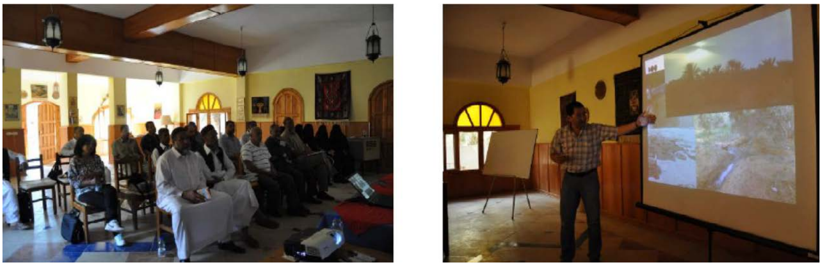

Figure 4: Focus Group Workshop on irrigation and water management, Siwa, Nov 2012.

The non-renewable groundwater of the Nubian Sandstone Aquifer is the only source of water in the Western Desert of Egypt and it is one of the major aquifer systems in northeast Africa. It is located between four countries – Libya, Egypt, Sudan and Chad – and has a huge storage capacity of about 200,000 bcm (billion cubic metres) of fresh water. However, only a small fraction (about 2% or 4,000 bcm) of this can be extracted in the Western Desert.

The results from the studies indicate that the deep groundwater from the Nubian Sandstone Aquifer can be extracted in the Western Desert at a rate of 2.4 bcm per year over a period of 100 years (see Table 1). Groundwater model studies showed that in the East Oweinat area and Siwa Oasis, groundwater can be exploited from the Nubia Sandstone Aquifer at an annual rate of 1.2 bcm and 0.14 bcm, respectively, over 100 years.

A. WATER SPRINGS

The most striking feature of Siwa is its springs. At one time it was said to possess 1,000 springs, but there are now fewer than 200 and of these only about 80 are of use for drinking and irrigation purposes. The water in them is particularly

Table 1: Basic data of the Nubian Sandstone Aquifer (Salem, 2002).

Country	Nubian system (Palaeozoic and Mesozoic sandstone aquifers) Area (km²)	Nubian system Fresh water volume in storage (km³)	Post Nubian system (Miocene aquifers) Area (km²)	Post Nubian system Fresh water volume in storage (km³)	Total volume of fresh water in storage (km³) (1)	Total recoverable ground-water volume (km³) (2)	Present extraction from the Post-Nubian system (km³)	Present extraction from the Nubian system (km³)	Total present extraction from the NSAS (km³)
Egypt	815,670	154,720	426,480	97,490	252,210	5,180	0.306	0.200	0.506
Libya	754,088	136,550	494,040	71,730	208,280	5,920	0.264	0.567	0.831
Chad	232,980	47,810	NA	NA	47,810	1,630	NA	0.000	0.000
Sudan	373,100	33,880	NA	NA	33,880	2,610	NA	0.840(3)	0.833
Total	2,175,838	372,960	920,520	169,220	542,180	15,340	0.570	1.607	2.170

NA: Not applicable.
(1) Assuming a storativity of 10^{-4} for the confined part of the aquifers and 7% effective porosity for the unconfined part.
(2) Assuming a maximum allowed water level decline of 100 m in the unconfined aquifer areas and 200 m in the confined aquifer areas.
(3) Most of this water is extracted in the Nile Nubian Basin (833 Mm^3/yr) which is not considered to be part of the Nubian Basin.

Source: CEDARE/IFAD Programme for the development of a Regional Strategy for the Utilisation of the Nubian Sandstone Aquifer System.

clear and sparkling; continuous streams of bubbles are always ascending to the surface, in some cases with such rapidity and violence as to give the impression that the water is boiling. Some of the springs, such as Ain el-Hammam and Ain Tamousa, are hot, which are in constant use by the women for bathing and washing clothes. Average ground water level rose from 150cm below ground surface in 1962 to 75cm below ground surface in 1987. This clearly affects agriculture by damaging the roots (see Figure 5).

The nature of irrigation water plays an important role in determining soil characteristics and productivity of land. The only source of irrigation water in Siwa oasis is the springs, which are spread all over the oasis. The water flow rate is about 200,000 m3/day. Therefore, it was important to study the quality of this water. Metals including Fe, Mn. Cu, Cd, Cr, Pb, Co and Zn were determined in water, soil and plant samples.

It was concluded from the results obtained and from the given classifications that these water sources are of relatively poor quality, since they contain large amounts of soluble salts. Such water is suitable for the irrigation of tolerant and semi-tolerant plants. Tolerant crops, viz. date palm or olive trees, are suitable for growing in the Siwa oasis, because they have great salinity resistance.

Figure 5: Field Visits of Water and irrigation features in Siwa, Nov 2012. (Source: the author)

Figure 6: Extraction zones of the Nubian aquifer (Source: Modified: Google Earth & Bakhbakhi, 2002)

B. WATER WELLS

The current annual groundwater extraction in the Western Desert is about 0.7 bcm, most of which is being utilized in irrigated agriculture and for domestic. Deep wells in some reclaimed areas (200 m in Siwa and 800 to 1,000 m in El-Farafra and El-Dakhla) are free flowing at relatively high rates (5,000 to 30,000 m3 per day) and high pressures (5 to 8 atmospheres at the wellheads) (see Figure 6). Control of the flow from these wells is difficult, due to problems associated with sudden back pressure in the water-bearing formation if the well is subjected to rapid and frequent shut-down. The back pressure can result in a collapse of the formation around the well, leading to abandonment of the well. While these wells can be controlled on a longer-term cycle (weekly or seasonally, for example), the continuous flow in the shorter-term produces water in excess of demand during the irrigation period; unused flow at night (the non-irrigation period) cause water logging, drainage problems, and soil salinization. These environmental effects may seriously reduce agricultural productivity.

3. Land Use

In this section, various land use patterns in the Oasis are reviewed and their impact on water usage, management and balance in the oasis is discussed. The main land use patterns that can be found in the Oasis are agriculture, tourism, industry and housing. The purpose of studying the land use is that it represents the demand side of water use in the Oasis. The following are the mainland uses found in the Oasis that have significant impacts on water demand. The balance between different land uses could help avoid unwanted environmental degradation of the Oasis as seen in Figure 7.

A. AGRICULTURE

Agriculture is considered the main economic activity within the oasis. Irrigation water comes mainly from the springs. The texture class of cultivated soil is either loam or sandy loam. The unused saline water from naturally flowing springs and the agricultural drainage water are poured into four main lakes, namely Siwa, Aghormy, Zeiton and Khamisa. Moreover, the migration of sand dunes from the southern and western directions seriously threaten agricultural activities, irrigation and drainage constructions, transportation, communications, as well as other aspects of socio-economic development in the oasis. The cultivated area has increased gradually as estimated by CAPMAS to have increased from 53.00km2 in 1990 to 87.95 km2 in 2008 (Figure 8). It is known that the agricultural area was maintained for centuries by the role of "the calculator" ("El-Hassab"), who was the individual with extensive endogenous knowledge regarding crops, seasons, water cycle and astronomy. This individual was responsible for allowing the addition of certain agricultural areas, crops, and irrigation systems to the area, while ensuring optimized water use, land and water resources, social justice, managing societal balances and negotiating power.

Figure 7: Signs of environmental deterioration in the Oasis: dying islands and palms due to increase in ground water level (top left); complete loss of plantation on Taghagheen Island due to reckless leveling adding about 100 cm of sand above ground level and causing plants to suffocate and die (top middle); sinking lands due to ground water level becoming higher than soil level (top right) and finally unplanned development in surrounding deserts and peripheries as the Oasis becomes more and more attractive to visitors and tourism (bottom). (Source: the author in various trips)

Main crops in the oasis are dates and olives. Everything else cultivated in the oasis is for local consumption. Other fruits found in abundance are excellent red grapes, figs, apricots, sweet lemons, bitter oranges, limes and pomegranate. For vegetables, the following could also be found: okra, eggplant, pumpkin, tomato, cress, onion, broad beans, garlic, mint, radish and pepper. Garlic is held in high regard in the prevention of sickness. It is only eaten for a period of 4 to 7 days in October, during which large quantities are consumed. The men and women separate during the garlic festival.

B. TOURISM

Siwa Oasis commands great historic interest due to the presence of Romanic monuments such as the temple of Alexander the Great and mountain of the Dead ("Gabal El-Mawta"). It was a center for Roman civilization, which makes

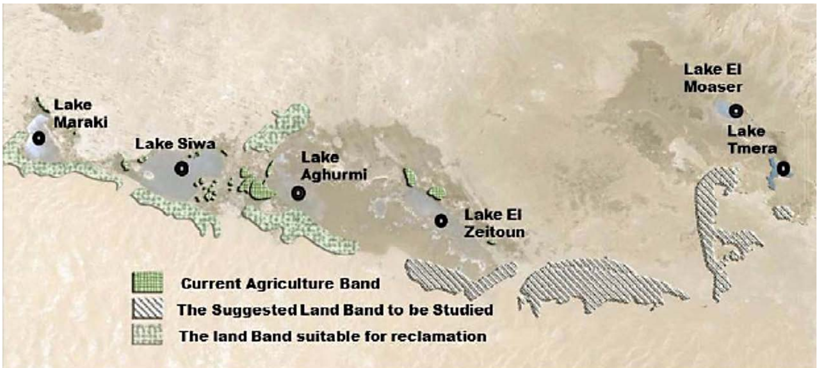

Figure 8: Existing agriculture lands, lands could be reclaimed and suggested sites for further studies (Source: developed by the author based on information from GOPP and site visits).

Natural Environment

Shali

Eco lodge in Siwa

Old city and the Mountain of the Dead

Visitors Centre of Siwa Natural Reserve Areas

Museum of the Siwian House (left) & Visitors Centre (right)

Figure 9: Tourist Attractions in Siwa (Source: the author, Nov. 2012).

it an attractive tourist site. The Temple of Jupiter Ammon is about one and a half miles east of Siwa. There is also Shali, which is the old city and means in local language the elevated city. The variety of ecosystems in Siwa presents a base for various tourism activities (Figure 9). Briefly, tourist attractions may be loosely categorized into six main categories.

Archeological sites: They feature the man-made environment since the dawn of humankind. This includes archeological attractions that date back to as old as Ancient Egypt – such as the Oracle of Amun in Siwa.

Natural landscapes: Such destinations offer outstanding geological sceneries formed through ages. This is either visited for scientific studies and research, or for appreciation of nature.

Wildlife appreciation: Some destinations are known for being the habitats of very beautiful, rare species of wild plants, while others host endangered species of wildlife.

Socio-cultural tourism: The oases offer great experience for socio-cultural exchange. Some tribes are still holding on to their own socio-cultural traditions, giving the visitors a chance to understand and appreciate their environment.

Adventure tourism: This kind of tourism has no specific location; the way to a certain destination may itself be the adventure. In the desert, this ranges from hiking, trekking, safaris, and expeditions to remote areas. In water areas, this also includes sand surfing, white water rafting, and canoeing. Overall, it encompasses any dangerous form of tourism. Egyptian Western Desert offers a wide range of adventures. For beginners, areas near the oases offer great experiences and for professionals, Gilf al-kebir is a quest for survival.

In the sixth category come other forms of more traditional tourism, such as the 3S tourism seeking Sun, Sand and Sea, coastal activities along the Mediterranean, and relaxation and therapeutic tourism – as in Siwausing hot springs and sand.

C. INDUSTRIES

The main industry in Siwa is the drying food industry. There are 3 old factories and 5 new ones using more developed techniques. It is the major industry as it depends on dates as the major product of the Oasis. Water bottling is another recent industry in the area with four major mineral water bottling factories: Safi, Aqua Siwa, El- Hayah, and El-Sadat factory. Traditional handcrafts is the main source for preserving the cultural heritage of Siwian handcrafts, which attracts tourists and visitors (Figure 10).

D. HOUSING AND LIFESTYLE

Siwa is one of the few Egyptian oasis communities that have managed to retain most of its traditional characteristics. This was partially due to the region's isolation, which was broken only in 1985 by the construction of the asphalt road connecting Siwa to Marsa Matruh.

Until very recently, the Siwian people kept and maintained a very strong link to their environment and held a sensible respect to natural elements (Figure 11). As the people of Siwa confronted the modern world, both their culture and environment were exposed to the risk of disruption. Until the mid-twentieth century, both the natural and social structures of the oasis were

Figure 10: Economic Activities in Siwa (Source: the author, Nov. 2012).

Figure 11: Respect to nature represented in integration of Palms within structures to avoid cutting them (left); sensible use of water in dry toilet (top-middle) and reuse of sewage water (top-right); use of Kourshif as natural building material (bottom-middle) and finally avoid building and development in agricultural areas (bottom-right) (Source: the author – various trips).

more or less constant. Thus, the changes in housing patterns were inconsiderable. This was maintained by the geographical isolation of the Oasis and the stable climatic conditions. However, the second half of the twentieth century witnessed dramatic change in the urban settlement of the oasis. This is also attributed to the successive floods and heavy rain beside the rapid and easy vehicular connection exists nowadays.

On another front, when the law of private property was introduced, locals had to present documents of their possessions. In contradiction to the prevailing social order, such new laws raised conflicts among families, breaking up extended family patterns and giving the way for nuclear family patterns to appear. Collectively, all these external influences have had a profound effect on the housing patterns of the oasis. After the heavy rains of 1985, Shali was completely abandoned and the traditional architecture of Siwa gradually disappeared. This is apparent in the new houses built at that time.

During the last decade of the 20th century, the Egyptian government showed interest in developing the region. This included the provision of electricity and other public facilities, the completion of Matrouh asphalt road, in addition to land reclamation projects. Local residents perceived concrete blocks as a sign of modernization. Thus, they followed the path, and subsequently, concrete became the main building material (see Figure 12).

Figure 12: Contemporary housing Styles in Siwa: public housing and current building techniques (top row) and the nostalgic contemporary housing styles built by foreigners and non-Siwians (bottom row) (Source: the author – Nov 2012).

4. Discussion: Future Extension Scenarios

The opinions and attitudes of the community for the possible scenarios of Siwa's future extension were investigated in a fact-finding mission in November 2012. In this event, several options for solving the need to extend the cultivated land were addressed. Also discussed were the supplementary activities of housing, industries and tourism as they could provide a combined positive impact by using excess agricultural wastewater, which is currently negatively affecting the soil, plants and all settlements in the main agglomeration and existing development. This event resulted in the following four development options (see Figure 13):

1. stop the extension and enhance and optimize the existing irrigation system;
2. extend to the east of Zaitouna Lake [East];
3. extend to the Sand Dunes to the west where most of excess water exists [Dunes-West]; and
4. move to Tabaghbagh Depression further in the East [Tabaghbagh].

After a rapid consultation process with some key authorities (e.g. Desert Research Centre, City of Siwa) and local natural leaders (Trip Shaikhs), the last option was denied. The reason for that was the fact that the cost for pumping the water up for about 60 m and then for a distance that can be around 80-90 km is a cost that far outweighs the benefit of getting rid of the excess water, which is minimal as the depression area is difficult to reclaim. In addition, the losses in water will be too great. This leaves no benefit with yet another downside of not adding agricultural area to the Oasis itself. The people would face a new situation of having less pressure from dealing with wastewater, which would encourage them to pump much more water from the ground reservoirs; this would not add to the local economy and creates a new pressure for reclaiming yet more land within the Oasis.

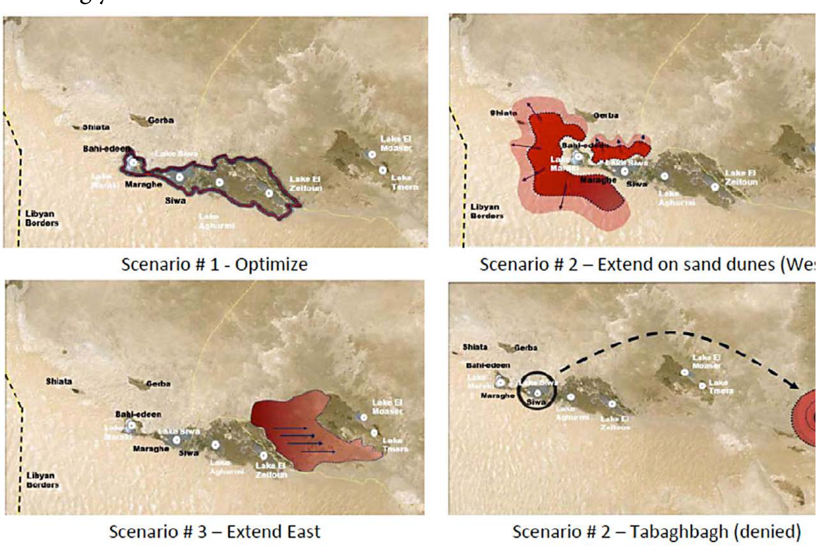

Figure 13: The four development scenarios (Source: developed within community workshops and visualized by the author).

This leaves the other three options and for each of those, SWOT analysis (strength, weakness, opportunities and threats) was applied given the existing and prospect situation (see Table 2). This analysis, however, requires further verification and confirmation using quantitative analysis; good wealth of field data and measurements would be necessary. For example, it was found from literature that the ground water outflow is about 1199 wells and springs with an annual discharge of 255million m3. Of this amount there is a quantity lost due to evaporation of around 222million m3 with the remainder going to the natural lakes of Siwa.

This leaves an annual surplus of ground water of 33 million m3 (i.e. continuous rises in water table level 4.5 cm/year with the continuation of using the flood irrigated agriculture). Irrigation is carried out as in Egypt by running the water through small channels into the various hoods, the different groups of these being shut off from each other by a slab of stone.

Due to discrepancies of information and data acquired from various sources, the next steps in research should rely heavily on preliminary interviews with specialists from the area and from relevant authorities. This will be focused on cross-checking available data and information and building a robust geographical and hydraulic database for the whole area. This should involve authorities dealing with irrigation, agriculture, tourism, industrial development, and local issues together with local knowhow.

Table 2: Advantages and disadvantages of each solution (Source: the author).

	Optimize	Dunes-West	East
Advantages	• Historically Preserve the oasis size and character • Encourage other economic activities by putting pressure on agriculture • Deals with the uncertainty of environmental balance by reducing interventions • Better use of water as a non-renewable resource	• Development already started on these dunes in Khameesa • Already attracted foreign and external investment • Helps to manage the creeping Eastern Sand Dunes on the Oasis • Allows future expansion of the oasis and thus reduces migration	• Capitalize on area linking the two lakes of Zaitouna and El-Maaser & Tamira • Increase the connectivity between the water bodies of the oasis • Diversely characterized site giving a good chance for diverse development option and activities
Disadvantages	• Reduces the diversity in possible agricultural products • Freezes the future capacity of the oasis • Conflicts with personal and group interests in developing certain lands and ownerships	• High risk from excess agriculture waste water on lower parts of the oasis • The existing pace of development shows clear overuse of land a resource • Unplanned and informal development with its conflict with ownership	• High cost for water transportation • Higher risks for balance of ground and surface water • Geographic bias towards the east in social terms • Terrain in that region is not plain as in other parts of the oasis

5. Conclusions

This paper is an attempt to review the issue of water management in the Siwa Oasis. The research methods used focused mainly on field visits, site observations and information from various focus groups and workshops held with local community members and authorities. The research provides an overview of key areas of interest to the local community as well as development options, pressures and current practices. This paper has confirmed data currently available on water sources for the Oasis which include natural springs or wells. Quantities of discharge were estimated according to the most prevailing literature. With this forming analysis of the water supply-side in the Oasis, the research then proceeded to explore the main land use patterns that currently exist within the Oasis to inform the demand-side of water use. Land uses of water were found to include agriculture, industries, tourism, and housing.

The research also discussed four strategic scenarios identified in a fact-finding mission and further discussions with the local community members and authorities. These scenarios were then analyzed using a SWOT analysis. The aim of this analysis was not to select the best scenario as this would require a further definition of development objectives, apart from the current focus of research on environmental aspects. It is only by integrating various points of view and the struggling development actors into one process that the product is more likely to be realized.

This points to the need for wider integrative research in which various actors, stakeholders and beneficiaries are consulted and involved in the process of developing an integrated regional model. This process should be complemented with a process of consultation, mobilization and an institutionalized integrated decision making process. This process is needed to make sure that the four main items of land use (agriculture, industry, tourism and housing) as well conflicting interests of various governmental and local stakeholders are not in any way directing the process into a single-viewed development.

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PAPER

15 | Measuring, Modeling Water Quality by Using Sensors and Statistical Analysis Techniques

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Abstract: The water quality of different water sources is measured using several parameters. Three different sources of water are studied in Alexandria, Egypt: The Mediterranean Sea, Mariot Lake, and mineral water extracted and bottled in the Siwa Oasis. The measured parameters are: concentrations of Sodium (Na), Magnesium (Mg), Calcium (Ca), Nickel (Ni); pH; conductivity; and temperature. The measured values are compared with the standard of water parameters given by the World Health Organization (WHO). The different devices and sensors used in measurements are: ICP-7500 sequential plasma Spectroscopy SHIMADZU, ASTM D1126-02, ASTM D5708-11, ASTM D4191-08, ASTM D1125-95, ASTM D4191-08, ASTM D1293-99, in addition to colorimetric and potentiometric sensors. The linear regression model based on these parameters is extracted, and the coefficients are calculated by using three statistical analysis methods namely: regstat, roubustfit, and curve fitting. The predicted values of the concentrations from the linear regression models are compared with the measured values, and the root mean square error (RMS) is calculated. The principal component analysis (PCA) method is applied for clustering the three sources of water according to the values of measured parameters. The results indicate that the Mediterranean Sea is recommended as an alternative water source. Mariot Lake is contaminated to a high degree.

Keywords: Component Mariot Lake, Mediterranean Sea, Statistical Analysis, Principal Component Analysis, Water Contamination, Spectrometer, Water Sensors.

1. Introduction

Lately, Egypt has been facing a serious threat in the shortage of water compared to neighbouring countries that share the same water source, the Nile River. Over time, Egypt's share is decreasing gradually, which led researchers to study alternate water resources as an alternative to meet the demand for drinking water. Ghanem *et al.* illustrated in their statistical analysis of four different sites in Alexandria, Egypt, that variation in water temperature, pH and dissolved phosphates are insignificant; however, the variation in total nitrogen and organic matter is significant.

Conway *et al.* (1996) introduced the potential of future availability of water in the Nile basin in Egypt, which is driven by the forces operating on three distinct spatial scales: river basin, regional, and global. Global and regional driving forces are taken from the results of global climate model experiments. Basiouny *et al.* (2008) evaluated the total trihalomethane

(THMs) at the new Benha water treatment plant in Egypt, in terms of initial chlorine dose, total organic carbon, bromide ion, contact time, temperature, algae and pH. Discriminate analysis is widely used due to its important role as a multivariate statistical analysis with different techniques (Fewtrell and Bartram, 2001; Yotter *et al.*, 2004; Fang *et al.*, 2006; Sakai *et al.*, 2000; Atkinson *et al.*, 1999; Shresha and Kazama, 2007; Li *et al.*, 2004; Van Griensven *et al.*, 2006). In Alexandria, Egypt, two different alternative water sources are studied. The Mediterranean Sea, which has a surface area of 2,500,000km^2 and Mariot Lake in north Egypt, south of Alexandria, which is brackish, with an area about 250 km^2. Mineral water originating from Siwa Oasis is taken from already packed bottles on the market. In this paper, seven parameters are measured by using different methods. These parameters are Magnesium, Calcium, Nickel, Sodium; in addition to, temperature, conductivity and pH.

It is found that, if these parameters increase or decrease beyond their acceptable level, they will inversely affect human health and cause many health hazards and diseases (Fewtrell and Bartram, 2001). Two methods are introduced in this paper to analyze and evaluate the measured parameters. The first method is a statistical analysis based on predicting a linear regression mathematical model of the measured data. It is constructed by using the measured parameters as independent variables to predict the total concentration for each water source. The coefficients of the linear mathematical model are calculated by using three statistical analysis methods namely: regstat, roubustfit, and curve fitting. The second method is the principal component analysis for clustering and distinguishing the three sources of water according to the measured parameters in each source.

2. Description

To detect the level of different parameters, several specimens have been taken from different locations of the three sites between January 2011 to April 2011 (see Figure 1). More than 100 measurements for the seven variables are used in the data analysis as a database.

2.1 MEASUREMENTS OF PH

WTW Inolab terminal levels and ASTM D1293-99 are used (ASTM, 2009). The instrument measurements range from 0 to 14 for measuring pH, and the temperature ranges from 0 to 80 °C. To measure pH, the electrochemical potential between a known liquid inside the glass electrode membrane and an unidentified liquid outside is measured. The reference electrode is potassium chloride (KCL) electrolyte. The pH of water must be close to the neutral pH 7.

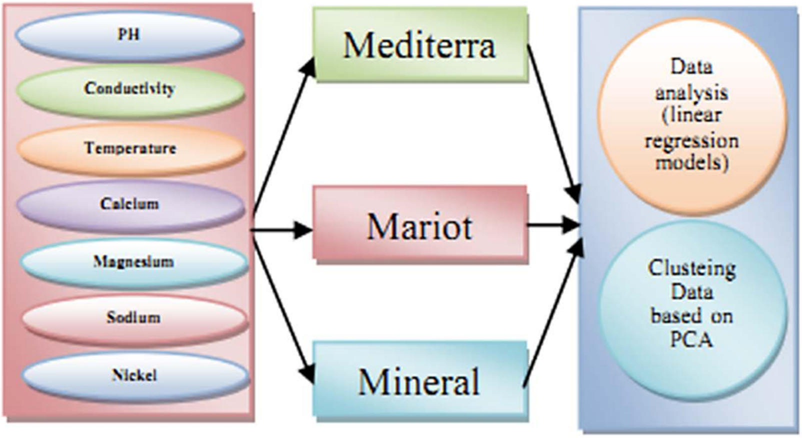

Figure 1: The procedures of the experimental work

2.2. MEASUREMENTS OF CONDUCTIVITY

TOACM-40v and ASTM D1125-95 are used to measure the electric conductivity based on potentiometric and colorimetric sensors (ASTM, 2009). The instruments measure the conductivity based on two plates in the sample.

A potential is applied across the plates and the current that passes through the solution is measured. Multiple measurements can be taken to produce the whole range of values for different parameters. The measurements using colorimetric sensors are based on either the direct discovery of an analyte via changes in the colorimetric dye alone, or the colorimetric sensor encompasses luminescent and colorimetric dyes in which the luminescent dye is the photon donor, and the colorimetric dye is the photon acceptor. The reagents differ according to the parameter being measured.

2.3 MEASUREMENTS OF CALCIUM AND MAGNESIUM

ASTM D1126-02 is used in measurements based on the EDTA titration method (ASTM, 2009). It is possible to differentiate between the hardness due to Calcium ions, or due to Magnesium ions using the titration method. It is based on the indicator changing its colour from red to blue in response to a chemical change, after adding specific reagents with certain concentrations according to the measured parameter. This method is applied in clear water that is free from chemicals, and contains Calcium or Magnesium. The minimum level of detection is about 2 to 5mg/L as $CaCO_3$, and the maximum level can be extended to all concentrations by sample dilution.

2.4 MEASUREMENTS OF NICKEL AND SODIUM

ASTM D5708-11 is used to measure the low concentration of Nickel (ASTM, 2009), while ASTM D4191-08 is used to measure the low concentration of Sodium (ASTM, 2009). ICP-7500 sequential plasma spectrometer SHIMADZU is used to measure the high concentration of Nickel and Sodium. It depends on the intensity of light emitted from plasma, at a specific wave length, which is used to determine the concentration of the sample to be tested (ASTM, 2009).

3. Results

The measured data from the three sources of water have been evaluated and analyzed by using two methods: the statistical analysis method and the principal component analysis method. All measurements have to meet the standard of water parameters given by the WHO as shown in Table 1. The measured data is collected and averaged over the range of the recorded temperature.

Table 1: Standard parameters of water in Egypt (Source: Fewtrell and Bartram, 2001)

Parameters	Standard
PH	6.5 – 9.2
Magnesium (Mg)	150 mg/L
Calcium (Ca)	200 mg/L
Sodium (Na)	200 mg/L
Nickel (Ni)	0.02 mg/L

4. The Statistical Analysis Method

The measurements for the three different water sources are conducted for different parameters. The relation between the different parameters and the recorded temperature are shown in Figures 2 to 7.

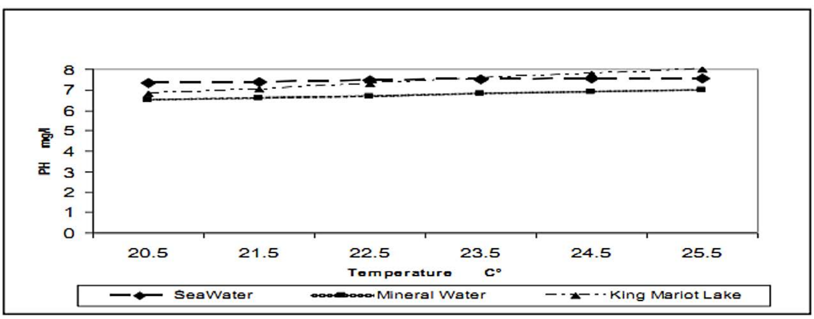

Figure 2: The comparison between average values of pH and temperature

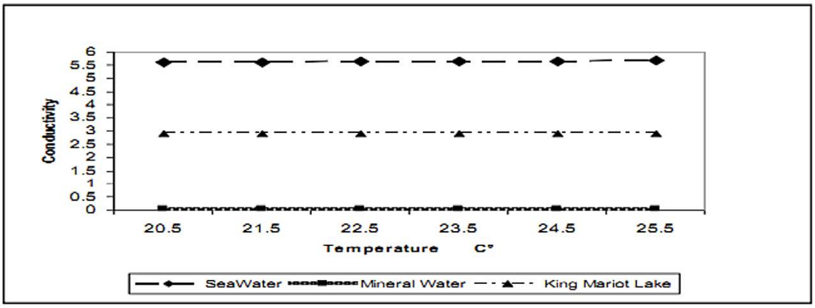

Figure 3: The comparison between average values of conductivity and temperature among three different sources of water

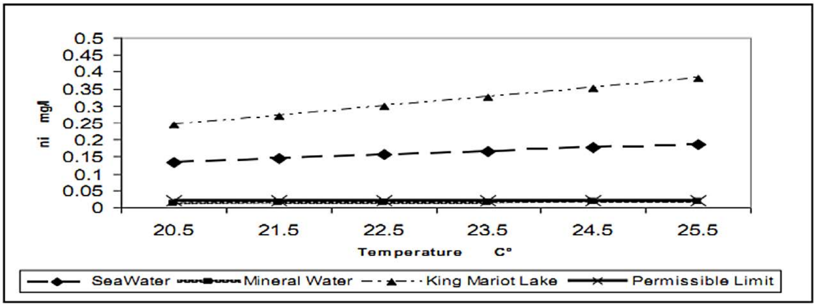

Figure 4: The comparison between average values of Ni and temperature among three different sources of water

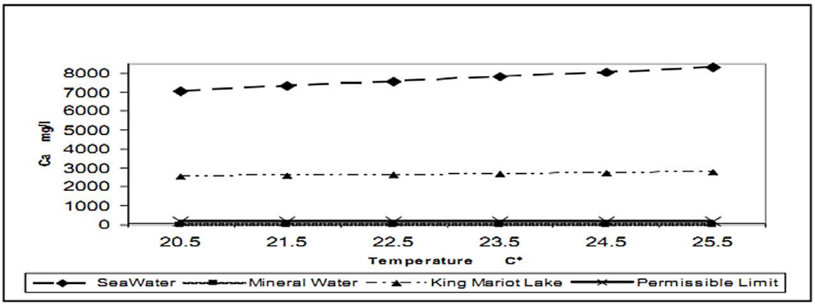

Figure 5: The comparison between average values of Ca and temperature among three different sources of water

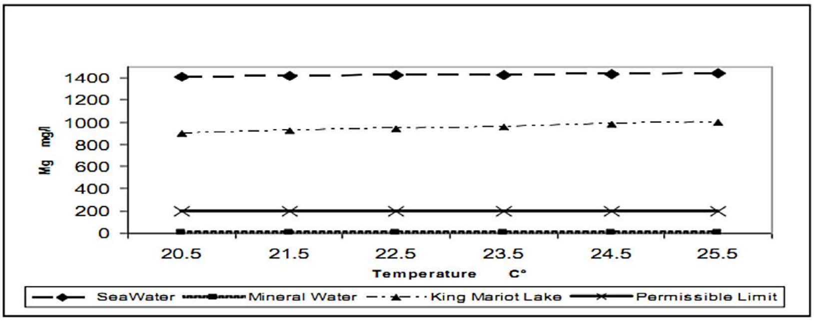

Figure 6: The comparison between average values of Mg and temperature among three different sources, of water

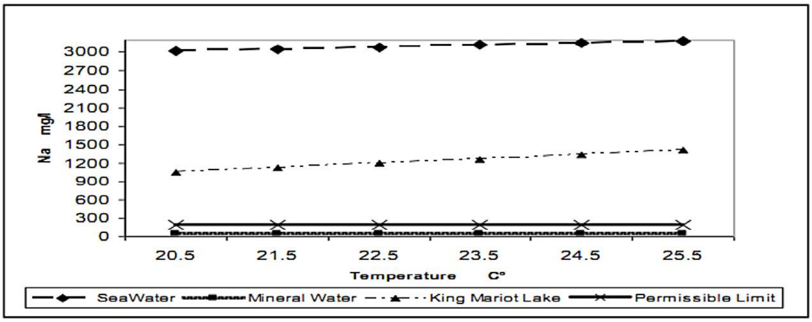

Figure 7: The comparison between average values of Na and temperature among three different sources of water

Table 2 shows the range of measurements, the average values, and the standard deviations of all parameters. It shows the comparison of all parameters among the three sources of water. From the previous figures and results, it can be observed that the alkalinity reading is the highest in Mediterranean Sea, followed by Mariot Lake then mineral water. In addition, the conductivity of Mediterranean Sea is the higher than that of Mariot Lake, and the conductivity is close to zero for mineral water. Sodium concentration is measured at the band of 589.592 nm, and Nickel concentration is detected at the band of 231.604 nm by using ICP-7500 sequential plasma spectroscopy. Mariot Lake has high concentration of Nickel.

A linear regression model is used to create the relationship between the measured parameters as shown in Equation 1 (Dally *et al.*, 1993; Gupta, 2005).

$$Y = B_1+B_2 X_1+ B_3 X_2 +B_4 X_3+ B_5 X_4+ B_6 X_5 + B_7 X_6 + B_8 X_7 \quad (1)$$

Based on the measured parameters, Y is the predicting concentration of each water source, where X_1 denotes Na, X_2 denotes Mg, X_3 denotes Ca, X_4 denotes Ni, X_5 denotes the temperature, X_6 denotes the pH, and X_7 denotes the conductivity.

The parameter B is called regression coefficient and is calculated by using three statistical analysis methods: regstat, roubustfit, and curve fitting.

Table 2: Statistical analysis results of some parameters for the three sources of water

Figure Number	Sources Of water	Parameters measured	Range Of measurements	Average Values $\bar{x}$	Standard deviations (σ)
2	Sea water	pH	7.3 – 7.8	7.5	0.485
	Mineral water		6.5 – 7	6.75	0.371
	Mariot Lake		6.8 – 7.9	7.435	0.352
3	Sea water	Conductivity s/m	5 – 5.9	5.45	0.218
	Mineral water		0.002– 0.0023	0.00215	0.00239
	Mariot Lake		2.5– 2.97	2.73	0.524
4	Sea water	Calcium concentration mg/l	7050– 8050	7550	0.231
	Mineral water		100 – 111	105.5	0.0011
	Mariot Lake		2080– 2085	2082	0.0012
5	Sea water	Magnesium Concentration mg/l	1395- 1490	1424.5	0.00234
	mineral water		55 – 65	60	0.0024
	Mariot Lake		900– 1000	950	0.0156
6	Sea water	Nickel Concentration mg/l	0.12– 0.18	0.15	0.135
	mineral water		0.001– 0.002	0.015	0.001
	Mariot Lake		0.25– 0.38	0.315	0.246
7	sea water	Sodium Concentration mg/l	3000– 3080	3040	0.195
	mineral water		60 – 80	70	0.001
	Mariot Lake		1050– 1250	1150	0.127

Table 3: Regstat results

	Mediterranean Sea	Mariot Lake	Mineral Water
Beta Coefficients	B1 = 4.2640	B1 = 3.8672	B1= 0.3159
	B2 = 1.2958	B2 = 0.8619	B2= 0.1139
	B3 = 0.201	B3 = 0.251	B3= 0.0190
	B4 = 0.1782	B4 = 0.7266	B4= 0.0368
	B5 = -1.6509	B5=-1.28081	B5= -2.1036
	B6 = 0.0214	B6 = 0.0185	B6= 0.0132
	B7 =- 0.131	B7 =- 0.115	B7 = -0.105
	B8 = - 0.157	B8 = - 0.123	B8= - 0.114

Table 4: Robustfit results

	Mediterranean Sea	Mariot Lake	Mineral Water
Beta Coefficients	B1 = 4.2388	B1 = 3.8405	B1 = 0.3150
	B2 = 1.2724	B2 = 0.7962	B2 = 0.1135
	B3 = 0.1151	B3 = 0.2155	B3 = 0.0190
	B4 = 0.0781	B4 = 0.1260	B4 = 0.0354
	B5 = -1.6349	B5 = -1.179	B5 = -2.106
	B6 = 0.0242	B6 = 0.0177	B6 = 0.0112
	B7 = -0.128	B7 =- 0.112	B7 = -0.99
	B8 = - 0.155	B8 = - 0.129	B8 = - 0.116

Table 5: Curve fitting results

	Mediterranean Sea	Mariot Lake	Mineral Water
Beta Coefficients	B1 = 3.785	B1 = 2.9861	B1 = 0.2919
	B2 = 1.2423	B2 = 0.742	B2 = 0.992
	B3 = 0.1093	B3 = 0.1956	B3 = 0.0112
	B4 = 0.0645	B4 = 0.114	B4 = 0.0254
	B5 = -1.435	B5 = -0.9879	B5 = -1.915
	B6 = 0.020	B6 = 0.0172	B6 = 0.0107
	B7 = -0.173	B7 = -0.118	B7 =- 0.110
	B8 = - 0.153	B8 = -0.124	B8 = - 0.112

Tables 3 and 4 present the calculated regression coefficients B using Regstat and Roubustfit, which perform multilinear regression for different variables "X_i" to predict "Y" as the output response of the total concentration. Table 5 presents the calculation of regression coefficients using curve fitting. Figures 8 to 10 show the output results of the predicting model of linear regression analysis based on the three statistical analysis methods. The total concentration in each water source is the y-axis with temperature ranges on the x-axis. Figure 8 shows the comparison among the three statistical analysis methods used to calculate the concentration in sea water. It is noticed that the concentrations are close to each other with respect to the value of RMS error = 0.212. Figure 9 shows the comparison of the three statistical analysis methods in Mariot Lake. It is noticed that the model is achieved with regstat and roubustfit, but the curve fitting has given a different value of concentration with RMS error = 0.834.

Figure 10 shows the comparison among the three statistical functions used in mineral water to achieve the linear model. It shows that the three statistical functions give the same concentration with RMS error = 0.0025.

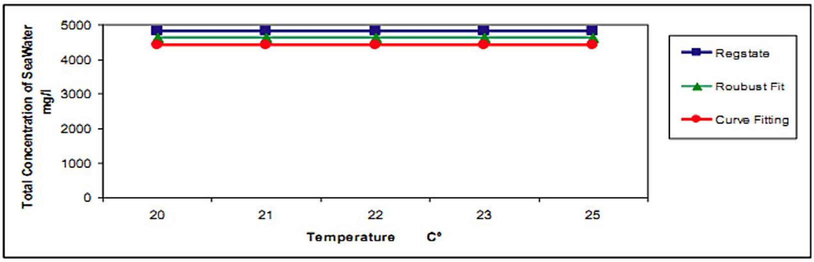

Figure 8: The predicting of the total concentration of sea water parameters with three statistical analysis methods

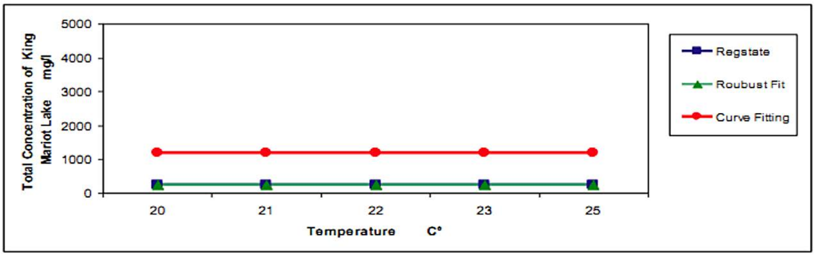

Figure 9: The predicting of the total concentration of Mariot lake parameters with three statistical analysis methods

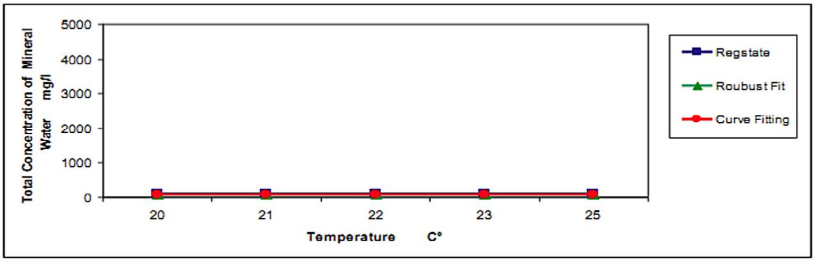

Figure 10: The predicting of the total concentration of mineral water parameters with three statistical analysis methods methods

5. The Principal Component Analysis Method

In this paper PCA is used to design and transform the original variables into new uncorrelated variables, which are linear combinations of the original variables. The new axes lie along the directions of maximum variance (Yotter *et al.*, 2004; Dally *et al.*, 1993). In the present case, the original data are expressed for six different parameters namely: Ca, Mg, Na, Ni, pH, and conductivity. The original data of the different parameters are measured with sensors and different devices.

The data is visualized on the two dimensional planes, as illustrated in Figures 11 to 13. Different colors indicate different parameters' concentration in each water source. In Figures 11 to 13, the concentrations of Ca, Mg, Na, and Ni, pH, and conductivity are indicated by numbers 1 to 6, respectively. The concentration of Ca (No.1) is located on the upper left of the plot for sea water, while it is located on the upper right of the plots for Mariot Lake and mineral water. The concentration of Mg (No.2) is located in the upper right of the plots for sea water and mineral water, while it is located in the upper left of the plot for Mariot Lake. The concentration of Na (No.3) is located in the upper right of the plot for sea water and upper left of the plots for Mariot Lake and mineral water. The concentration of Ni (No.4) is located in the lower right of the plot for sea water, upper right of the plot for Mariot Lake, and lower left of the plot for the mineral water. The level of pH (No.5) is located in the lower right of the plots for sea water and Mariot Lake, while it is located in the lower left of the plot for mineral water. The level of conductivity (No.6) is located to the lower left of the plot for all three water sources. Clustering is based on the different locations in the patterns and different scales which are relative to the different ranges of concentration in each source.

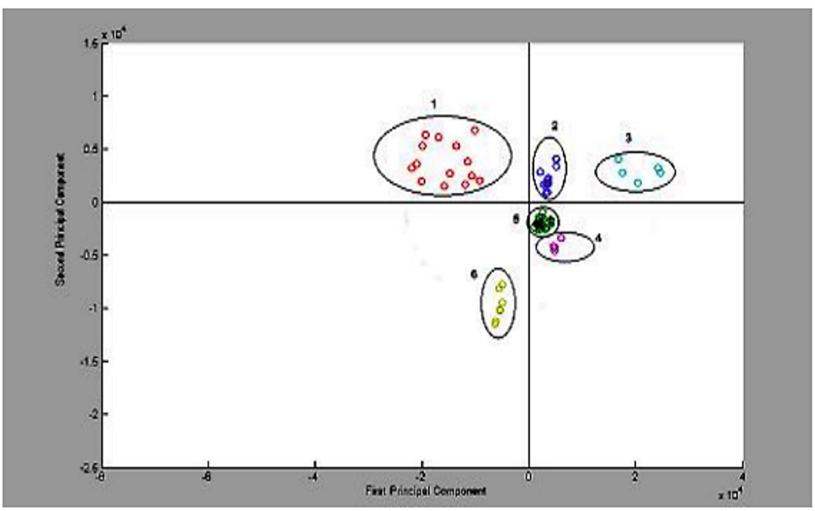

Figure 11: The clustering using PCA for different parameters in sea water 1-Ca 2- Mg 3- Na 4- Ni 5- pH 6- Conductivity

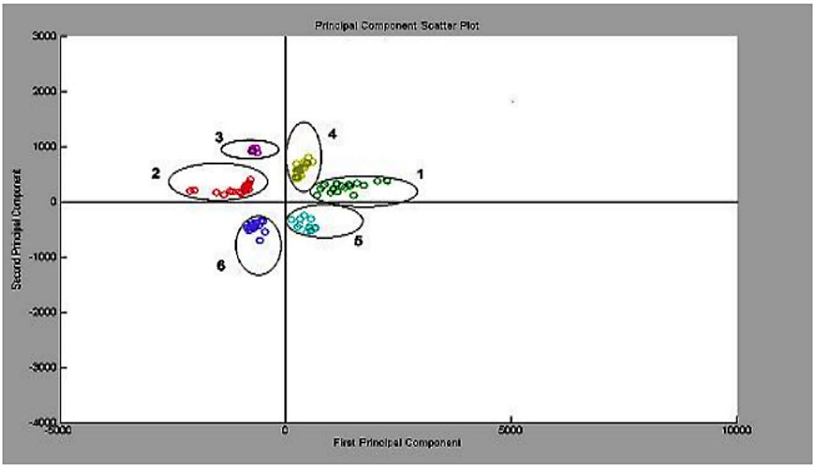

Figure 12: The clustering using PCA for different parameter in Mariot Lake 1-Ca 2- Mg 3- Na 4- Ni 5- pH 6- Conductivity

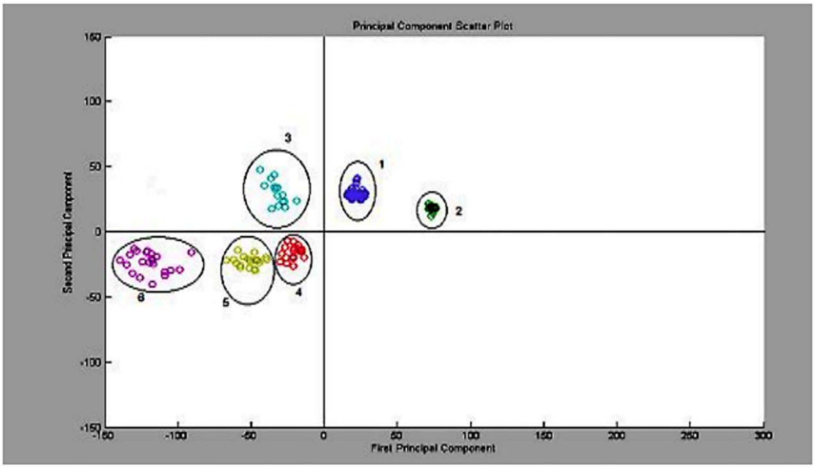

Figure 13: The clustering using PCA for different parameters for Mineral water 1-Ca 2- Mg 3- Na 4- Ni 5- pH 6- Conductivity

Larger scale is found in sea water as shown in Figure 11 for sea water, followed by Figure 12 for Mariot Lake, then Figure 13 for mineral water. This is due to high concentration of Ca, Mg, Na in sea water. For this reason, these parameters are located above the axes, followed by Mariot Lake, then mineral water. Figure 12 shows that in Mariot Lake the high concentrations of Ca, Mg, Na, are above the axes, while Ni indicates high concentration relative to the other parameters. Figure 13 shows that in mineral water the high concentrations of Ca, Mg, Na are above the axes, which indicate high value of concentrations relative to the other parameters. Distinguishing among different water sources is due to different locations of the water parameters around the axes of PCA method.

6. Conclusions

The shortage of water in Egypt can be attributed to growth of the population and increasing demand on its shared source, the Nile River. Other sources of water have been studied to determine a suitable source that can be used along with the Nile River, after treatment. Water samples have been taken from Mediterranean Sea, Mariot Lake, and mineral water bottled in the Siwa Oasis and studied to compare their levels of minerals to the maximum allowable levels as defined by the World Health Organization for drinking water. The measurements are made by using different devices and sensors.

The linear regression mathematical model is predicted and used to calculate the total concentration of each specimen. Three statistical methods, regstat, roubustfit, and curve fitting, are used to calculate the regression coefficient in the predicted linear model. It is concluded that the prediction of the concentration values by using the linear regression model, regstat and roubustfit has given the value of concentration close to the measured value in Sea water and Mariot Lake, according to the value of RMS error. It is worth mentioning, that they have given similar values of concentrations for mineral water. Curve fitting has given the predicted output of concentration similar to the measured values for sea water and mineral water. However, it has given different results for Mariot Lake.

The measurements show that Mediterranean Sea has high concentrations of Na, Mg, Ca, while Mariot Lake has a high concentration of Ni. This is due to the presence of discharge of debris from factories that negatively influence human health. The linear model also shows that the variation in temperature is insignificant.

The principal component analysis used in clustering parameters in the three water sources is relative to the concentrations and ranges of difference of each parameter. According to the above measurements and results, the Mediterranean Sea is recommended as an alternative source after treating the water in a desalination plant. The hazards in Mariot Lake are very high due to the existence of not only Ni, but also other heavy metals and chemical wastes. The result indicates that the water quality of Mariot Lake is contaminated to a high degree, while quality of sea water is better and less contaminated. It is recommended that Alexandria governorate raises factories' awareness against discharging pollutants and chemicals in Mariot Lake and Mediterranean Sea. It is necessary to follow the standards of dispensing emissions.

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PAPER 16

Statistical Analysis Techniques for High Quality Water

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Abstract: Water quality standards usually change from one application to another. For industrial applications, high water quality is required for the protection of boilers and turbines. Desalinated water is used, but there are still problems caused by its salts and silica concentrations. Some important parameters for desalinated water have been studied which are Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (k), Sulfate (SO_4), Silica (SiO_2), Chloride (Cl), and Fluoride (F); in addition to pH and conductivity. The linear regression model, based on these parameters, is extracted and its coefficients and error are calculated using Regstat method. The principle component analysis (PCA) is applied for clustering water parameters according to the value of measured parameters. The results indicate that it is important to follow the desalination process by another purification process to improve water quality. The demineralization process can decrease ionic impurities significantly, so its use is recommended to protect industrial components from deposits and corrosion.

Keywords: Desalination, Demineralization, Regstat method, Principle component analysis (PCA).

1. Introduction

Recently, Egypt has been trying to expand in the industrial field, especially in the field of electricity generation, oil refining and petrochemicals production. Water is required for use in industrial equipment such as steam generators, closed cooling systems and water injection combustion systems. The water quality required varies depending on its use (Gibbons, 1988). Sea water can be used for cooling systems but it cannot be use for steam generation because of high salts and silica concentrations, so desalinated water has been used. In the present paper, ten parameters in water are measured using different equipment. These parameters are Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Sulfate (SO), Silica (SiO_2), Chloride (Cl) and Fluoride (F); in addition to pH and conductivity. It is found that desalinated water contains high salts level, especially sodium and calcium salts. Following demineralization, water quality becomes compatible for various industrial purposes.

2. Demineralization Process

Desalinated water is passed through a polishing mixed bed, consisting of cation and anion resin. The two resin components are kept in the same vessel and intermixed by agitation with compressed air. The grains of resin are thus arranged side by side and the whole bed behaves like an infinite number of anion and cation exchangers in series, thus producing treated water of high quality. When salts or silica concentration of the treated water starts to increase, the regeneration process shall be started (Ehrlich, 2009). To carry out regeneration, the two types of resins are separated hydraulically as the anion resin is lighter; it rises to the top while the heavier cation resin falls to the bottom. Once the anion and cation resins are separated, each of them is simultaneously regenerated with caustic and acid solutions, respectively. Cation resin is regenerated with sulfuric acid 4% and anion resin with 3.0% caustic solution. Any excess regeneration is removed by rinsing each bed separately. After partially emptying of the vessel, the two resins are remixed with air supplied by the blower. After thorough air mixing, the vessel is refilled. Rinsing is completed and the vessel is then ready to put in the service cycle.

3. Instrumentation

To detect the level of different parameters, several samples have been taken from the Mediterranean Sea and the desalination plant, and the new demineralization plant within Sidi Krir Power Station (an electricity generating station) between October 2011 to July 2012. More than 150 samples for ten variables are used in the data analysis.

3.1 MEASUREMENT OF CONDUCTIVITY

The PUR-Sense model 410vp is used for the automatic, continuous measurement of conductivity of fluids. Conductivity indicates the sum of all ions in the water. It can be used in power plants, boiler feed water and steam. Metal plates are dipped into the solution and a known alternating voltage is applied; a certain current results that is proportional to the resistance. Measurements range from 1 uS/cm to 1400 mS/cm with an accuracy of +/- 4 % (PUR-Sense, 2010).

A four-wire resistance measuring method is used. The four-wire technique uses four conductors to connect the resistance to the measuring instrument. Only the outer two conductors carry substantial current. The inner two conductors connecting to the voltmeter carry negligible current and therefore drop negligible voltage along their lengths. Voltage dropped across the current carrying wires is irrelevant, since that voltage drop is never detected by the voltmeter. Since the voltmeter only measures voltage dropped across the resistor and not the resistance plus wiring resistance, the resulting resistance measurement is much more accurate. In the case of conductivity measurement, it is not wire resistance that we care to ignore, but rather the added resistance caused by plating of the electrodes. By using four electrodes instead of two, we are able to measure voltage dropped across a length of liquid solution only, and completely ignore the resistive effects of electrode plating as shown in Figure 1.

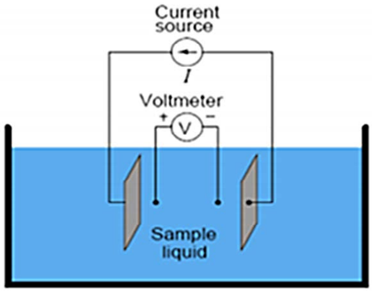

Figure 1: Four wire conductivity sensor (Source: PUR-Sense, 2010).

3.2 MEASUREMENT OF PH

Color change is a common pH test method used for manual laboratory analysis, but it is not well suited to continuous process measurement. By far the most common pH measurement method in use is an electrochemical special pH sensitive electrode inserted into an aqueous solution that generates a voltage dependent upon the pH value of that solution. Electrochemical pH measurement is based on the Nernst equation, which describes the electrical potential by ions migrating through a permeable membrane (Swan Analytical).

$$V = \frac{RT}{nF} \ln\left(\frac{C_1}{C_2}\right) \quad (1)$$

Where:

V = *voltage produced across membrane due to ion exchange, in volts (V);*
R = *universal gas constant (8.315 J/mol • K);*
T = *absolute temperature, in Kelvin (K);*
n = *number of electrons transferred per ion exchanged;*
F = *Faraday constant, in coulombs per mole (96,485 C/mol e−); and*
C_1 and C_2 = *concentration of ion in measured and reference solution, respectively, in moles per liter.*

The Nernst equation describes the amount of electrical voltage developed across a special glass membrane due to hydrogen ion exchange between the process liquid solution and a buffer solution inside the bulb formulated to maintain a constant pH value of 7.0. Special pH-measurement electrodes are manufactured with a closed end made of this glass with a small quantity of buffer solution contained within the glass bulb (see Figure 2). If the ionic concentrations on both sides of the membrane are equal, no Nernst potential will develop.

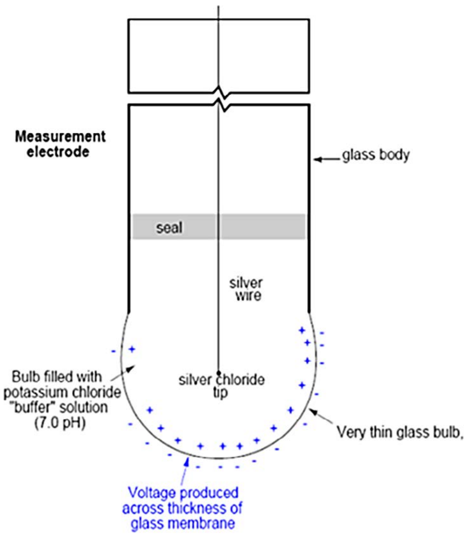

Figure 2: pH sensor with thin glass bulb (Source: Swan Analytical).

3.3 MEASUREMENT OF ANIONS AND CATIONS

The Dionex DX-120 ion chromatograph is a liquid chromatography technique using ion exchange mechanisms and suppressed conductivity detection for the separation and determination of anions and cations. According to Kohlraush's law of independent migration, conductivity is directly proportional to concentration. The conductivity of a dilute solution is the sum of the individual contributions to conductivity of all the ions in the solution multiplied by their concentration (Metito Overseas Ltd, 2010).

$$K = \sum_i \frac{\lambda_i C_i}{1000} \qquad (2)$$

Where:

K = conductivity in S/cm; and

C_i = concentration of the ions in equivalents/L.

The ionic limiting equivalent conductivity, λ_i, is specific for each ion. It is the conductivity of the ion divided by the concentration and extrapolated to infinite dilution. Table 1 lists limiting equivalent conductivities for a number of organic and inorganic ions.

Table 1: Limiting equivalent conductivities at 25 °C (Source: Dionex, 1998).

Anions	λi	Cations	λi
OH-	198	H^+	350
F-	54	Li^+	39
Cl-	76	Na^+	50
Br-	78	K^+	74
I-	77	$NH4^+$	73
NO3-	71	Mg^{2+}	53
HCO3-	45	Ca^{2+}	60
SO4-	80	Sr^{2+}	59
Acetate	41	$CH3NH3^+$	58
Benzoate	23	$N(CH3Ch2)4^+$	33

4. Statistical Analysis

4.1 REGSTAT METHOD

Figures 3 to 9 show the measurement data for 150 samples of Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Sulfate (SO_4), Silica (SiO_2), Chloride (Cl) and Fluoride (F). Each figure contains the results of both types of waters, which are compared with the permissible limit of this parameter as used in Metito Overseas Ltd, Sharjah, UAE (Metito Overseas Ltd, 2010).

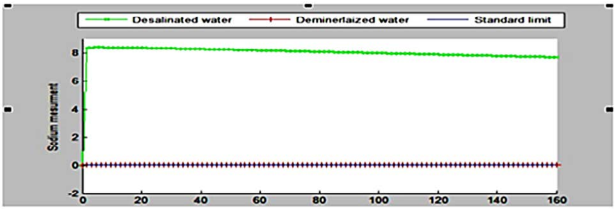

Figure 3: Comparison between sodium concentrations with standard limits for concentration

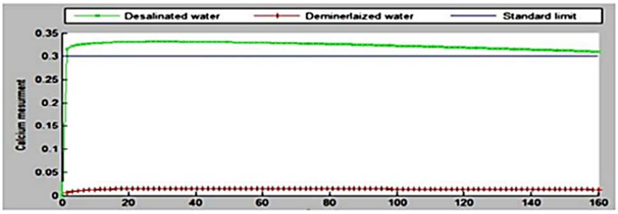

Figure 4: Comparison between calcium concentrations with standard limits for concentration

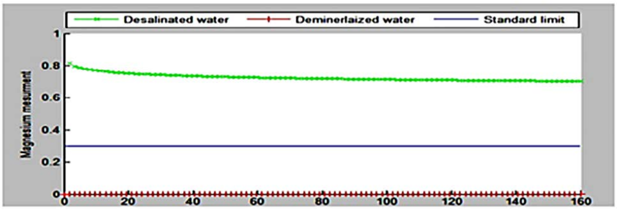

Figure 5: Comparison between Magnesium concentrations with standard limits for concentration

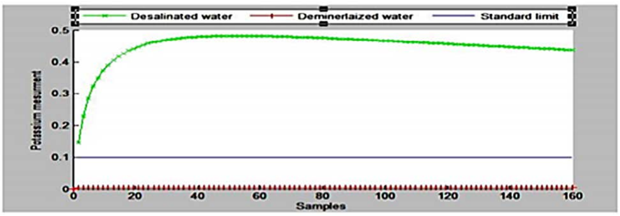

Figure 6: Comparison between Potassium concentrations with standard limits for concentration

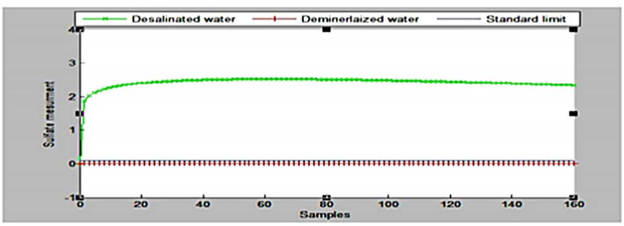

Figure 7: Comparison between Fluoride concentrations with standard limits for concentration

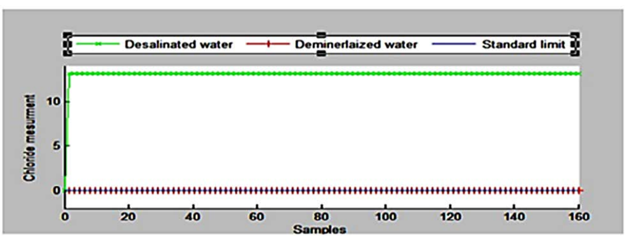

Figure 8: Comparison between Sodium concentrations with standard limits for concentration

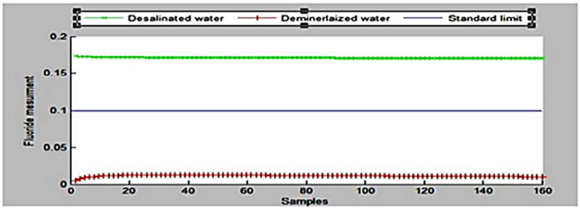

Figure 9: Comparison between Sulfate concentrations with standard limits for concentration

A linear regression model is used to create the relation between the measured parameter, as shown in equation (3), and β in which regression coefficients are calculated using regstat method, where calcium, chloride, fluoride, magnesium, potassium, sodium and sulfate are represented by variable X from X_1 to X_7 (Morsi, 2008).

$$Y=\beta_1+\beta_2X_1+\beta_3X_2+\beta_4X_3+\beta_5X_4+\beta_6X_5+\beta_7X_6+\beta_8X_7 \quad (3)$$

Beta coefficients are calculated using regstat method as shown in Table 2.The total concentration (Y) is calculated by taking a sample from the measured data with regression coefficients and the result is shown also in Table 2. The measurements of different parameters for both types of waters are indicated in Table 3 with average, standard deviation and error.

Table 2: Beta coefficient for desalinated and demineralized water

Beta	Desalinated	Demineralized
β 1	46.4542	-29.7014
β 2	48.1988	-665.023
β 3	-2.0692	323.9808
β 4	-5.3931	1473.230
β 5	-7.7259	-2127.47
β 6	-10.487	-1621.62
β 7	-1.3765	1475.750
β 8	-1.1727	1879.275
Y	7.0614	2.0218

Table 3: Statistical analysis results of measured parameters

Type of water	Parameters	Range	Average	Standard value	|Error|
Desalinated water	Calcium (ppm)	0.27 - 0.61	0.44	0.3	0.14
Demin water	Calcium (ppb)	11.14 - 18.01	0.014	0.3	0.286
Desalinated water	Sodium (ppm)	5.21 – 10.35	7.78	0.01	7.77
Demin water	Sodium (ppb)	3.01 – 7.25	0.00513	0.01	0.048
Desalinated water	Magnesium (ppm)	0.42 – 0.98	0.7	0.3	0.4
Demin water	Magnesium (ppb)	1.01 – 3.15	0.0028	0.3	0.297
Desalinated water	Sulfate (ppm)	1.15 - 3.96	2.55	0.1	2.45
Demin water	Sulfate (ppb)	13.70 - 20.41	0.0176	0.1	0.082
Desalinated water	Potassium (ppm)	0.21 - 0.85	0.53	0.1	0.43
Demin water	Potassium (ppb)	2.41 - 7.92	0.0056	0.1	0.0944
Desalinated water	Chloride (ppm)	11.25 - 17.32	14.29	0.01	14.19
Demin water	Chloride (ppb)	14.20 - 18.25	0.0162	0.01	0.006
Desalinated water	Flurried (ppm)	0.10 - 0.21	0.15	0.1	0.05
Demin water	Flurried (ppb)	7.81 - 13.72	0.017	0.1	0.083
Desalinated water	Silica(ppm)	0.01- 0.02	0.015	0.01	0.005
Demin water	Silica(ppb)	10- 20	0.015	0.01	0.005
Desalinated water	PH	6.5 - 7.8	7.15	7	0.15
Demin water	PH	5.5 - 7.5	6.50	7	0.5
Desalinated water	Conductivity(μs/cm)	10 - 25	17.50	0.1	17.4
Demin water	Conductivity(μs/cm)	<0.2	0.2	0.1	0.1

4.2 PRINCIPAL COMPONENT ANALYSIS (PCA)

The principal component analysis (PCA) is used to create uncorrelated variable from the original variable and make clustering for seven different parameters for desalinated water and demineralized water. PCA is a technique that reduces the data, performs a variance analysis between factors and projects data to a line, which minimizes the projection error (Basiouny *et al.*, 2008). The eigenvector which is used for projection lies in the direction of the largest variance (Combes, 2010). In this paper the data are expressed from seven different parameters: Sodium (Na), Calcium (Ca), Chloride (Cl), Potassium (K), Magnesium (Mg), Sulfate (SO_4) and Fluoride (F).The data are illustrated in two dimensional spaces as shown in Figures 10 and 11. Different colors indicate different parameters' concentrations in each type of water. Calcium (Ca), Sodium (Na), Magnesium (Mg), Sulfate (SO_4), Potassium (K), Chloride (Cl), Fluoride (F) are indicated from 1 to 7, respectively. Figure 10 shows that desalinated water contains high value of concentration of the measured parameters compared to Figure 11, which illustrates the concentrations of the measured parameters of demineralized water. The discrepancy between the characteristics of each type of water is due to the different location of parameters around the axes of PCA. The concentration of calcium is located on the upper right of the plot for desalinated water, while it is located on the upper left for demineralized water. The concentration of sodium is located on the upper right of the plot for desalinated water, while it is located on the lower right for demineralized water. The concentration of magnesium is located on the middle lower of the plot for desalinated water, while it is located on the lower left for demineralized water. The concentration of sulfate is located on the lower left of the plot for desalinated water, while it is located on the upper middle for demineralized water. The concentration of potassium is located on the upper left of the plot for desalinated water, while it is located on the upper right for demineralized water. The concentration of chloride is located on the lower left of the plot for desalinated water; while it is located on the upper left for demineralized water. The concentration of fluoride is located on the upper left of the plot for desalinated water, while it is located on the lower left for demineralized water. Clustering is based on different locations and different scales which changes with the concentration of each parameter.

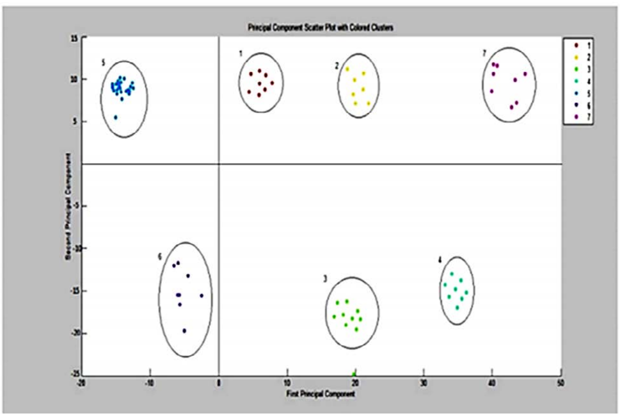

Figure 10: The clustering using PCA for desalinated water parameters

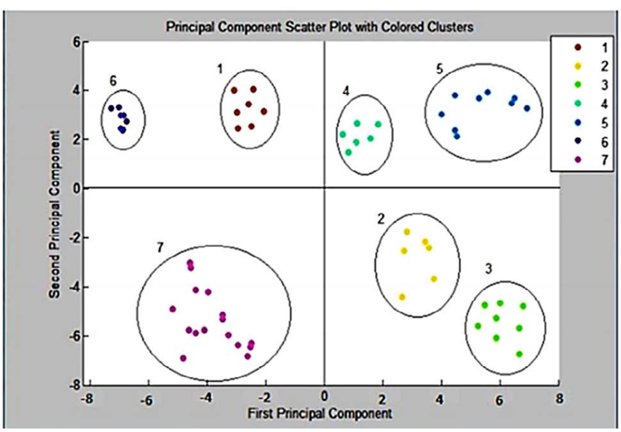

Figure 11: The clustering using PCA for demineralized water parameters

5. Conclusions

Improving the quality of water used in industrial applications is very important to protect industrial equipment components. New technologies such as DX120 ion chromatograph and conductivity and PH sensors have been used. Analysis of these parameters using the regstat method was carried out to study the change of parameters' concentrations. Principle components analysis (PCA) was also used to clustering of the component.

According to the above measurements and analysis, the demineralized water proves that it treats desalinated water by removing ionic impurities, which are naturally present in water, so that it can meet high water quality standards to be compatible with its purpose.

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PAPER 17

Biochar Usage as a Cost-Effective Bio-Sorbent for Removing NH_4-N from Wastewater

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Abstract: In this study, the removal of ammonium ions from synthetic wastewater by novel adsorbents including biochar powder derived from peanut hulls, rice husk, sunflower seed husk and wheat straw, was investigated. The pore analysis, specific surface area, SEM images and FT-IR spectra were used to characterize the surface and reactivity of biochar. Mathematical models were used to analyze the adsorption isotherms. Adsorption isotherm of ammonium ions using batch technique showed that, at equilibrium conditions, the removal rate increased linearly with increasing initial concentration of ammonium ions in water (40 – 2000 mg L^{-1}). After 24 h of reactions, the average amount of NH_4^+ removed by different sources of biochar ranged from 39.00 to 77.05 % regardless of the type of associated anions (Cl^- or SO_4^{2-}). Sunflower biochar appeared to have the highest efficiency in NH_4-N removal with the initial concentrations of NH_4-N (40 and 200 mg L^{-1}) while peanut biochar showed the adsorption peak with the high initial concentrations (400 and 2000 mg L^{-1}). Concentrations of ammonium ions recovered from biochar surfaces represented 0.2 – 0.39% of the total removed NH_4^+-N and reflected the surfaces' strong sorption forces. The characteristics of pore volume, area and size distribution of biochar and tendency to increase the percentage of small nano-pores, as shown by SEM images, may strengthen the removal results. The adsorption equilibrium fitted well to both the Langmuir and Freundlich models. The results suggest the tested biochar materials are cost effective adsorbents with high adsorption capacities and a recalcitrant nature that can be used in wastewater treatments.

Keywords: Biochar, ammonium ion removal, nitrogen control, wastewater treatment, adsorption, novel adsorbents.

1. Introduction

Much of the world's population is already experiencing a water crisis. The continued increase in water demands is expected to surpass greenhouse warming in shaping the state of global water systems by 2025. The ways in which the global water supply is directly affected by anthropogenic impacts remains poorly articulated but could be an important facet of the global change conversation (Vörösmarty *et al.*, 2000). Climate change will impact both water quantity and quality, which then affect food availability, stability, access and utilization. The expected decrease in food security will increase the vulnerability of poor rural farmers, especially in the arid and semi-arid regions (Bates *et al.*, 2008). Over the last two decades, there has been public awareness of the importance of using non-conventional water resources to mitigate the increased water demand for irrigation and horizontal agricultural expansion. Wastewater is considered to be one of the major non-conventional water resources that can be, after treatment, directed to irrigation activities. Since wastewater treatment and reuse systems are generally capital-intensive, innovative treatment technologies have to be highly efficient and cost-effective. In Egypt, the annual amount of wastewater generated exceed 13.0 billion cubic meters and the treated amounts are less than 1% (Loutfy, 2010).

Nitrogen compounds are considered one of the major contaminants in wastewater. Therefore, their removal from wastewater is receiving wide attention because the discharge of these contaminants is evidenced in the growth of algae and aquatic plants. Wastewater treatment facilities have to be designed for nitrogen control given ammonia is the primary contaminant of concern (Alberta Environment, 1999). The ammonium concentration may be quite specific to the source of the wastewater. For example, aquaculture water requires ammonia removal at levels of less than 1.0 mg L^{-1} whereas, in municipal wastewater treatment, levels may be up to ten times this level and in industrial wastewater levels may exceed 10 mg/L (Jorgensen and Weatherley, 2003).

There are numerous technologies for removing of NH_4-N from wastewater, but adsorption is a common technique in this field, using adsorbents such as natural and synthetic zeolite, silicate clay minerals including sepiolite. Aguilar *et al.* (2002) investigated physicochemical removal of NH_4-N using activated silica, powdered activated carbon and precipitated calcium carbonate. Zeolites have been extensively used to remove ammonium from secondary effluents, sewage and industrial wastewater (Booker *et al.*, 1996; Englert and Rubio, 2005; Wang *et al.*, 2006). Zeolites are characterized by their porous structure and active surfaces containing alkali or alkaline earth cations reversibly fixed in the cavities can easily be exchanged by surrounding positive ions (Tsitsishvili and Andronikashvili, 1992). But these types of ion exchangers are expensive with respect to their removing efficiencies. Therefore, the recalcitrant carbonized polymers called biochar has been recently introduced as bio-sorbent materials for use in the removal of various types of contaminants from wastewater such as pigments (Malik, 2003; Soldatkina *et al.*, 2009) and heavy metals (Beesley and Marmiroli, 2011; Uchimiya *et al.*, 2010).

Biochar comes as a byproduct from the biofuel production process (pyrolysis) and its physicochemical properties are related to process conditions (heat, oxygen limitation, and time) and characterization of raw materials (feedstock). The purpose of this study is to evaluate the capability of biochar derived from crop residues of peanut hull, rice husk or wheat straw for the removal of ammonium ions from NH_4-N-contaminated water and to relate the adsorption efficiency to their surface and morphological properties.

2. Materials and Methods

The feedstock of peanut hull (PHF), rice husk (RHF) and wheat straw (WSF) used in this study were collected from the local market. The collected biomaterial was extensively washed with tap water to remove soil and dust. The washing process was repeated with distilled water then the biomaterial was dried in an oven at 70 °C for 24 h. Dry feedstock was split into two parts, one part was crushed and sieved by a 0.5 mm polypropylene sieve then preserved in the desiccators for use. The other part was used for preparing the biochar and activated carbon materials. The dried RHF, PHF and WSF samples were put into flexible aluminum dishes and sealed by aluminum foil, then transferred into a muffle furnace and heated at an increasing rate of 25 °C per minute until 450 °C, then fixed at this temperature for 15 minutes. The heating process was carried out under limited O_2 conditions (pyrolysis). After cooling to ambient temperature inside the muffle furnace, the produced biochar samples of rice husk (RHB), peanut hull (PHB) and wheat straw (WSB) were crushed and sieved using a 0.5 mm polypropylene sieve then stored in plastic jars. Total carbon (Walkley-Black wet digestion method; Nelson and Sommers, 1982) and nitrogen (digested and determined according to Bremner and Mulvaney, 1982) contents of the resulting biochar are listed in Table 1.

Surface and Morphological Properties of Biochar

Analysis of pore area, volume and size as well as specific surface area of RHB, PHB, and WSB were determined using N_2 sorption isotherms run on Beckman Coulter SA(TM) 3100 Surface Area and Pore Size Analyzer. The Brunauer-Emmett-Teller (BET) method was used to determine mesopore-enclosed surfaces. On the other hand, SEM analysis was carried out for the biochar samples using a Scanning Electron Microscope Jeol model 6360 OLA. Fourier Transform Infrared (FTIR) spectra of the adsorbents were recorded in the range 400–4000 cm^{-1} using SHEMATZU infrared spectrophotometer, model FT/IR-5300, JASCO Corporation, Japan.

Ammonium Adsorption Isotherm

In a batch adsorption experiment, four grams of RHB, PHB or WSB were transferred into one-liter double jacketed reaction vessels and stirred (at a rate of 300 rpm) with distilled water for 24 h before the addition of ammonium chloride (NH_4Cl) or ammonium sulfate ($(NH_4)_2SO_4$) by final concentration 2000, 10000, 20000 or 100000 mg NH_4-N kg^{-1} biochar. The final solid-to-solution ratio was 1:200. The adsorption isotherm was conducted for 24 h at 30 °C by constant-temperature water path circulation. Then the suspension samples were withdrawn by syringe needle and filtered using 0.45μm Gelman membrane filter. Concentration of NH_4-N in the supernatants was determined by Kjeldahl automatic distillation and titration (Auto Kjeldahl Unit K-370). The amounts of adsorbed NH_4-N (q) by biochar samples were calculated according to the following equation:

$$q = [(C_o - C_i) \times V/1000\ m] \quad (1)$$

where C_o is the initial concentration of ammonium (mg L^{-1}), C_i is ammonium concentration after adsorption (mg L^{-1}), V is the volume of wastewater (ml) and m is the mass of biochar (g). To estimate the maximum adsorption capacity and evaluate the adsorption intensity of ammonium onto biochar, models of Langmuir and Freundlich were used to fit the experimental data. The two models' linear forms are:

$$\text{Langmuir model: } C_e/q_e = 1/ab + C_e/b \quad (2)$$

$$\text{Freundlich model : } \log q_e = \log K_F + 1/n \log C_e \quad (3)$$

where C_e (mg/L) is the equilibrium concentration in the solution, q_e (mg g^{-1}) is the ammonium adsorbed at equilibrium, *b* (mg g^{-1}) is the maximum adsorption capacity, *n* is the Freundlich constant related to adsorption intensity, and *a* (L mg^{-1}) and K_F ((mg $^{-1}$g) (L mg^{-1})1/*n*) are the adsorption constants for Langmuir and Freundlich models, respectively.

Ammonium Recovery Experiment

The desorption experiment was done using 2.0 M KCl solution to recover the absorbed ammonium from the biochar (Keeney and Nelson, 1982). Based on the dry weight of biochar samples, biochar samples were shaken with KCl solution with the ratio 1:5 using reciprocating shaker for 2 h, then filtered as in the original tests using filter paper to remove the solids. NH_4-N concentration in filtrate was measured by distillation and titration as mentioned above. The amounts of recovered NH_4-N were calculated by the subtraction from the total NH_4-N adsorbed (removed) on biochar.

3. Results and Discussion

Properties of Bio-sorbents

Table 1 illustrates that pyrolysis of RHF, PHF and WSF at 450 °C for 15 minutes condensate the carbon content in all used biomass and more than 50% of initial mass was lost as volatile gases (58.72 – 60.12 %). Carbon content increased from 31.18 % in RH to 77.42 % in PH as a fixed carbon structure in biochar. Thermal activation of the biomass increased the specific surface area (SSA) about two times in PHB and WSB and 10 times in RHB (Table 1). Also, values of total pore volume indicated to valuable increments as a result of pyrolysis of all samples. These results reflect that the pyrolysis process increased the surface reactivity of biochar and the stability against biodegradation compared to the feedstock. SSA and pore volume are considered essential values for the characterization of biochar as a sorbent material. Our results correlate with other studies (e.g., Lataye *et al.*, 2009 and Della *et al.*, 2002). We have to note that the values of SSA and pore volume obtained for RHB, PHB and WSB should be specified at 450 °C, 15 minutes and feedstock powder of 500 micron particle size because there are wide variations in the obtained values depending on the type and particle size of feedstock, temperature and residence time in pyrolyzer.

Table 1: Some charcteristics of feedstock and biochar samples used in adsorption study

Property	RH	PH	WS
Before pyrolysis (feedstock)			
total carbon, %	27.900	31.000	26.240
Total nitrogen, %	1.190	2.010	0.970
Surface area, $m^2\ g^{-1}$	5.540	1.001	2.538
Total pore volume, $cm^3 g^{-1}$	0.015	0.012	0.018
After pyrolysis (biochar)			
Volatiles, %	59.640	60.120	58.720
solid material, %	40.360	39.880	41.280
total carbon, %	36.600	55.000	43.640
Total N, %	0.520	1.090	0.770
BET Suface area, $m^2\ g^{-1}$	56.070	1.900	4.557
Total pore volume, $cm^3 g^{-1}$	0.040	0.013	0.019

The Fourier Transform Infrared (FTIR) is one of the important techniques helping to identify the characteristic functional groups and partially clarifying the chemical structure of the biochar. The wave numbers (cm^{-1}) of FTIR spectra of biosorbents before (feedstock) and after (biochar) the pyrolysis process were used to determine the vibrational frequency changes in functional groups as a results of the thermal activation (Table 2). Due to the high content of silicon in rice husk (Mahmoud *et al.*, 2011), the different functional groups in which silicon exists (e.g., siloxane Si–O–Si and silanol Si–OH) were clearly observed in IR spectra. Figure 1A presents FTIR absorption spectra of raw feedstock (RHF) and biochar (RHB). The IR spectra gave typical bonds of Si–O–Si stretching at 1035.7 for RHF and at 1091.63 cm^{-1}, 794.62 cm^{-1} and 457.1 cm^{-1} for RHB. The bands at 3392.55 and 2925.81 cm^{-1} in RHF spectrum and 3415.7 cm^{-1} in RHB spectrum correspond to the O–H vibrations

(Liou, 2004; Chaudhary and Jollands, 2004; Ibrahim *et al.*, 1980). It can be observed from Figure 1A (spectrum of RHB) that pyrolized rice husks are characterized by very broad band extended from 3965.37 to about 2000 cm^{-1}. The O–H stretching mode of hexagonal groups and adsorbed water can be assigned to this band. The position and asymmetry of this band at lower wave numbers indicate the presence of strong hydrogen bonds. The adsorption band observed at 2925 cm^{-1} in RH spectrum was related to aliphatic C–H groups and the very small peak near 1710.74 cm^{-1} in RHB spectrum was attributed to the C=O stretching vibrations of ketons, aldehydes, lactones or carboxyl groups. Further description of surface functional groups characterized both RHF and RHB are illustrated in Table 2. With respect to siloxane and silanol groups, the IR spectrum of the biochar obtained did not differ significantly from that of raw rice husks, except for the quite higher intensities of the bands at 1091 and 457 cm^{-1}.

Table 2: The wave numbers (Cm-1) of FTIR spectra of biosorbents and expected corresponded functional groups before (feedstock) and after (biochar) pyrolysis.

Rice Husk			
Feedstock		Biochar	
Frequency (Cm-1)	Functional group	Frequency (Cm-1)	Functional group
3392.55	OH alcoholic	3965.37	O-H (alcoholic, phenols)
2925.81	OH (carboxylic), C-H (aliphatic)	3415.7	O-H (alcoholic, phenols)
1652.88	C-C=C alkenes	1710.74	C=O strech (ketones, saturated aliphatic)
1409.87	C-H alkenes in plane bend	1604.66	C=C alkene, aromatic ring
1035.7	Si-O-Si, C-O stretch (ethers)	1091.63	Si-O-Si, C-N stretch (aliphatic amines)
570.89	C-Cl alkyl halide strech	794.62	Si-O network, C-H aromatic
478.31	Si-O-Si network	457.1	Si-O-Si
Peanut Hull			
Feedstock		Biochar	
Frequency (Cm-1)	Functional group	Frequency (Cm-1)	Functional group
3394.48	O-H and N-H (mixed stretching vibrations	3398.34	O-H stretching vibrations
2925.81	C-H stretch (alkanes)	1591.16	N-H bend (amines)
2160.13	C≡C stretch (alkynes)	1402.15	C-C (aromatics)
1633.59	N-H bend (amines)	1122.49	C-N stretch (aliphatic amines)
1411.8	C-C stretch (aromatic)	781.12	C-Cl stretch (alkyl halides)
1261.36	C-H (alkyl halides)	615.25	C≡C; C-H bend (alkynes)
1051.13	C-N stretch (aliphatic amines)		
599.82	C-Cl stretch (alkyl halide)		
Wheat Straw			
Feedstock		Biochar	
Frequency (Cm-1)	Functional group	Frequency (Cm-1)	Functional group
3994.3	C-H and O-H stretching vibrations	3409.91	O-H stretching vibrations
3402.2	C-H and O-H stretching vibrations	2958.6	C-H stretch (alkanes)
2918.1	C-H and O-H stretching vibrations	2356.85	O-H stretching vibrations
2383.85	O-H stretching vibrations	1593.09	N-H bend (amines)
1631.67	C-C=C (alkenes), N-H bend (amines)	1384.79	C-C=C (alkenes), N-H bend (amines)
1373.22	C-H asymetric deformation	1101.28	Si-O-Si; C-N stretch (aliphatic amines)
1245.93	C-H asymetric deformation	792.69	Si-O network, C-H aromatic
1054.99	C-N stretch (aliphatic amines)	597.89	Si-O-Si; C-Cl (alkyl halide)
590.18	Si-O-Si; C-Cl (alkyl halide)	459.03	Si-O-Si network
464.81	Si-O-Si network		

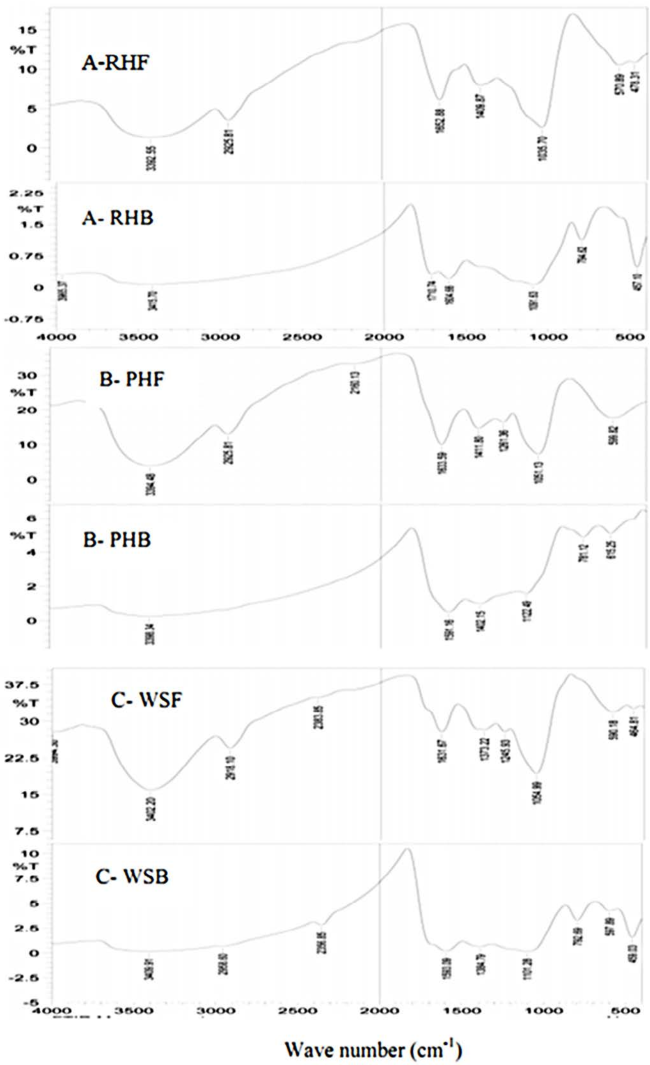

Figure 1: FTIR spectra of the feedstock and biochar of rice husk *(A), peanut hull (B) and wheat straw (C) obtained by slow pyrolysis at 450 °C.*

The peanut hull consists of polyphenol such as catechol, pyrogallic acid and m-rihydroxybenzene, mineral, lipid, and cellulose, etc. Sorption can occur by the polar functional groups of these constituents, which include carboxyl groups and phenolic hydroxyl as bonding agents (Zhu *et al.*, 2009). FTIR spectrum of the PHF and PHB in the range of 4000–500 cm^{-1} is shown in Figure 1B, it could be seen, the band at 3398 cm^{-1} of PHB was ascribed to the mixed stretching vibration absorption band of amino and hydroxyl groups. The small band obtained at 1591 cm^{-1} was assigned to the carboxyl group stretching vibration or assigned to C=C in plane aromatic vibrations from lignin formations (Garside and Wyeth, 2003). The peak at 1402 cm$-^{1}$ was caused by the phenolic O–H bending. The peak at 1122 cm^{-1} is indicative of the OH in-plane bending cellulose. The small bands at 781 and 615 cm^{-1} represent C-H aromatic and alkayl bend, respectively as well as reflect the silicon functional groups occurrence. Comparable FTIR results were obtained for chemically pyrolyzed peanut hull by Ozer *et al.*, (2007).

The FTIR spectra of WSF (Figure 1C) showed that the dominant peaks in the region between 3994.300 and 2918.1 cm^{-1} are due to stretching vibrations of CH and OH. The prominent peak at 1631.67 cm^{-1} in the WSF is attributed to either the acetyl and uronic ester groups of the hemicelluloses or the ester linkage of carboxylic group of the ferulic and p-coumeric acids of lignin and/or hemicelluloses (Sain and Panthapulakkal, 2006; Sun *et al.*, 2005). This peak disappeared completely in the thermally treated materials (WSB) because of the removal of most hemicelluloses and cellulose from the feedstock. The peak at 1373.22 cm^{-1} in the WSF represents the C=C stretch of aromatic rings of lignin (Sain and Panthapulakkal, 2006; Sun *et al.*, 2005; Xiao *et al.*, 2001). This peak was shifted to 1384.79 cm^{-1} by high intensity in WSB which deduce more condensation and tendency toward lignin formation. The peak at 1245.93 cm^{-1} for the WSF – which disappeared in the FTIR spectra of WSB - reflects C–H asymmetric deformations (Sun *et al.*, 2005). The peak at 1054.99 cm^{-1} of the WSF was split into two peaks at 1101.28 and 792.69 cm^{-1} after the thermal activation (WSB), all of which are owing to C–O stretching (Xiao *et al.*, 2001). From the spectral analysis, we can conclude that FTIR illustrates the importance of both organic and inorganic groups located on feedstock and biochar surfaces and the pyrolysis process imposes more occurrences of inorganic (resistant) surface groups on biochar.

The scanning electron micrographs were taken for biochar samples and illustrated in Figures 2A-2F. The SEM images of the RHB (Figures 2A and 2B) show that the surface structure is intact pieces and appeared to be uneven and had cracks. The images of PHB (Figure 2C and 2D) indicated that PHB has different macromolecular structure and showed the clear porous characteristic of surfaces and the development of voids. Similar morphological features of PHB were observed in WSB (Figures 2E and 2F).

Ammonium Removal Efficiency

The results of adsorption isotherm of NH_4-N onto biochar surfaces are demonstrated in Figure 3. The removed amounts of NH_4-N from wastewater varied according to the initial concentration of N in wastewater and the type of biochar. In the wastewater containing 2000 mg N kg^{-1} biochar, PHB showed the highest

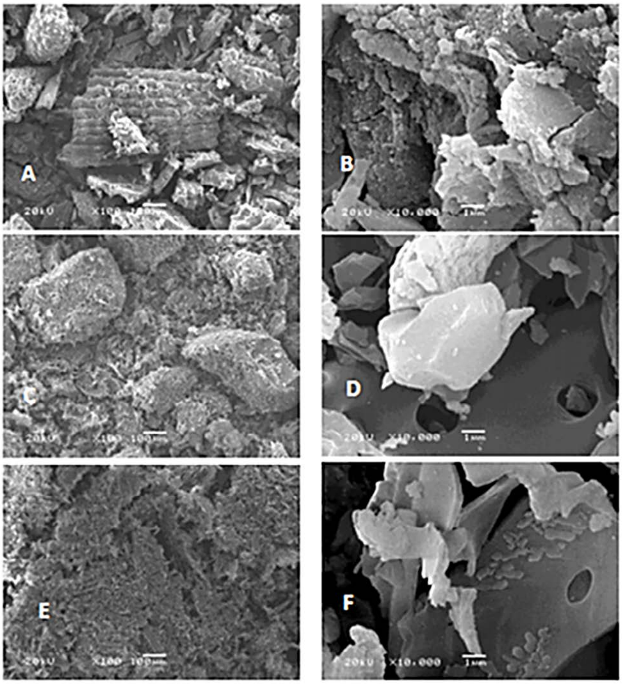

Figure 2: The images of scanning electron microscope representing the changes and voids formation on the surface of biochar samples of rice husk *(A,B), peanut hull (C,D) and wheat straw (E,F).*

efficiency in NH_4-N removal (66 %) regardless the type of associated anions (Cl^- or SO_4^{2-}). Meanwhile, RHB showed the lowest efficiency with this level of contamination (39% for SO_4^{2-} for and 42.7% for Cl^- form). With the higher contamination of wastewater by ammonium (10000 and 20000 mg NH_4-N kg^{-1} biochar), all types of bio-sorbents showed similar efficiency in removing process (60.5 – 69.5%). Then the removing percentages decreased when the wastewater contained 100000 mg kg adsorbent (49 – 57%). But, in general, PHB was superior in removing NH_4-N from wastewater (Figure 3). Although the efficacy of tested biochars in ammonium removal varied, they are considered effective when compared to the currently used adsorbents. According to the study by Hussain *et al.* (2006), using a mixture of lime stone and granular activated carbon by ratio 25:15, about 58% of NH_4-N was removed in a batch adsorption experiment with shaking time of 150 min and settling time of 120 min with initial concentration of 2.5 mg L^{-1} NH_4-N; the removal percentage was 39% for initial concentration of 100 mg L^{-1} NH_4-N. In another study by Aguilar *et al.* (2002), the percentage of removed NH_4-N by activated silica, powdered activated carbon and precipitated calcium carbonate was very low (3-17%). Also, Abdul Aziz *et al.* (2004) used activated carbon and lime stone to remove ammoniacal nitrogen (N-NH3) from the municipal solid waste leachate. They found that about 40% of ammoniacal nitrogen with concentration of more than 1000 mg L^{-1} could be removed either by activated carbon or a mixture of carbon with limestone at mixture ratio of 5:35.

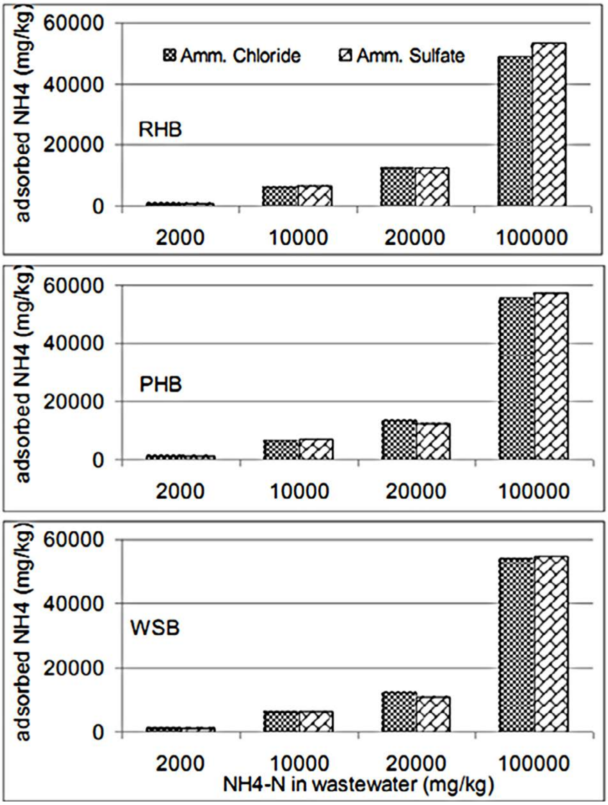

Figure 3: Adsorbed NH_4-N on RHB, PHB and WSB after 24 hours as a function of ammonium salt and initial ammonium concentration.

Although the increase in the ammonia adsorption follows the trend of an increase in the surface area of biochar, RHB (SSA 56.07 m^2 g^{-1}) presented a lower rate of $NH_{4-}N$ removal than PHB (SSA 1.9 m^2 g^{-1}). Therefore, other factors can be the leading influence, such as the type and dominance of surface functional groups on biochar, aromatic-to-aliphatic ratio of the structure or the degree of crystal-to-amorphous phase of biochar. Seredych *et al.* (2009) attributed the higher performance in $NH_{4-}N$ removal by different types of graphite to the presence of amorphous fractions of carbon, which can be formed by milling or during exfoliation. The ammonium NH_4^+ adsorption isotherms were studied at different initial concentrations ranging from 2000 to 100000 mg kg^{-1} biochar. The adsorption constants and correlation coefficients for NH_4^+ onto RHB, PHB and WSB were obtained from Langmuir and Freundlich isotherms as shown in Figure 4. Correlation coefficients suggested that the Langmuir model fit the data better than the Freundlich model. The maximum adsorption capacities of PHB $(NH_4)_2SO_4$ and NH_4Cl (9.4 and 6.73 mg g^{-1}, respectively) were higher than those of RHB (4.46 and 5.13 mg g^{-1}, respectively).

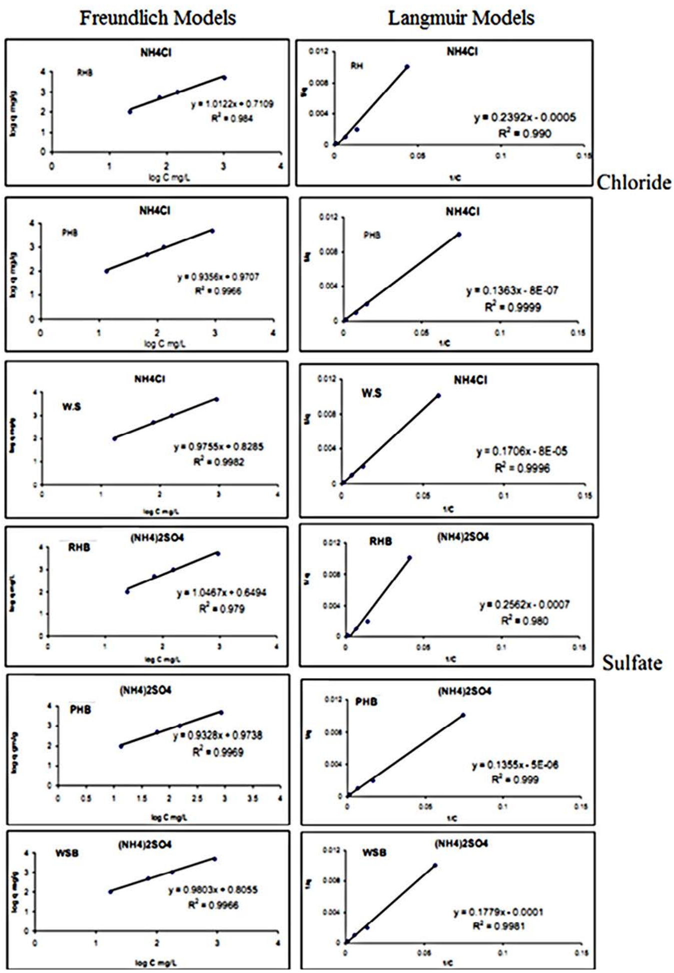

Figure 4: Adsorption isotherm curves according to Langmuir and Freundlich models to describe Ammonium (chloride and sulfate forms) adsorption onto the surfaces of RHB, PHB and WSB.

Ammonium Recovery from Biochar

The experiment of adsorbed NH_4-N recovery from biochar indicated that KCl extractant (2.0 mol L^{-1}) was not able to recover significant amounts of adsorbed ammonium from biochar surfaces. About 0.2% and 0.39% of the total sorbed NH_4^+-N were released from biochar treated with $(NH_4)^2SO_4$ and NH_4Cl solutions, respectively. These results reflected strong sorption forces of the PHB surfaces toward ammonium ions. During thermal decomposition of peanut hull biomass, mass loss occurs mostly in the form of organic volatiles, leaving behind voids, which form an extensive pore network. The morphological features of PHB and WSB surfaces shown by SEM images indicated the occurrence of micro-cavities which seem to work as irreversible sinks in which NH_4^+ ions were assumed to be strongly bonded by the internal–or hidden–functional groups of biochar. This envisioned structure could play a role in the irreversibility of NH_4^+ adsorption. Therefore, the recalcitrant nature of biochar will help in long-lasting this phenomenon and may support some thoughts that can be pursued to explain by biochar.

4. Conclusions

The obtained results confirm the importance of biochar produced from rice husk, peanut hull and wheat straw as efficient bio-sorbent for ammonium removal from wastewater. Further studies are urgently needed to explore the removal mechanisms and interpret the fate of removed ammonium if it is fixed by the porous structure of biochar or volatilized depending on the alkaline nature of biochar.

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Chapter Four

Sustainability

PAPER

18 Sustainable Manufacturing Indicators

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Abstract: Concerns about sustainable development have attracted the attention of international, governmental, non-governmental organizations, practitioners and academics. The main objective of sustainable development is the efficient use of current available resources to satisfy the current needs without depriving future generations from meeting their own needs. Manufacturing is an indispensable activity to provide people with their basic necessities in food, shelter, safety and even entertainment. However, practicing this important activity leads to known adverse effects on the environment. Depletion of natural resources, pollution of air and water, production of low quality products are examples of these adverse effects. Sustainable manufacturing is sought to be a modest step to resolve the presented dilemma. It is well known that if we want to control something, we must be able to measure it. Therefore, it is imperative to devise relevant indicators to measure sustainability of a manufacturing facility prior to controlling and then enhancing it.This paper is intended to introduce sustainability indicators that sufficiently and effectively cover inputs, manufacturing operations and products produced by a facility. A sustainability space is visualized as a three-dimensional space, with environmental, economic and social coordinates. A manufacturing facility will be represented as a point in this sustainability space. Our ultimate intention is to formulate a global indicator measuring sustainability of a manufacturing facility.

Keywords: Sustainability, manufacturing, sustainability indicators, Analytic Hierarchy Process.

1. Introduction

According to the United States Environmental Protection Agency (EPA), 19% of 2004 global greenhouse gas emissions are caused by Industry. These emissions are mainly caused by the burning of fossil fuel for energy generation, in addition to the chemical reactions involved in transforming inputs to outputs. This figure excludes the emissions from electricity generation, which is included in emissions from energy supply generation, an area responsible for 26% of 2004 global greenhouse gas emissions (EPA). Manufacturing is an indispensable activity providing people with their basic necessities in food, shelter, safety and even entertainment. However, conducting this important activity entails adverse effects on the environment. Depletion of natural resources, pollution of air and water, production of low quality products are a few examples of these adverse effects.

The increasing concern about sustainability due to the continuous depletion of non-renewable sources, and shrinking landfills, has initiated the necessity to create sustainable manufacturing activities. Hence, it has become necessary to assess the degree of sustainability in industry, in order to set plans on how to improve it and to provide for more sustainable industry. The current work intends to introduce sustainability indicators that sufficiently and effectively cover inputs, manufacturing operations and outputs produced by an industrial facility. Sustainability is measured in a multi-dimensional space to cover its totality. A sustainability space is visualized as a three-dimensional space with environmental, economic and social coordinates. Our ultimate intention is to formulate an overall indicator for measuring the sustainability of a manufacturing facility.

The remainder of this paper is structured as follows: Section 2 reviews relevant literature; Section 3 describes the suggested framework for developing a sustainability index for manufacturing; the weighting process of the different criteria via AHP is introduced in Section 4; an implementation of the proposed framework to an industrial facility is described in Section 5; and finally, the conclusions are drawn in Section 6, and possible areas of future work are suggested.

2. Sustainability Indicators in Manufacturing: Review of Literature

Since the initiative for sustainable development was made by an international organization, the United Nations World Commission on Environment and Development (WCED), the majority of indicators measuring sustainability are on a global, regional or county level. Joung *et al.* (2013) conducted a review on sustainability indicators and identified that many sets and indices have a focus on the sustainable development of a region or country, such as 2005 Environmental Sustainability Indicators (ESI), Environment Performance Index (EPfl), Environmental Pressure Indicators for European Union (EPrl), European Environmental Agency Core Set of Indicators (EEA-CSI), Organization for Economic Cooperation and Development (OECD), Dow Jones Sustainability Indexes (DJSI), International Organization for Standardization (ISO) Environment Performance Evaluation (EPE) standard (ISO14301), and United Nations-Indicators of Sustainable Development (UN-CSD).

Yet, there is a need to assess the degree of sustainability on a process or company level. The presented review of literature is limited to indicators used on process, product or company level.

Labuschagne *et al.* (2005) presented a framework for assessing the sustainability of industries. Their framework is particularly suitable for process industries. The model includes the three pillars of sustainability: economic, environmental and social.

In its effort to improve the economic and social well-being of people around the word, the Organization for Economic Co-operation and Development (OECD) has developed the OECD sustainable toolkit (OECD, 2011). The toolkit provides a total of 18 indicators categorized according to input, operations and output. It is observed that the indicators are mainly environmental. Direct consideration of social and economic aspects is lacking. The advantage of the toolkit is that it includes a set of measurable indicators that make use of easily accessible data.

A categorization of indicators for sustainable manufacturing that classifies a large number of indicators into appropriate categories and subcategories was suggested by the National Institute of Standards and Technology (NIST) (Joung *et al.*, 2013). Five main categories identified the dimensions of sustainability: environmental stewardship, economic growth, social well-being, technological advancement, and performance management. The proposed categorization by Joung *et al.* (2013) aimed to integrate all the possible sustainability indicators associated with manufacturing into a repository from which companies can choose to assess sustainability for their products and processes.

A number of authors have considered measuring sustainability across the supply chain (Erol *et al.*, 2011, Hassini *et al.*, 2012, Olugu *et al.*, 2011). This allows for the evaluation of sustainability without forcing valuations to be reduced to a single, one dimensional standard (Erol *et al.*, 2011).

From the reviewed literature it can be concluded that there is a need for developing indicators measuring sustainability that are simple to implement and interpret. The majority of developed indicators consist of a large number of indicators and causes ambiguities to manufacturers as to which indicator to use in addition to the difficulties in data collection especially in developing countries. It is our main objective to develop a set of indicators that fully describe the total aspects of sustainability and are easy to implement.

3. Sustainability Measurement Framework

A manufacturing process is a process that converts a set of input resources and materials into a pre-specified output product possessing targeted utility. Through the conversion process, value is added; however, wastes in various forms are created. A manufacturing process is shown in Figure 1.

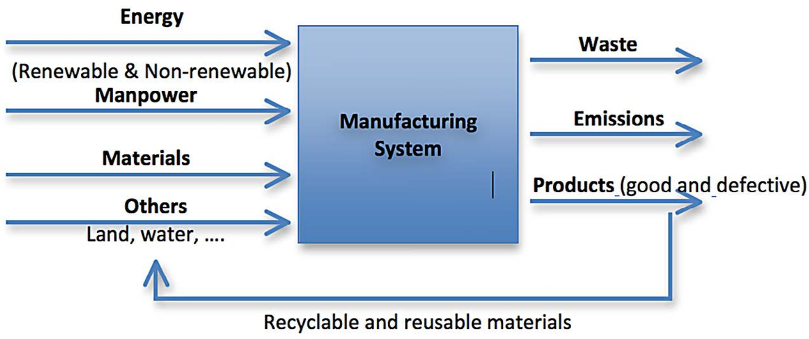

Figure 1: Manufacturing System inputs and outputs.

According to the United States Department of Commerce, sustainable manufacturing is the creation of a manufactured product with processes that have minimal negative impact on the environment, conserve energy and natural resources, are safe for employees and communities, and are economically sound (ITA, 2011).

Hence, there is a need to measure the degree of sustainability of manufacturing processes/systems. Since sustainability is measured across several dimensions, the indicators used to assess the different dimensions vary and have different measuring units. In the proposed framework, each indicator should be normalized and expressed in a dimensionless quantity in order to be able to aggregate different indicators into a Sustainability Index (SI).

4. Sustainability Index Hierarchy

The sustainability index is comprised of three main components: environmental, economic, and social. In order to assess the degree of conformance with respect to each dimension a number of indicators are necessary to encompass all aspects of each dimension. The hierarchy of suggested indicators is shown in Figure 2. The first tier of the hierarchy includes the three dimensions: 1) the environmental component measures the extent to which natural resources are depleted during the manufacturing process in parallel with the amount of wastes and undesirable emissions produced as byproducts that have adverse effects on the environment; 2) the economic indicator measures the value added through the manufacturing process and the efficiency of the process and is further subdivided into eleven sub-indicators; and 3) the social dimension indicator reflects the well-being of the labor and their development and is further subdivided into four sub-indicators. The indicator identification, definition and improvement direction are presented in Table 1. Environmental indicators consist of two hierarchies and are identified by I_{1ij}, where 1 indicates the first element in the Hierarchy *1*, and *i* and j represent the i^{th} and j^{th} elements in Hierarchy levels 2 and 3, respectively. Both economic and social indicators have only one level of subcategories and are thus labeled I_{kl}, where *k* and *l* indicate the k^{th} and l^{th} indicators in Hierarchy levels 1 and 2, respectively.

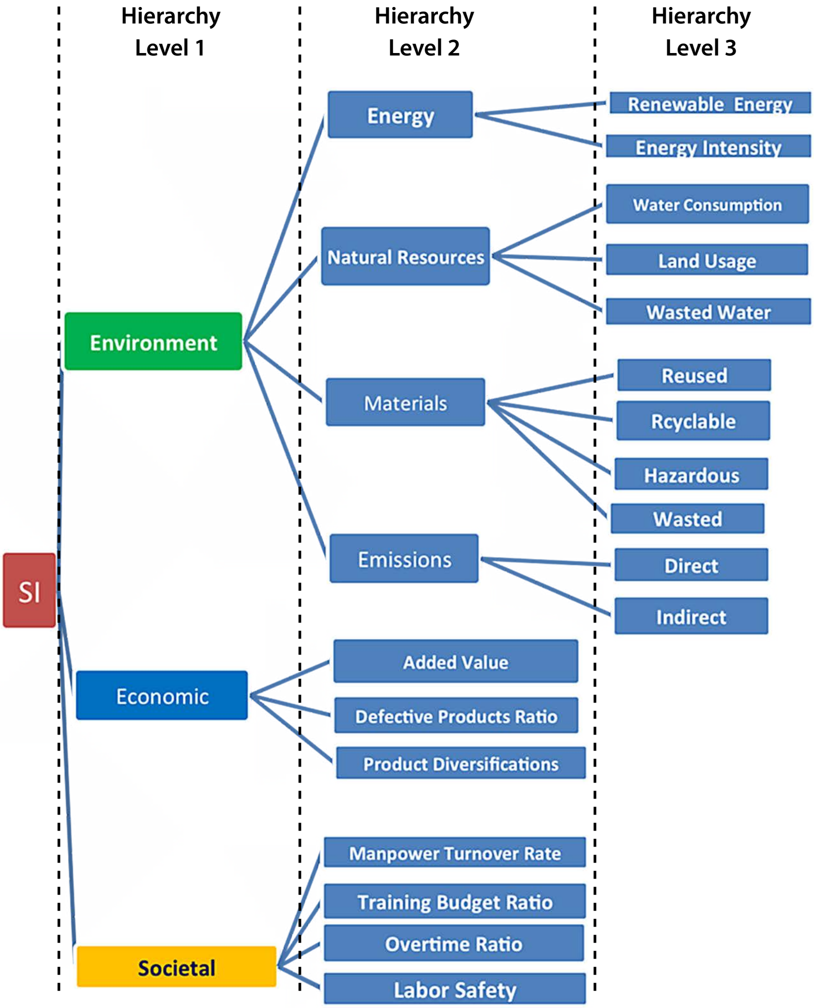

Figure 2: The hierarchy of indicators used for calculating the sustainability index.

Table 1: Indicators used in calculating the sustainability index

dimension		Indicators					Optimality direction
					Description	ID	
1	Environmental	1	Energy	1	Renewable energy ratio	I_{111}	Max
				2	Energy Intensity	I_{112}	Min
		2	Natural resources	1	Water consumption	I_{121}	Min
				2	Land usage	I_{122}	Min
				3	Wasted water ratio	I_{123}	Min
		3	Materials	1	Reused material ratio	I_{131}	Max
				2	Recyclable material ratio	I_{132}	Max
				3	Hazardous material ratio	I_{133}	Min
				4	Wasted material ratio	I_{134}	Min
		4	Emissions	1	Direct emissions	I_{141}	Min
				2	Indirect emissions	I_{142}	Min
2	Economic	1	Added value			I_{21}	Max
		2	Defective product ratio			I_{22}	Min
		3	Production diversification			I_{23}	Max
3	Societal	1	Manpower Turnover rate			I_{31}	Min
		2	Training Budget ratio			I_{32}	Max
		3	Overtime ratio			I_{33}	Min
		4	Labor intensity			I_{34}	Max

The following criteria are considered in selecting the relevant indicators:

- *Measurability:* can be simply measured using quantitative or qualitative data.
- *Ease of access to data:* is based on data that is readily available in the facility; no extra effort is needed for data collection.
- *Non-dimensionality:* is indicated as a ratio of the same units to facilitate the aggregation of all indicators into a single dimensionless value.
- *Relevancy:* relates directly to the dimensions of sustainability

Next, definition and formula of each individual indicator are discussed.

4.1 ENVIRONMENTAL DIMENSION INDICATORS

The environmental indicators encompass a set of 11 indicators as described next. The environment is affected by the manufacturing process in different aspects. First, natural resources are depleted and energy is consumed in the course of transforming the materials into finished goods. Hence the following indicators attempt to assess the environmental impact of the manufacturing operation.

Manufacturing is an energy intensive process; the use of renewable resources could have a considerable benefit in reducing the negative effects resulting from the use of traditional non-renewable resources. The renewable energy ratio indicator measures the proportion of renewable energy used to the total amount of energy required. The increase in this indicator achieves more sustainability.

$$I_{111} = \frac{Quantity\ of\ Renewable\ Energy}{Total\ Energy\ Consumption} \qquad (1)$$

Energy presents a vital input in the manufacturing operation. In order to assess the degree of energy consumed relative to all the other resources input to the system, the following ratio in Equation (2) is applied. The more energy is consumed, the less sustainable the manufacturing operation. Thus the ratio is subtracted from 1, so that the minimization of the ratio is guaranteed to achieve an increased sustainability level.

$$I_{112} = 1 - \frac{\$\ value\ of\ Energy\ Consumption}{\$\ value\ of\ Total\ Inputs\ to\ production} \qquad (2)$$

Water is among the critical resources used in manufacturing. The proposed indicator is calculated as per (3). It relies on measuring the amount of water used per product. Since, the amount of water may exceed the product volume; zero is used whenever the ratio turns negative.

$$I_{121} = Max\left[1 - \frac{Annual\ Water\ Consumption}{Annual\ Quantity\ produced}\ , 0\right] \qquad (3)$$

The erecting of facilities affects the nature and the biodiversity, thus a minimization of the space occupied by facilities is to be minimized as indicated by (4) in order to preserve the nature.

$$I_{122} = 1 - \frac{Area\ of\ Covered\ Land}{Total\ Area\ Used} \qquad (4)$$

In order to preserve the water resources, it is favored to minimize the amount of water wasted in the manufacturing facility as indicated in (5).

$$I_{123} = 1 - \frac{Wasted\ Water\ annually}{Total\ Water\ Consumption} \qquad (5)$$

At the end of the manufacturing operations some material contained in defective products may be reused in the production process instead of being disposed of. Reuse is considered as sustainable practice and is expressed by (6).

$$I_{131} = \frac{Quantity\ of\ Reused\ Material}{Total\ Input\ Material} \qquad (6)$$

Some of the scrap resulting from manufacturing can be reentered to the manufacturing process as substitute to virgin materials. The more recyclable content, the more sustainable the operation is. Equation (7) indicates the ratio of recyclable material to total material used.

$$I_{132} = \frac{Quantity\ of\ Recyclable\ Material}{Total\ Input\ Material} \qquad (7)$$

The use of hazardous material is to be minimized in a sustainable manufacturing system. Hazardous material necessitates special treatment in disposal in order to avoid their negative effect on the environment. The ratio of hazardous material to the total material input to the system is used as in (9) to reflect the effect of hazardous material.

$$I_{133} = 1 - \frac{weight\ of\ Hazardous\ Material}{weight\ of\ total\ input\ material} \qquad (8)$$

The scarcity of landfill for the disposal of wasted material calls for minimization of wastes. Equation (9) measures this aspect through the calculation of the portion of wastes generated through the manufacturing process.

$$I_{133} = 1 - \frac{weight\ of\ Wasted\ Material}{weight\ of\ total\ input\ material} \qquad (9)$$

Greenhouse gases include carbon dioxide (CO_2), methane (CH4), hydro fluorocarbons (HFCs), nitrous oxide (N2O), per fluorocarbons (PFCs) and sulphurhexafluoride (SF6). They may result directly from the manufacturing operations on site, or indirectly through either the process of electricity generation or the transportation activities. The two sources of emissions are formulated by (10) and (11), respectively. The indicator described in (10) measures the weight of gases generated, expressed in kilograms of carbon dioxide equivalent (CO_{2e}), per total weight of material used. It presents the direct emissions from the manufacturing operations.

$$I_{141} = 1 - \frac{Weight\ of\ GHG\ locally\ produced}{Weight\ of\ total\ input\ material} \qquad (10)$$

If c_{p1} and c_{p2}, present the amount of emissions resulting from the generation of 1 MW of electricity and the transportation per unit distance, respectively, the ratio of indirect emissions to the total weight of finished products is expressed by (11).

$$I_{142} = 1 - \frac{C_{p1} * MWH\ consumed + C_{p2} * Distance\ of\ transportation}{Weight\ of\ annual\ quantity\ produced} \qquad (11)$$

4.2 ECONOMIC DIMENSION INDICATORS

The economic dimension generally assesses the economic benefit and the amount of products resulting from the manufacturing system.

Added value is taken as a measure of economic benefit. It is compared to the total monetary value of the total production as described in (12).

$$I_{21} = \frac{Added\ Value}{\$\ Value\ of\ production} \qquad (12)$$

Defective products indicate the inefficiency of the manufacturing system. The generation of defective products means the unconscious consumption of resources which cannot be recovered, in addition to customer dissatisfaction and lost opportunities of profit. To assess the amount of defective products the loss function is applied as per (13).

$$I_{22} = 1 - Loss\ Function \qquad (13)$$

A sustainable manufacturing system uses the same resources to generate a multitude of products, thereby satisfying customers' needs with a minimum level of resources. Product diversification is used in (14) to assess this aspect, where N is the number of different products produced, Q is the maximum possible number of diversified products in the considered industry, and is the ratio of the quantity produced of the *i^th^* product to the total production. The calculation is based on the entropy principle.

$$I_{23} = \frac{\sum_{i=1}^{N} P_i\, ln(P_i)}{ln(1/Q)} \qquad (14)$$

4.3 SOCIAL DIMENSION INDICATORS

The social dimension indicator focuses on the manpower in the facility, considering their safety (equation 19) and development (equations 15-18).
A sustainable manufacturing system should provide stable job opportunities for the society members. This concept is measured by (15) through the number of fired or resigned employers. Firing and resignation may reflect the stability of the system and the employer- employee relationship.

$$I_{31} = 1 - \frac{Annual\ firings\ and\ resignations}{Total\ Manpower} \qquad (15)$$

The technical and skill development of the labor force is a crucial requirement for increased productivity. This is achievable through worker training. The ratio of budget reserved for training to all other expenses (16) is used to assess the degree the company is involved in the development of its workforce.

$$I_{32} = \frac{Training\ Budget}{Total\ Expenditures} \tag{16}$$

Although overtime is rated 150% of regular time, it has a negative effect on workers due to the overload they become subjected to. Hence, a sustainable manufacturing system should preserve the energy and well-being of its workforce and minimize the overtime as given in (17).

$$I_{33} = 1 - \frac{Annual\ Overtime}{Annual\ Regular\ time} \tag{17}$$

Labor intensity is measured in (18) through the comparison of the expenditure dedicated for the labor encompassing wages, incentive, insurance and others to the total amount of expenditure by the company including manufacturing and overhead costs.

$$I_{34} = \frac{Labor\ Expenditures}{Total\ Input\ Expenditures} \tag{18}$$

4.4 SUSTAINABILITY INDEX SI

The calculation of the sustainability index is achieved in two steps. First, the indicators within each of the three dimensions are algebraically added using their respective weight to obtain a single measure for each. The three resulting measures are the environmental indicator (I_{EN}), economic the indicator (I_{EC}), and the societal indicator (I_{SC}) and are obtained using equations (19–21), respectively.

$$\boldsymbol{I_{EN} = \sum_{i=1}^{4} \sum_{j=1}^{n_i} w_{1ij} I_{1ij}} \tag{19}$$

$$\boldsymbol{I_{EC} = \sum_{l=1}^{3} w_{2l} I_{2l}} \tag{20}$$

$$\boldsymbol{I_{SC} = \sum_{l=1}^{4} w_{3l} I_{3l}} \tag{21}$$

Second, the three resulting economic, environmental and societal indicators are considered as three components of sustainability vector in a three-dimensional space to arrive at the sustainability index (SI).

$$\boldsymbol{SI = \sqrt{I_{EN}^2 + I_{EC}^2 + I_{SC}^2}} \tag{22}$$

5. AHP Approach to Criteria Weighting

In order to arrive at an overall measure of sustainability, it is necessary to determine the relative importance of the different criteria and their sub-criteria. The Analytical Hierarchy Process (AHP) is commonly used multi-criteria decision model. It is based on pairwise comparison of a number of criteria, to arrive at a ranking for each criterion. "The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales. The comparisons are made using a scale of absolute judgments that represents, how much more, one element dominates another with respect to a given attribute" (Saaty, 2008).

To determine the criteria weight for all the indicators a total of six pairwise comparison matrices are necessary: one for the main hierarchy level (environment, economic, and social) (Table 2); three for the second hierarchy level (Table 3, Table 4, and Table 5); and two for the third hierarchy level (Table 6 and Table 7). The pairwise comparison is established on a nine-point scale reflecting the relative importance of each pair. A rate of one indicates that the pair being compared is equally important and the increase in the rate indicates the superiority of the first to the second element being compared. Thus, the scale of 3 means that element 1 is moderately important to element 2. The scale of 5, 7 and 9 indicate the strong, very strong, and extremely strong importance, respectively. The corresponding reciprocals, i.e. (1/2, 1/3,…, 1/9) give the reverse comparison between element 2 and 1.

Table 2: Pairwise comparison table for the main SI components

	Environmental	Economic	Societal	Weight
Environmental	1	7	2	0.615019763
Economic	0.142857143	1	0.333333333	0.092621871
Societal	0.5	3	1	0.292358366

Table 3: Pairwise comparison table for the environmental criteria

	Energy	Natural Resources	Materials	Emissions	Weight
Energy	1	0.2	2	1	0.141227
Natural Resources	5	1	9	3	0.595277
Materials	0.5	0.111111111	1	0.2	0.05788
Emissions	1	0.333333333	5	1	0.205615

Table 4: Pairwise comparison table for economic criteria

	Added Value	Defective Products	Production Diversification	Weight
Added Value	1	5	9	0.748164414
Defective Products	0.2	1	3	0.180402113
Production Diversification	0.111111111	0.333333333	1	0.071433473

Table 5: Pairwise comparison table for societal criteria

	Manpower Turnover Rate	Training Budget Ratio	Overtime Ratio	Labor Intensity	**Weight**
Manpower Turnover Rate	1	2	0.333333333	3	0.209275
Training Budget Ratio	0.5	1	0.2	3	0.133142
Overtime Ratio	3	5	1	9	0.597824
Labor Intensity	0.333333333	0.333333333	0.111111111	1	0.059758

Table 6: Pairwise comparison table for natural resources criteria

	Water Consumption	Land Usage	Wasted Water	Weight
Water Consumption	1	0.2	2	0.167594108
Land Usage	5	1	7	0.73797054
Wasted Water	0.5	0.142857143	1	0.094435352

Table 7: Pairwise comparison table for material related criteria

	Reused Materials	Recyclable Materials	Hazardous Materials	Wasted Materials	Weight
Reused Materials	1	3	0.5	2	0.281126
Recyclable Materials	0.333333333	1	0.2	0.5	0.089921
Hazardous Materials	2	5	1	2	0.448617
Wasted Materials	0.5	2	0.5	1	0.180336

"The priorities (are) obtained in exact form by raising the matrix to large powers and summing each row and dividing each by the total sum of all the rows, or approximately by adding each row of the matrix and dividing by their total" (Saaty, 2008).

The judgment of the decision makers may be inconsistent; therefore it is necessary to analyze the Inconsistency of the pairwise comparison. This is achieved through calculating an inconsistency measure, Inconsistency index (ICI) and Inconsistency ratio (ICR).The preference ratings given by the decision maker are considered consistent if ICR is less than or equal 0.1. Inconsistency index and ratio are calculated according to expressions (23) and (24), respectively.

$$ICR = \frac{\lambda_{max} - n}{n-1} \qquad (23)$$

$$ICI = \frac{ICR}{RI} \qquad (24)$$

Where n is the size of comparison matrix, λ_{max} is the eigenvalue, and RI is the random index depending on the matrix size.

The pairwise comparison is to be conducted by a number of decision makers to arrive at the relative weight for each criterion. The weights obtained from the subjective judgment of each decision maker are aggregated using the geometric mean as per (25) and (26) for environmental criteria weights and environmental and societal criteria weight, respectively.

$$w_{1ij}^{m} = \left(\prod_{m=1}^{n} w_{1ij}^{m}\right)^{1/n} \qquad \text{for all } i \text{ and } j \quad (25)$$

$$w_{kl}^{m} = \left(\prod_{m=1}^{n} w_{kl}^{m}\right)^{1/n} \qquad \text{for all } k \text{ and } l \quad (26)$$

Where w_{1ij}^{m} indicates the weight w_{1ij} given by the m^{th} decision maker, and n represents the total number of decision makers involved in setting the criteria preferences.

6. Framework Implementation

The proposed framework has been implemented for assessing the sustainability of a small size printing and packaging company in Alexandria, Egypt. The main products for the company are

- Folded carton boxes for secondary and primary packaging of food and non-food goods
- Laminated paper bags as primary packaging for food products.

The main processes performed by the company are receipt and inspection of raw materials, printing, varnishing, cutting, gluing, packaging and shipping to customer.

The plant extends over an area of 3000 m^2 with a workforce level of 50 workers. The plant operates on a one-shift basis, six days per week. The company under study holds four quality certificates: ISO 9001, ISO 14001, ISO 22000, and OHSAS 18001. The markets targeted include local and European markets, among others.

6.1 DATA COLLECTION

The data needed to calculate the different indicators were collected from the company and are provided in Table 8. It is noted that the data required for calculating the indicators do not require special data collection, since they are among the available data recorded for any plant. They coincide with other data needed by other implemented quality systems; hence no extra burden is associated with the assessment of sustainability.

6.2 RESULTS

Based on the values given in Table 8 and using equations (1)–(21), the results of the different indicators are given in Table 9.

According to (22), the value of SI is 0.58. The value of SI is a dimensionless quantity and can be used to benchmark the performance of a specific plant over time. In order to obtain an SI value in terms of a percentage, the current value has to be compared with the largest possible SI value. The latter is obtained by substituting all indicator value in equation (22) by 1, the ideal case of perfect sustainability. Using the calculated weights, the largest possible SI value is 0.72. Dividing 0.58 by the largest possible SI value of 0.72 will result in a sustainability value of 0.815 or 81.5%.

Table 8: Plant data

ITEMS	VALUE	ITEMS	VALUE	ITEMS	VALUE
Quantity of Renewable Energy (KW)	0	Wasted Water annually (liter)	360,000	Training Budget (EGP)	40,000
Total Energy Consumption (KW)	160,000	Quantity of Reused Material (ton)	317	Total Expenditures (EGP)	3,800,000
$ value of Energy Consumption (EGP)	120,000	Total Input Material (ton)	7,920	Annual Overtime (hr)	23,400
$ value of Total Inputs to production (EGP)	30,000,000	Quantity of Recyclable Material	500	Annual Regular time (hr)	120,000
Annual Water Consumption (liter)	1,800,000	Quantity of Hazardous Material (ton)	15	Labor Expenditures (EGP)	2,400,000
Annual Quantity produced (ton)	6,900	Quantity of Wasted Material (ton)	203	Total Input Expenditures(EGP)	33,800,000
Area of Covered Land (sqm)	1,680	Annual firings and resignations (worker)	6	Total Sales (EGP)	37,503,074
Total Area Used (sqm)	3,000	Total Manpower (worker)	50	Number of different products produced (N)	12
Maximum possible number of diversified products (Q)	12				

Table 9: Indicators calculation results

Indicator	Symbol	Indicator Value	Weight	I*W
Ratio of Renewable Energy	I111	0	0.01167	**0**
Energy Intensity	I112	0.996	0.07002	**0.0697**
Water Consumption	I121	0.907874696	0.13491	**0.1225**
Land Usage	I122	0.44	0.10546	**0.0464**
Wasted Water Ratio	I123	0.8	0.04155	**0.0332**
Ratio of Reused Materials	I131	0.04	0.00752	**0.0003**
Ratio of Recyclable Materials	I132	0.063131313	0.00322	**0.0002**
Ratio of Hazardous Materials	I133	0.998169192	0.02074	**0.0207**
Ratio of Wasted Materials	I134	0.974368687	0.00995	**0.0097**
Direct Emissions	I141	1	0.13432	**0.1343**
Indirect Emissions	I142	0.978092568	0.13432	**0.1314**
Added Value	I21	0.098740546	0.11193	**0.0111**
Defective Products Ratio	I22	0.975	0.03314	**0.0323**
Production Diversification	I23	0.938309933	0.01256	**0.0118**
Manpower Turnover Rate	I31	0.88	0.02064	**0.0182**
Training Budget Ratio	I32	0.010526316	0.02128	**0.0002**
Overtime Ratio	I33	0.805	0.10582	**0.0852**
Labor Intensity	I34	0.071005917	0.02096	**0.0015**

7. Conclusions and Future Work

Measuring sustainability is an essential practice and major determinant for setting plans for improving sustainability of manufacturing plants. There is a need for developing indicators measuring sustainability and which are simple to implement and interpret. The majority of developed indicators consist of a large number of indicators and causes ambiguities to manufacturers as which indicator to use in addition to the difficulties in data collection especially in developing countries. The proposed framework for measurement of sustainability of manufacturing facilities is based on a three level hierarchy covering the three dimensions of sustainability: economy, environment, and society. Relative weights of different criteria involved in determining the overall sustainability are obtained via AHP. The proposed model is characterized of its simplicity and ease of implementation, since it relies on data readily available in the plant.

The proposed framework may be implemented on different industries and SI value may be used to monitor the progress in sustainability over time. Further research may include the use of fuzzy sets to elicit qualitative preferences from the decision makers.

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PAPER
19

Sustainable Tourism in Egypt: Western Desert as a Potential for Future Ecotourism

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Abstract: Tourism in Egypt is one of the main sources of foreign currency and its direct and indirect contribution to the economy is around 10% of GDP. Yet, most of the tourism business in Egypt relies on beach tourism at the Red Sea, cultural tourism in Upper Egypt and local beach tourism at the North Coast. These three main tourism areas account for around 90% of the total touristic activities in Egypt and unfortunately they hardly follow a sustainable tourism approach but rather a commercial attitude. Assessing tourism business in Egypt for sustainability practices points to Siwa Oasis as one of the most prominent and outstanding areas for sustainable tourism. It might have been advantaged by being remote and poorly connected to main urban centres which helped in limiting negative impacts of rapid urbanization. It also benefited from individual initiatives which tried to counter the disadvantages of remoteness by being an oasis of ecotourism. There are other places in Egypt, especially on the Western Desert and around the Nile Valley, like Fayoum and Aswan, which have the potential to develop in the direction of ecotourism or in a complementary direction. This paper aims to study the conditions and components of ecotourism in Siwa with the objective of drawing the outline boundaries and conditions for this business in Egypt. The paper then tries to set the premise for a national road map to expand the sustainable tourism business in Egypt and tests the applicability of these boundary conditions and components in two other potential locations of Fayoum and Aswan.

Keywords: Ecotourism, Sustainable Tourism Strategy, Siwa Oasis, El Fayoum Oasis.

1. Introduction

Tourism is one of the most important and influential sectors of the Egyptian economy; it contributes 11% of the country's GDP, 12.5% of the total direct and indirect job opportunities and 20% of hard currency revenues as stated by the central bank of Egypt (CBE) in 2010 (Nasr, 2011). Accordingly, the Egyptian government continually seeks new policies and revenues that would help this sector flourish, which would consequently improve other development sectors.

Egypt is characterized by its rich biodiversity, heterogeneous cultural treasures and adventurous seashores. These features are distributed all around Egypt, so with a planned and managed tourism strategy, development would be achieved in a regional sense. However, there are some touristic sites that have not been well exploited till now; they may introduce a new perspective of Egypt worldwide.

Tourism in Egypt can be categorized into three main groups: international beach tourism at the red sea; cultural tourism in Upper Egypt, Cairo and Alexandria; and local beach tourism at the North Coast. These three main tourism groups account for around 90% of the total touristic activities in Egypt. However, they all follow the mass tourism concept, which can be defined as "the act of visiting a destination with large amounts of people at one time" (Answers, 2013). Usually this trend of tourism implies relatively fancy hotels, improved infrastructure and a diverse range of restaurants and cafes, without putting the socio-economic characteristics of the local people or the ecological profile of the environment into consideration. This results in numerous impacts on the environment ecologically, economically and culturally, most of which are irreversible. Accordingly, the world has changed the way it deals with sensitive sites and a more sustainable approach has been introduced: ecotourism.

Ecotourism is defined by The International Ecotourism Society (TIES) as "responsible travel to natural areas that conserves the environment and improves the well-being of local people." (TIES, 1990) In fact, ecotourism deals with sensitive ecosystems and indigenous people, mainly aiming to give the world the chance to explore these sites with the least impact on the ecosystems while trying to conserve their cultures in a rapidly globalizing world.

2. Ecotourism as a New Development Strategy

"Although ecotourism is subject to multiple definitions, it is typically contrasted to traditional tourism. Its attraction is derived essentially from the ecological and economic sustainability it is supposed to embody" (Dujon, p.56, 1999)

Ecotourism's main concern is the conservation of the natural ecosystem and indigenous cultures. By protecting the ecosystem, which is the main driver of tourists to come to such places, this kind of tourism shall be considered sustainable. Recently, many countries view ecotourism from a new perspective as they seek to develop remote regions and preserve protected areas (Lash, 1997). However, due care should be given when relying on ecotourism as an economic generator. A pre-planned strategy and a well-managed monitoring system are the basic ingredients for ecotourism to be considered a sustainable approach for development.

2.1 ECOTOURISM STRATEGY "CONSERVATION AND DEVELOPMENT"

A successful ecotourism strategy's main pillars are: retaining the ecological sustainability of the natural resources and the wise management of them (Dujon, 1999) as well as improving the welfare of local communities (Figure 1).

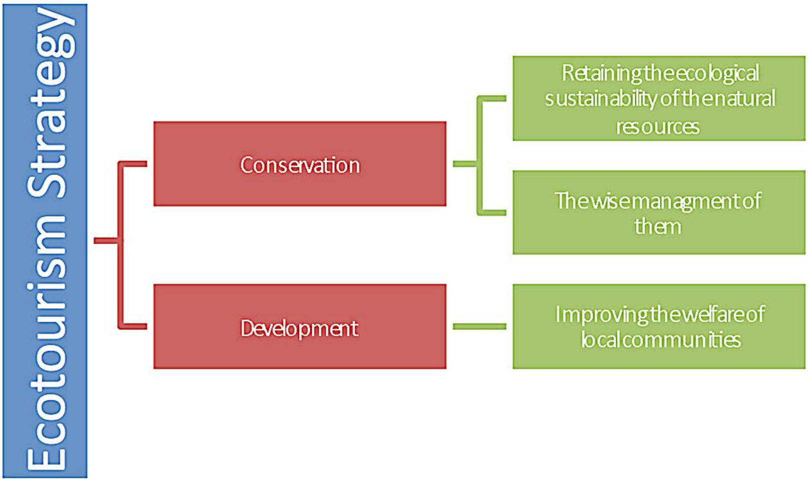

Figure 1: Ecotourism strategy's main pillars (Source: the author).

Conservation

Preserving the ecosystem is ecotourism's top priority in ensuring its sustainability. Accordingly, natural resources are given due care so that ecotouristic activities would have minimal or, preferably, no impact on the environment.

Wise management requires adequate planning, design and construction procedures for new touristic facilities in a way that enhances, rather that weakens, the natural setting. In addition, great attention has to be directed to the allowed number of visitors and their visitation modes in a way that do not impose a negative impact on the natural resources (Abdel Meguid, 2012). On the contrary to mass tourism, ecotourism does not target a large sector of tourists. Hence, appropriate marketing policy should be agreed on and maintained by the stakeholders, in order to target the appropriate sector and by predefined numbers.

Development

Successful management of ecotourism requires the collaboration of different stakeholders. As stated by Dabour (2003), tourism is one of the world's largest industries worldwide that involve a large network of businesses and services as well as a wide range of stakeholders, from governmental and intergovernmental organisations to private sector, non-governmental organizations (NGOs), tourists and host communities. As ecotourism is a form of the tourism industry, the same principles are still valid.

However, this type of tourism endorses a great sensitivity to the ecosystem and its local people. Consequently, the community based ecotourism (CBET) concept has emerged, representing one of the major keys for success for the sustainability of ecotourism as a development strategy. CBET, according to Suansri, can be defined as “tourism that takes environmental, social and cultural sustainability into account. It is managed and owned by the community, for the community, with the purpose of enabling visitors to increase their awareness and learn about the community and local ways of life” (Suansri, 2003, p. 15 cited in Byczek, 2011).

“Communities are part of ecotourism ecosystems, and these community residents should have the greatest voice in the development and the conservation of their natural resources.”(Lash, P.10,1997)

Community involvement embodies their participation in resource management, which helps in increasing the local awareness on the value of the natural resources (Barna *et al.*, 2011), as well as giving them access to the generated income (Dujon, 1999), which help in improving their living conditions. Hence, ecotourism can contribute to the development of remote areas or create revenues for the preservation of biologically rich areas (Barna *et al.*, 2011) such as national parks or protected areas.

Another main issue that must be considered for the effectiveness of community involvement is land ownership. Frequently, protected areas are owned by the government, which gives them the option of selling these areas to private entrepreneurs. On the other land, the local community are the peoples preserving such areas and usually they are one of the most important attractions in such places. These people do not own the land from the legal perspective. Hence for a sustainable ecotourism strategy, this issue has to be solved and the government should commit to protecting such areas (Lash, 1997), which in turn will increase their sense of belonging to the land and their commitment to this approach.

2.2 INDIGENOUS PEOPLE IN A FAST GLOBALIZING WORLD

“The opportunity to experience a different culture is also typically described as ecotourism. Here the argument is made that in addition to generating income, residents are encouraged to preserve their culture in a rapidly changing global environment that erodes local traditions.” (Dujon, p.5,1999)

Protecting the culture of indigenous people is another challenge confronting ecotourism. Indigenous culture includes its people’s traditional daily life skills such as building shelters, arts and crafts (Lash, 1997), their religious beliefs and celebrations. Although many have kept their culture through all of these centuries, it is being threatened now. As an increase in the number of tourists in some places result in a noticeable improvement in the local living conditions, their culture becomes less distinct, or in other words, globalized. For example, Silvio Barros II (1995) (Lash, 1997) noted an example where a native Brazilian family was famous for their special baking and attracted many tourists. They gave the family substantial amounts of money, which encouraged the family to buy modern equipment. In the following year, tourists were not satisfied at all, but the family continued to bake using the modern tools (Lash, 1997). So how can this dilemma be resolved?

If the proposed policies can enable indigenous people to make the main decisions regarding the amount, location, timing and nature of tourist visitation to the protected areas, this would decrease the globalizing effect as well as promoting the self-pride of the local community and pivoting them to their environment and habitat. "Thus, local people are empowered to control the direction of cultural change, and the commodification of some cultural events and places may be viewed as desirable". (*Barna et al.*, p5, 2011)

2.3 ECOTOURISM AND SUSTAINABILITY

Sustainability, in general, aims to achieve the balance between three main pillars of social, economic, and environmental aspects; these three pillars represent the main ingredients for the continuity of life. Similarly, sustainable tourism is defined as "tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities." (The World Tourism Organization), or alternatively, "tourism that respects both local people and the traveller, cultural heritage and the environment." (UNESCO, http://www.unesco.org).

Accordingly, we can conclude that any mode of tourism has the potential to be sustainable (see Figure 2). However, ecotourism or, more precisely, community based ecotourism can be considered the closest to sustainability since they take into account the preservation of the environment as a viable pillar in additional to local community participation. It can be said that these are the major components that ensure sustainability.

Figure 2: Relation between sustainability and tourism modes
(Source: www.sustainabletourismmanagement.com)

3. Ecotourism Industry

3.1 ECOTOURISM MAJOR COMPONENTS

The major elements in a successful destination can be introduced as:

a) the community;
b) a set of travel attractions;
c) a market (de Silva, 1998); and
d) the environment.

These components are the main drivers of ecotourism (shown in Figure 3); each driver consists of a set of minor elements that identifies it. These elements include:

- encouraging Local participation and ownership;
- sustaining the livelihood of the locals;
- execution by small local entrepreneurs;
- a natural resource base (topography, biodiversity and culture);
- targeting of small groups;
- a learning experience for the visitor;
- use of local resources;
- low consumption of non-renewable resources; and
- seeking to have the least negative impact on the environment (Gathered from different sources).

3.2 ECO-DESTINATIONS

Eco-destinations can be defined as places suitable for ecotourism activities and can adopt the major components of the ecotourism.

The United Nations Environmental Programme (UNEP) has identified a number of characteristics of eco-destination as follows:

a) natural features preserved within a protected landscape;
b) low density development, where natural areas are abundant and the built landscape does not dominate;
c) the main natural features of the ecosystem, such as waterways and wildlife areas, shouldn't be influenced by that tourism;
d) the presence of small community businesses owned by indigenous people that demonstrate their cultural being such as jewellery and gourmets making and their indigenous food;
e) outdoor recreation zones ensuring interaction between the locals and the visitors and preserving the fragile resources;
f) a variety of local festivals and events;
g) the provision of clean and basic public facilities for tourists and locals to share as public showers and toilets; and
h) friendly interaction between local people and visitors in natural meeting places as local shops or benches by the sea (Epler Wood, 2002).

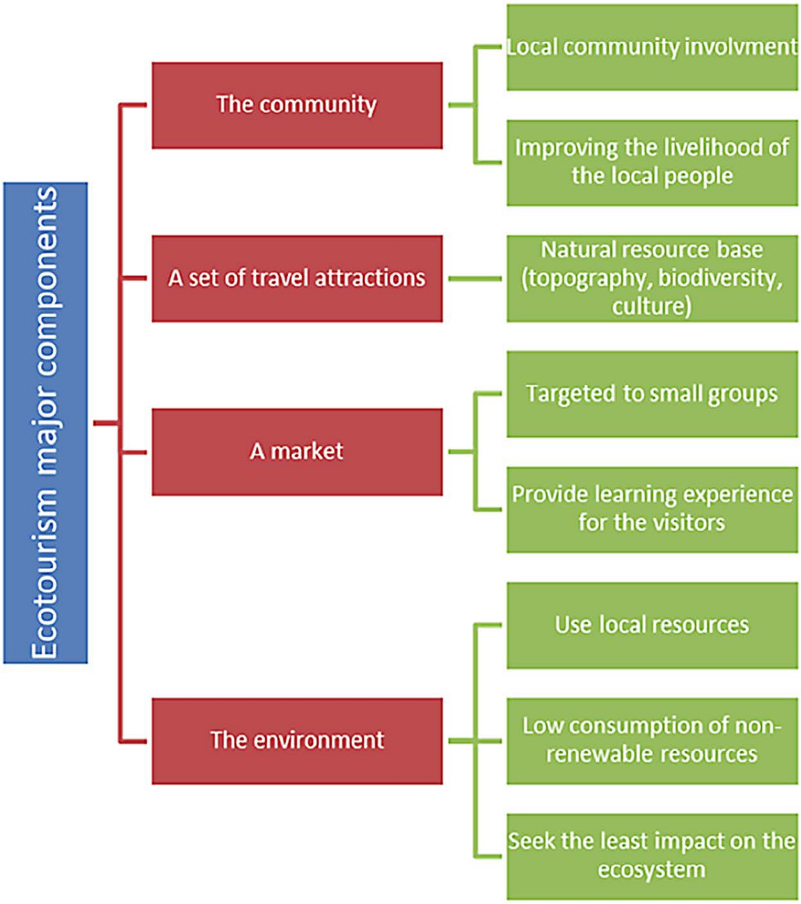

Figure 3: Major components of ecotourism (Source: the author).

In summary, these characteristics can be grouped into 3 categories named by Chandra de Silva (1998) as follows: Focal, Complementary, and Support attractions (see Figure 4), where:

a) the Focal attractions represent the most distinctive element of the natural environment and/or cultural heritage in the destination;
b) the Complementary attractions represent the added value to the ecosystem making it richer and more diversified experience. They encourage the eco-tourist to stay a longer period, generating a chance for additional economic revenue for the local people; and
c) the Support attractions represent the artificial facilities and services ensuring the contentment of the tourists. They include eco-lodges, visitor centres, activities services as horse riding and safari trips, and local guidance.

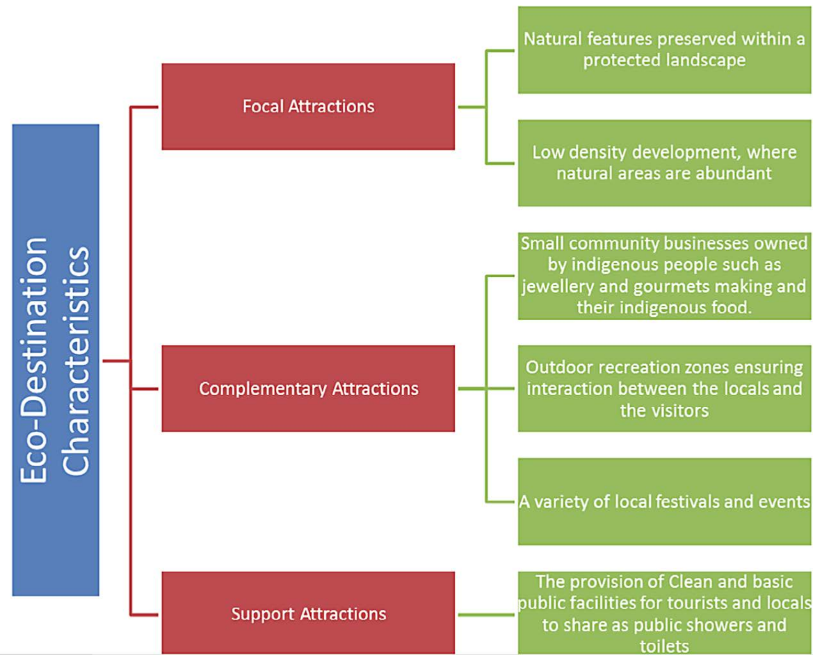

Figure 4: Hierarchy of characteristics of eco-destinations (Source: the author).

4. Ecotourism in Egypt

According to Cattane (2011), 100,000 eco-tourists have visited the Egyptian deserts and gone on safari tours in the western and eastern deserts of Egypt in 2010. Hence, we can say that Egypt is on the right track for being an international eco-destination. Egypt was ranked 18th among 50 countries worldwide as the most likeable tourist destination and the first in the Middle East and North Africa (MENA) region (Nasr, 2011). This can be a great asset that Egypt can build on, by adding a new means of attraction targeting a different segment and by rebranding Egypt as an eco-destination.

4.1 EGYPT'S PROTECTED AREAS

Egypt became aware of the great importance of its unique ecosystem and biological diverse species. In recognition of that it has signed a number of international conventions concerning the conservation of ecosystems, such as the National Biodiversity Strategy and Action plan in 1997, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the International Conservation Union (IUCN) (Hanafy, 2005). Consequently, it has established numerous decrees concerned about the conservation of the biological species and their environments.

For example, in 1983 law 102 of Protected Areas was issued declaring Ras Mohamed as the first protectorate. Currently, Egypt has declared 30 groups of protected areas that represent more than 15% of the total area (www.eeaa.gov.eg). These protectorates are a means by the government for protecting and sustaining endangered biological species and ecosystems (see Figure 5).

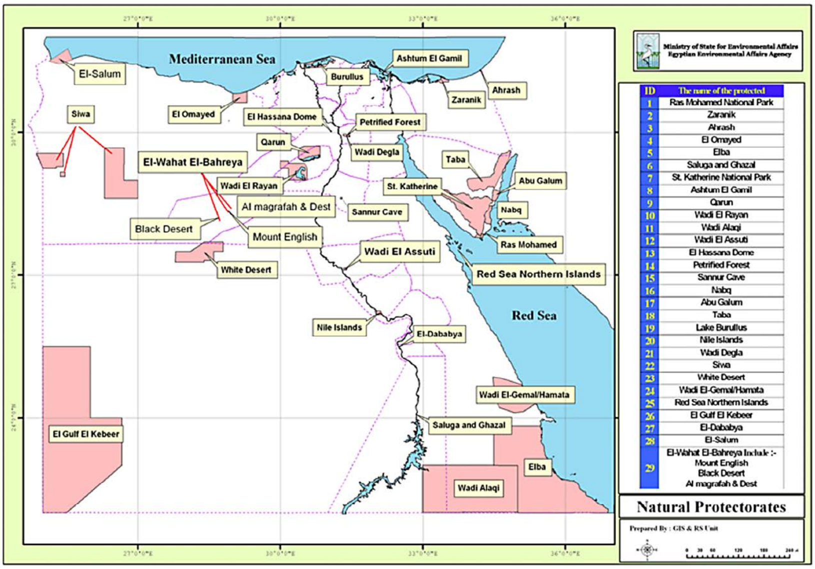

Figure 5: Locations of the declared Egyptian protectorates (Source: www.eeaa.gov.eg).

4.2 Ecotourism in Siwa Oasis

Siwa is the largest oasis in Egypt with an approximate area of 1175 km2. It is located about 800 km west of Cairo and 300 kilometers inland from the Mediterranean Sea. It is situated in a depression of 20 meters below sea level. It is connected to the other oasis and urban centers through roads and trails as it is the gate to the many Safari trip to the Western Desert as well as a main link between Egypt and Libya. Historically Siwa was on the main trade line between North Africa and Egypt including annual pilgrimage and seasonal trips. The main road leading to it now is Matrouh–Siwa Road with a length of 306 km (illustrated in Figure 6).

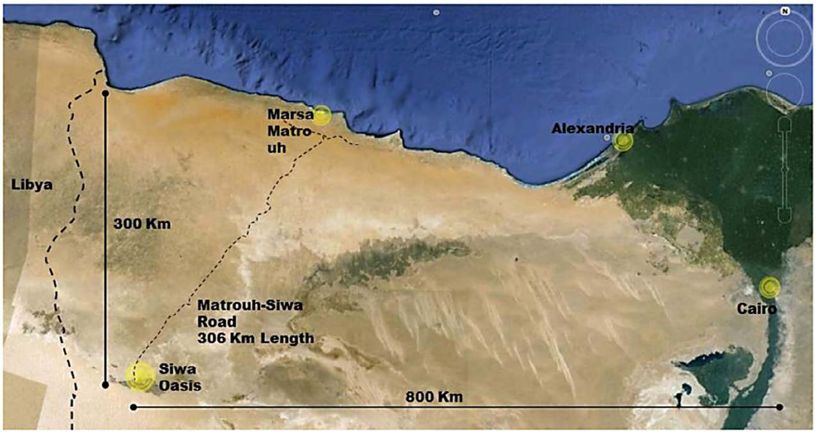

Figure 6: Location of Siwa Oasis (Source: Google Earth modified by the author).

Siwa oasis is characterized by its beautiful nature, a distinctive local community, and historical monuments. By analysing Siwa oasis assets according to the eco-destination characteristics described above, the extent of its success in ecotourism can be determined.

Focal Attractions

Siwa oasis is widely known for its:

a) Natural features:

- Beautiful scenery of the desert, the palm and Acacia groves as well as olive trees, and large lakes
- Sand dunes and mountains
- Hot water springs, where the water emerging from them includes ordinary and sulphurous water
- Dry climate (Bourse, 2011)

b) Cultural features:

Siwa is characterized by its historical importance and indigenous culture, because it has a number of historical monuments such as:

- The Temple of Jupiter Amun (temple of secrets), the Temple of Nectanebo II and Gabal Al-Mawta (Mountain of the Dead).
- Ruins of olive mills from Greek Roman age
- Graveyards dating back from the ancient Egyptian era and the Greco-Roman era (Bourse, 2011)

Complementary Attractions

Siwa oasis has a distinctive urban character and indigenous people that make it unique from any other area. The indigenous people have their own traditions and beliefs as well as their events, festivals, and traditional food and handicrafts. These characteristics can encourage the tourists to stay for a longer period of time to explore this unique environment and to interact with the local community.

Support Attractions

Siwa oasis has a number of eco-lodges and hotels that accommodate tourists. The main advantage of eco-lodges is their resemblance to traditional Siwian homes, which provide tourists with an authentic, local experience. In addition, Siwa has a number of activities tourists can participate in, such as desert safari trips, sand surfing and camel rides. The provided infrastructure is fairly good.

Hence, generally, Siwa oasis encompasses almost all the aspects of a successful eco-destination. On the other hand, there is an insisting question that has to be considered: what is the optimum management strategy to ensure its future success and sustainability?

Factors Behind the Success in Siwa Oasis

Siwa oasis has been isolated for a long period of time, which has enabled it to preserve its unique rural character and traditions. They manage their lives through community-based decisions, most of the times taken by the chief of the tribe. Adrère Amellal can be considered the most impressive eco-lodge located in Siwa oasis. This eco-lodge can be considered a success story and a replicable model.

"Neamatalla's Siwa project is a promising way forward for Egyptian tourism, which attracted more than 10 million people and about $11 billion of revenue to the country in 2008. Neamatalla's proponents say his business model is worth replicating, not only in Egypt, but also other parts of the Middle East." (Alameddine *et al.*, p.1, 2010)

The story begins by Neamatalla, the Egyptian businessman, who was fascinated by the nature and the social environment Siwa oasis possess. So he decided to erect a project (Adrère Amellal?) that would encourage other people to see what he saw as well as benefiting the local community. Neamatalla notes that much of the success was the spectacular surrounding landscape of the eco-lodge's site, which the government has provided him. Moreover, he insisted on preserving the local urban character by having the design of his eco-lodge mimic the locals' houses. This created an additional experience and joy for the tourists. Additionally, Neamatalla encouraged local handicrafts and employed Siwans in his eco-lodge. This boosted the Siwan's pride and sense of belonging, improved their standard of living, and impressed the tourists. (Alameddine *et al.*, 2010).

This initiative can be considered as community based ecotourism, as there is a consensus among local communities on the importance of tourism to the local economy in Siwa (Abul Hawa *et al.*, p.3, 2007).

Therefore, the main factors that led to this great success include:

- appropriate planning guidelines, as the unique site with the beautiful surrounding scenery was one of the most important aspects of its success. Hence, the government should give due care to the locations of the eco-lodges and main facilities that will be provided in these sensitive spots;
- community involvement, through employment at the eco-lodge and the sale of local crafts at the market, improved their standard of living and their well-being;
- conservation of the rural character, which pleased both the tourists and the local community;
- preservation of the environment during the construction phase, with the traditionally built eco-lodge consuming relative low amounts of non-renewable energies;
- availability of the basic infrastructure; and
- collaboration of the different stakeholders of the projects – the government, the private sector represented as Neamatalla, and the local community – was the major factor.

5. Egypt's Roadmap for Sustainable Ecotourism

In light of all that has been discussed, a framework can be formulated to ensure the sustainability of ecotourism in Egypt.

5.1 GOVERNANCE

- Formulating a conservation policy that identifies the types of activities that can be done in the protected areas and their allowable locations.
- Identifying the carrying capacity of each protectorate that won't affect the ecosystem and the local community through a participatory approach.
- Assuring the importance of environmental impact assessments (EIA) for any future projects in the protected areas.
- Improving a well-constructed monitoring system to ensure the commitment to the conservation policy.

5.2 PLANNING GUIDELINES

- Implementing proper pre-planning and management of the provided land for development and its relation with the protected areas.
- Adopting a participatory planning approach concerning the identification of the locations of the land for development, in order to avoid any disturbance to the local community traditional lifestyle.

5.3 OWNERSHIP

- Solving the problem of ownership of the local community's lands with the government in order to relieve their concerns and worries regarding tourism.
- Involving the private sector in tourism by providing them with land either for rent or permanent tenure.

5.4 PARTNERSHIPS AND ALLIANCES

- Collaborating with different stakeholders, which is one of the most important factors of the success of ecotourism, especially by involving the local community.

5.5 EMPOWERING THE COMMUNITY

- Teaching the local community.
- Building capacity for the local community to be able to serve in the eco-lodges and deal with the tourists through different activities.
- Establishing an ecotourism enterprise incubator that encourages small to medium sized tourism business thus helping the locals increase their standard of living. (Conservation International and the George Washington University)

5.6 INFRASTRUCTURE

- Improving the accessibility to the eco destinations.
- Providing the basic infrastructures at the planned activities zones
- Providing main services such as eco-lodges and public toilets.
- Establishing a visitor center to provide the basic information about the place and local guidance.

5.7 MARKETING

- Rebranding Egypt as an ecotourism destination.
- Opening new market segments in new countries.

6. El Fayoum Oasis as an Eco-destination

El Fayoum is an oasis located in the north of the western desert in Egypt. El Fayoum governorate covers an area of 6068 km2 (www.fayoum.gov.eg). El Fayoum is located about 90 km southwest of Cairo (Santagata *et al.*, 2006). It can be said that it is well connected to the main urban centres like Cairo, Beni Seuf, and Helwan, mainly through Giza-Luxor Road and Cairo-El Fayoum Desert Road (see Figure 7). It is also connected to other Egyptian oases through El Wahat El Bahreya- El Giza road.

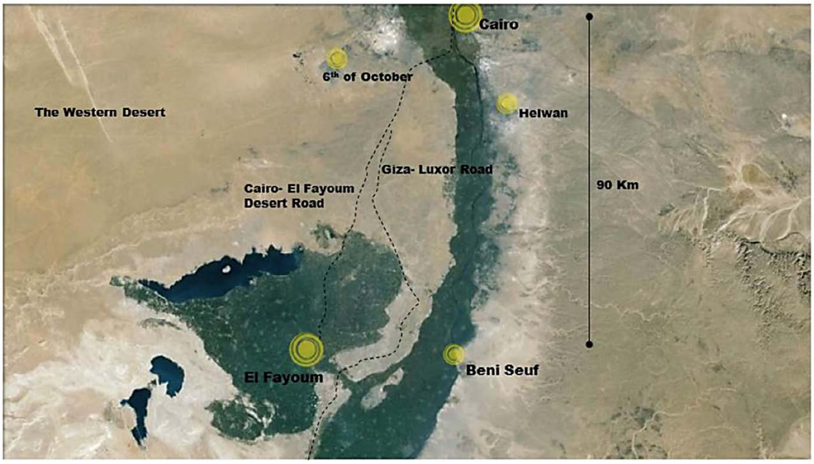

Figure 7: Location of El Fayoum Oasis (Source: Google Earth modified by the author).

EL Fayoum is rich with a number of assets that qualifies it to be a vibrant eco-destination. It is characterized by its diversity as it embraces the desert beauty along with relieving agricultural areas, and captivating lakes and waterfalls. In addition, it has witnessed several civilizations dating back to 4500 B.C. and passing through all the different eras in Egyptian history. Furthermore, El Fayoum has indigenous people who have their own distinct cultures and handicrafts. Collectively, El Fayoum can be considered as a comprehensive eco-destination combining natural, cultural and demographic assets.

6.1 EL FAYOUM OASIS ASSETS FOR BEING AN ECO-DESTINATION

El Fayoum oasis is a beautiful one-of-a-kind destination full of treasures and amusements. It is poised to be a successful eco-destination through a substantial number of complementary assets.

Focal Attractions

El Fayoum oasis is widely known for its diverse ecosystems. It can attract eco-tourists with totally different interests. It embraces this diverse range of activities and with some planning and marketing, it can become a viable global eco-destination.

a) Natural features:
- Beautiful scenery of the desert, sand dunes, and hills.
- Two main protectorates, Wadi Rayan and Qarun lake, declared by the Egyptian governorate
- Wadi Hitan (whales valley), classified as a world heritage site 2005 (Santagata *et al.*, 2006), is considered a remarkable open-air museum enclosing over 407 known whale skeletons. The site has the richest collection of ancient whales worldwide. (Wafik *et al.*, 2011)

- The location of Qortani Mountain to be considered by the UNESCO as a natural heritage area (EEAA, 2008),
- Distinctive flora and fauna.
- Scenic lakes and waterfalls next to captivating water wheels.
- These lakes are one of the important bird watching sites globally as Lake Qarun and Wadi el Rayan are considered home for thousands of birds species.

b) Cultural features:

El Fayoum has a number of historical monuments from different eras such as:

- Ein El Selyeen Steps, Abgeeg Obelisk;
- Um El Borygat City;
- Qaroun Palace, the ancient city of Madi;
- Virgin Mary Church, the Hanging Mosque; and
- El Haddeer Water Wheels.

Complementary Attractions

El Fayoum's indigenous people have their own traditions, costumes, and handicrafts. They have even inherited these handicrafts from the different cultures they have witnessed; for example, they have been mastering pottery since the Pharaonic era and handmade textiles since 5000 B.C. Their handicrafts include poetry, basketry and palm products, handmade textiles, rowboats, fishing nets, and mats made from El-Samar plant. (Environmental Design Group, 2007a)

Nazla and Tunis local villages can be considered as open heritage museums that tourists can visit to gain local experience (Environmental Design Group, 2007a).

Support Attractions

It can be said that El Fayoum is well connected to main urban centers, and supplied by fairly good infrastructure. However it lacks sufficient hotels and eco-lodges. There are only 8 hotels with a capacity of 340 rooms (Information and Decision Support Centre, 2008), which is insufficient for such a vibrant place.

On the other hand, El Fayoum oasis can accommodate a number of different activities for its visitors. They include desert safaris, sand surfing, magnificent bird watching, fishing, and opportunities to watch locals create indigenous handicrafts (see Figure 8).

Generally speaking, El Fayoum oasis is a perfect site for ecotourism. So why is it not an eco-destination? What is it lacking?

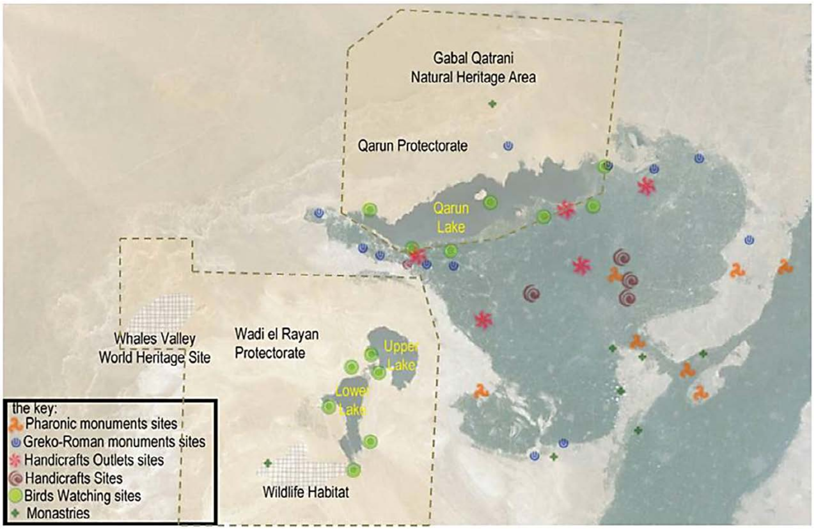

Figure 8: Attractions of El Fayoum Oasis (Source: www.cissong.org modified by the author)

6.2 ECOTOURISM STRATEGY FOR EL FAYOUM OASIS

The Egyptian government became aware in recent years of the great importance of ecotourism as a development tool to alleviate poverty. Acknowledging that El Fayoum oasis has great potential to become an eco-destination, El Fayoum Tourism Authority (FTA), in collaboration with the International Cooperation South South (CISS), the Italian NGO, and the Environmental Design Group (EDG), has conducted an ecotourism development plan 2005-2015. They have adopted a participatory planning approach through extensive discussions with the locals, NGOs, naturalists, entrepreneurs, businessmen, and government leaders. They have identified major key issues as:

- *"Developing long term ecotourism development plan*
- *Infrastructure and service improvement,*
- *Marketing support,*
- *Environmental education for the local population,*
- *Identifying the opportunities of interpretive themes and itineraries*
- *Providing modules of itineraries design like camel trekking, bird watching, crafts and local lifestyle and hiking itineraries."* (Environmental Design Group, 2007b).

Reflecting on the national roadmap for sustainable ecotourism that was described earlier, some issues were included in the 2005-2015 plan; however there are other issues that have to be tackled in order to ensure a sustainable approach and consequently, sustainable economic benefits.

6.3 THE APPLICABILITY OF THE NATIONAL ROADMAP

El Fayoum oasis has the assets for being an eco-destination, so the national roadmap for ecotourism should be applied to gain awareness of the actions required to turn El Fayoum oasis into a sustainable eco-destination (see Table 1).

Table 1: Analysis of the proposed ecotourism development plan of El Fayoum Oasis according to the national roadmap for sustainable ecotourism (Source: the author).

The Road Map's Checkpoints	Application
1. **Governance:** Formulating a conservation policy that identifies the types of activities that can be done in the protected areas and their allowable locations.	The EEAA authority is responsible for such decisions; however, collaboration may be the missing link.
2. **Governance:** Identifying the carrying capacity of each protectorate that won't affect the ecosystem and the local community through a participatory approach.	This aspect if of great importance as it has an environmental and a social dimension. Accordingly, the ecotourism plan should place a high priority on this aspect.
3. **Governance:** Assuring the importance of environmental impact assessments (EIA) for any future projects in the protected areas.	The EEAA authority should develop a SEA plan for El Fayoum oasis to identify the capacity of the protectorates and estimate the effect future tourism development would have on them.
4. **Governance:** Improving a well-constructed monitoring system to ensure the commitment to the conservation policy.	Great attention should be asserted to this aspect to ensure sustainability and the preservation of the ecosystem.
5. **Planning guidelines:** Implementing proper pre-planning and management of the provided land for development and its relation with the protected areas.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
6. **Planning guidelines:** Adopting a participatory planning approach concerning the identification of the locations of the land for development, in order to avoid any disturbance to the local community traditional lifestyle.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
7. **Ownership:** Solving the problem of ownership of the local community's lands with the government in order to relieve their concerns and worries from such tourism.	To assure warm reception from the local people to the tourists and such development, the issue of land ownership has to be solved first.

8. **Ownership:** Involving the private sector by providing them with land either for rent or permanent tenure.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
9. **Partnerships and alliances:** Collaborating with different stakeholders, which is one of the most important factors of the success of ecotourism, especially by involving of the local community.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
10. **Empowering the community:** Teaching the local community.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
11. **Empowering the community:** Building capacity for the local community to be able to serve in the eco-lodges and deal with the tourists through different activities.	This has to be integrated into the development plan, in order to prepare the local community for a transformation in their lifestyles.
12. **Empowering the community:** Establishing an eco-tourism enterprise incubator that encourages small to medium sized tourism business thus helping the locals increase their standard of living.	This aspect gives the local community the chance to get involved in the development, not only by servicing it but by being a part of it; it ensures their complete commitment and participation.
13. **Infrastructure:** Improving the accessibility to the eco destinations.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
14. **Infrastructure:** Providing the basic infrastructures at the planned activities zones	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
15. **Infrastructure:** Providing main services such as eco-lodges and public toilets.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
16. **Infrastructure:** Establishing a visitor center to provide the basic information about the place and local guidance.	This has to be incorporated into the development plan.
17. **Marketing:** Rebranding Egypt as an ecotourism destination.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015
18. **Marketing:** Opening new market segments in new countries.	This aspect has been fulfilled by El Fayoum Ecotourism Development Plan 2005-2015

Results

After analysing the proposed El Fayoum Ecotourism Development Plan 2005-2015 using the national roadmap, it is obvious that it has fulfilled a number of aspects. However, it still lacks some major pillars that ensure the sustainability of ecotourism as a reliable economic driver and the preservation of the endangered ecosystems (see Figure 9).

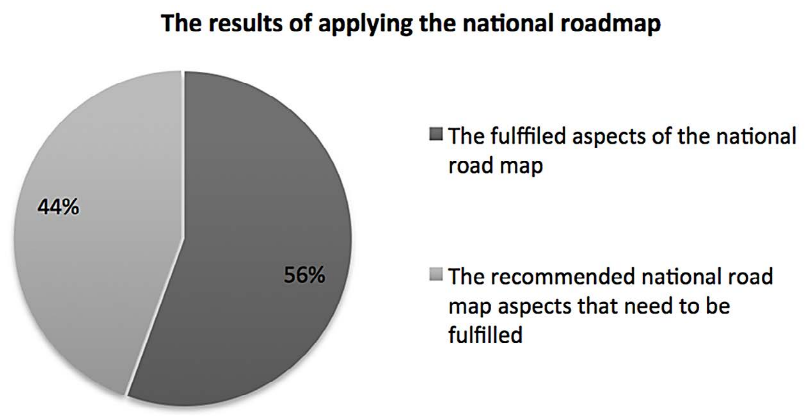

Figure 9: The result of the analysis of El Fayoum Ecotourism Development Plan 2000-2015 (Source: the author).

7. Conclusions

As tourism contributes a substantial share to the country's economy, it requires due care in order to ensure its continuity. Consequently in recent years, the world introduced ecotourism as a new mode of tourism that pays attention to the preservation of the environment. This mode was subject to a number of alterations and experiences and is now being sought as a development and conservation tool. This mode of tourism overcomes the major disadvantages of mass tourism, such as destroying the environment due to the excessive usage of local resources as well as the marginalization of the local community in favour of foreign tourists.

Nowadays, every country seeks a mode of tourism that is sustainable and capable of providing economic welfare while preserving the ecosystem. However each mode has different features. So what is the best mode for Egypt to adopt?

Egypt has a number of distinctive ecosystems that support endangered species. Hence, in order to preserve and develop these sites, Egypt can adopt ecotourism as a tool of development and conservation. However, community based ecotourism is considered to be a more sustainable approach than ecotourism, as it takes the social side of the community into consideration as well; encouraging the local community to participate in the management of their environment and lives.

On one hand, ecotourism's concept is to limit the number of tourists to preserve the ecosystem and not disturb it. On the other hand, mass tourism becomes important to the economic benefit from developing these regions into touristic sites is a priority, since most of these regions suffer from poverty and marginalization. Therefore, there are 3 situations that can be adopted in order to attain both sustainability and economic welfare: "optimum", "best", and "better". The "optimum" situation is attained by promoting ecotourism in a sustainable way with local community engagement, preserving the environment, and attaining economic welfare, then consequently developing the region. This scenario can be applied in the protectorates of El Fayoum oasis. Whereas the "best" situation is attained by the promoting a site and encouraging a large number of tourists to visit it, reaping the economic benefit, but at the same time having the ability to make it a sustainable approach without damaging the assets or decreasing its appeal. This situation can be applied in El Fayoum urban center, by building hotels that can accommodate the numbers of tourists, then providing a transportation mode to the touristic sites. The "better" situation is attained by the ability to accommodate the large number of tourists and at the same time preserving the environment (see Figure 10).

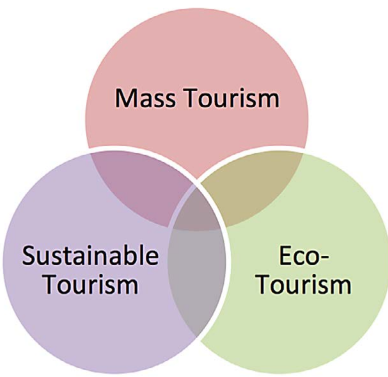

Figure 10: The relation between different modes of tourism (Source: the author)

However none of this can be achieved without proper planning policy and an active monitoring system to assure the solidity of the natural ecosystem and endangered species.

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PAPER

20 Traffic Congestion Sustainable Solutions: Mass Transportation (Railway Upgrade)

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Abstract: Traffic Congestion is a major problem in most cities. It's a non-productive, time-wasting activity for most people especially private transportation. It results in the inability to forecast travel time accurately, leading drivers to allocate additional time to travel "just in case", thus spending less time on productive activities. The stress and frustration experienced by motorists encourages road rage and can negatively impact health. Traffic congestion also reduces air quality and is a major contribution to the use of enormous amounts of non-renewable energy and the associated generation of carbon emissions. The size of the problem varies from one area in a city to another, but overall, it is a major problem for all mega cities. Alexandria is directly affected by this problem. Its linear planning may be exacerbating the congestion due to the long distances one has to travel to reach a certain destination; however, it can also be used as a suitable solution if handled properly. Various attempts to solve the problem have been made but none have been proven to be effective. Surprisingly some of these attempts have caused even more traffic congestion. In order to find the proper solutions for traffic congestion in Alexandria, various factors must be studied carefully to make a decision based on previous experiences of other cities with similar conditions. This research aims to study traffic congestion caused by the increase in private vehicle ownership and possible sustainable solutions, which will be focussed on the upgrade of an existing railway. Mass transportation, such as rail, ensures safety, improves air quality and saves energy, time, money and space. Upgrading the existing railway and choosing suitable parking spots to encourage the "park and ride" concept is a suggested solution to decrease the congestion problem. A careful study of the railway's current condition and the important points it can connect is essential to reaching the right design decisions. If executed properly, this proposal can solve a big part of the traffic congestion problems in many areas in the city.

Keywords: Traffic congestion, Alexandria, Egypt, railway design, mass transportation, sustainable transportation.

1. Traffic Congestion

1.1 INTRODUCTION

Traffic congestion is a problem that is directly related to the chosen area of study. Not all causes and solutions of the problem can be generalized. Street network design, land use, traffic management and operation, and passenger and motorist behaviour are all factors that affect traffic flow. While studying an area, none of these factors can be ignored as they are all directly connected to each other.

Since Alexandria is a developing, growing, and crowded megacity, mass transportation should be a priority in the government's infrastructure and circulation upgrade plans, which is not the case at present. A public mass transportation network in Alexandria barely exists. Affordable public transportation modes currently available in Alexandria include the bus, tramway, and motorized tricycles with passenger cabins called "toktok", which are unreliable as there are no specific routes, schedules, or stops. The conditions a person has to bear to use the public transportation system are inhumane because of the lack of maintenance and overcrowded vehicles. This discourages most of the middle and upper class from using public transportation at all, leaving to "the poor". When in desperate need of public transportation, the upper and middle classes' choice is the taxi, which is expensive and unreliable.

The government prefers to spend money on developing roads and does not consider alternative public transportation options that may be more effective and efficient for public use. This encourages more people to purchase cars, as the wisest and fastest mode of transportation (Luoma *et al.*, 2010)

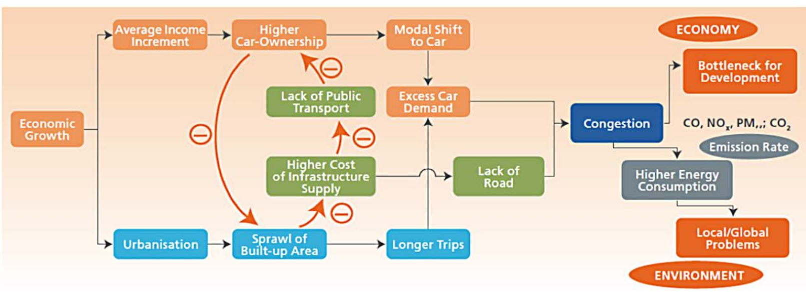

Figure 1: Motorization and urbanization may threaten the economy and environment (Source: Hayashi, 2010).

There are multiple solutions for traffic congestion problems. Every solution is suitable for a certain area and has its pros and cons. Possible solutions include widening roads, developing construction bypasses (inner ring roads, outer ring roads), implementing bus lanes, designating one way streets, increasing the cost of car parking, prohibiting single occupancy vehicle traffic from the city center, improving public transportation options and putting in place the "park and ride" system. Another suggested solution is upgrading the railway system, combined with utilization of the "park and ride" system for the linear city. This mass transport option is efficient and will service most of Alexandria's sectors. Therefore, this paper will study the viability of this idea, the process and requirements of upgrading the existing railway system, as well as possible solutions of marketing the idea to the public.

1.2 TRAFFIC CONGESTION IN MEGACITIES

Developing megacities that do not have a rail-transit system suffer from major congestion problem and disastrous CO_2 emission levels. Mass transportation combined with the "park and ride" system, especially with railway, has been found to be very effective in maintaining mega-cities sustainable.

Many metropolitan areas have developed transportation plans and strategies to outline their vision for the future. For example, New York's regional transportation plan aims to meet the transportation needs of the city and region for the next twenty years and more while improving travel speed (PlaNYC 2007). The specific initiatives include improving local commuter rail service. São Paulo's integrated urban transportation plan—PITU (2020)—includes: the integration of the transportation network, thereby efficiently utilizing the available resources; the reduction in the use of private means of transportation; improvement in the quality of transportation services; and preservation and promotion of urban spaces (Luoma *et al.*, 2010)

Both plans aim to alleviate traffic congestion by improving mass transportation systems and reducing the use of private vehicles. The goal is to apply this concept in the case of Alexandria while creating a suitable framework guided by the previous experiences of other mega cities.

Hayashi (2010) created a method to reduce the traffic congestion and therefore reduce the CO_2 emission level. It involves three steps: firstly, AVOID trips, secondly, SHIFT from high carbon mode to low carbon transport systems, and finally, IMPROVE the mode through technology and policy.

Avoid

The construction of new roads encourages the users to own private vehicles, which makes it possible for them to choose a residence that is far away from their workplace. This causes further trips and more CO_2 emissions. To AVOID these long trips, the spotlight must be directed on the mass transportation system and in this case the railway.

Hayashi (2010) selected several mega-cities for comparison, including Tokyo, Bangkok and Beijing. Benefiting from the priority given to its rail transit system, Tokyo suffered less road congestion during its urbanization process. On the other hand, Bangkok experienced its infamous congestion in the 1980s due to a highly car dependent transport system, with no urban rail transit system. The deferral of rail construction has an important relationship with heavy road congestion in these cities. In Bangkok, for example, the poorest traffic conditions were observed in areas whose urban rail transit systems were the least developed. Another important factor to heavy road congestion is the convenience of the road infrastructure in place. Beijing suffers from heavier congestion than Bangkok because its road network was completed sooner, which allowed its residents to form car-reliant habits early in the city's urbanization.

Shift

The first question to be asked is which mode of transportation is a better solution for less congestion?

Most decision makers prefer to develop the road system to relieve traffic congestion but they overlook the fact that developing the railway system can absorb the traffic demand and reduce the demand of car use. One of the reasons why railway development is avoided is its high construction cost.

The second question to be asked is which mode is a better investment for lower CO_2 emissions? According to Hayashi (2010), within urban centres, greater advantages can be gained from improved rail transit systems in areas with higher population densities.

There are instances where cars are the optimal transportation mode – one that emits the lowest CO_2 emissions. This is the case in areas whose population density falls under 3,500 person/km^2. In most developing megacities, the population density is often much higher than that; hence, the rail transit systems are highly recommended for those cities, while cars are not.

Improve

Hayashi (2010) states:

> *"If we really need to use cars – a high carbon emission system – in densely populated areas because public transportation is not available for some origins and destinations, we should then improve the technology for engines, fuels and networks.*
>
> *As we can see in the analysis, advancements in engine and energy consumption technology alone are insufficient to achieve CO2 reduction targets. In this forecast, it is assumed that, firstly, the vehicle statistics are provided by the Ministry of Land, Infrastructure, Transport and Tourism (Japan) and IEA (China) and, secondly, that vehicle-km is proportionate to the number of vehicles.*
>
> *One scenario to consider is that CO_2 emission rate per vehicle is the same in the future as that in 2010. The other scenario is that frontier technology for vehicles and their energy consumption (e.g. electric vehicles, fuel cell vehicles, and carbon capture and storage) will be improved and proliferated to reduce CO_2 emission rate per vehicle in the future. Japan has declared its target for an 80% reduction of CO_2 by 2050 based on 1990 levels. However, the eventual reduction will obviously be lower than 80% if it hinges solely on technological*

progress. In China, the CO_2 emission will continue to increase dramatically if mitigation efforts are dependant only on advancements in technology. Therefore, it is imperative to promote the AVOID, SHIFT and IMPROVE measures outlined above.“

2. Problem Statement

For Alexandria, the lack of organized controlled public transportation systems is alarming and the government cannot disregard this issue. The public transportation options currently available in Alexandria are: the tramway, which doesn't cover the whole city, is overcrowded in rush hours and is hardly maintained; the railway, which is in terrible condition thus only used by the lower class and most of the train cabins do not have seats or doors; the bus, which is also in terrible condition with no place to sit or even stand and no fixed stops or schedule; micro- and mini-bus, which are not safe, especially for females; "toktok", which is illegal but still exists; the Red Bus, which is sometimes used by the middle class because it is more expensive than the other public transportation options and difficult for the lower class to afford; and "Taxi Call", which is extremely overpriced but safe and clean.

The poor condition of the public transportation system has led the middle and upper classes to purchase private vehicles, and in some cases, one for every member of the family with a valid driving license. The capacity of the streets and the available parking spots are not designed to accommodate the high number of vehicles. The increase in private car ownership in Alexandria is causing a major problem and will continue to rise as nothing is being done to solve or at least alleviate the public transportation problem.

Therefore, this paper will concentrate on the upgrade of the railway system combined with the "park and ride" system. The suggested case study is upgrading the existing railway and choosing suitable spots where an individual can park their vehicle and ride the rail. The railway of Alexandria starts at "Mehatet Masr" station and ends at Abou Quir. "Sidi Gaber" station is considered to be the main terminal although it is not at the beginning of the line. This goes back to the station's location, as it is more suitable than "Mehatet Masr" due to Alexandria's linear form. The secondary stations are neglected and unfamiliar to many of the middle and upper classes.

The theory of the increase of private car ownership is based on observation as a user and proven by a questionnaire targeting the middle and upper class. The questionnaire is expected to support the theory. A full study of all the existing station locations and their surrounding urban context is crucial to the upgrading process. The social aspect has to be regarded as it affects the behavior of users, which is a major issue reflecting directly on the upgrading process.

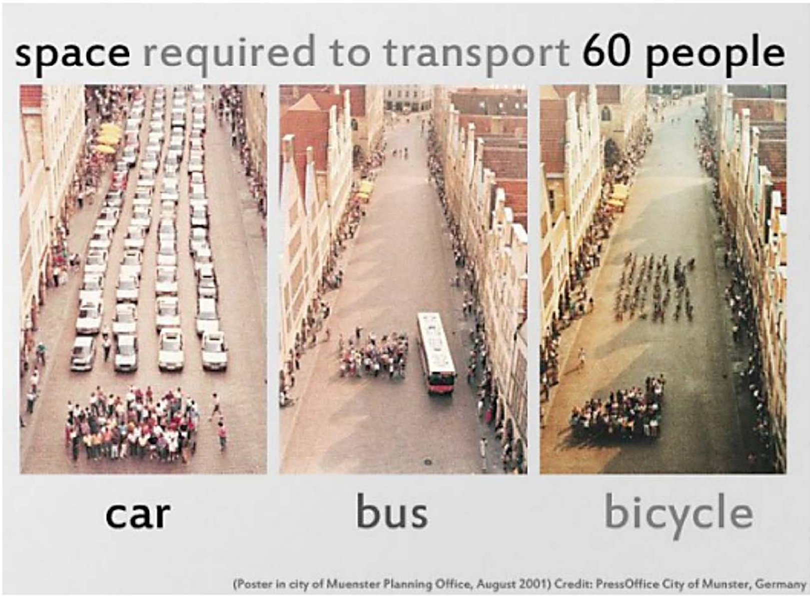

Figure 2: The space required to transport sixty people using private cars, a bus or bicycles (Source: Google images).

3. Proposed Solutions

Since Alexandria is a linear city, the solutions mentioned above can be very effective. This railway can connect important spots and make it possible for the users to reach them without having to go through the trouble of being stuck in a traffic jam. Therefore, studying the land use around the railway line will have a major effect on the decisions regarding the upgrade and the chosen areas for the parking.

The challenge will not only be the upgrading of the railway; it will also be trying to change people's behavior. The citizens of the city are used to riding their own vehicles and are convinced that this is the easiest, safest, most comfortable way of travel. Therefore, the authorities must involve the people when making the decision on upgrading the railway system. Public participation can have a major effect on the project.

People must realize the advantages of using the public transportation system and how it can save them time and energy and even money.

The first suitable step to be taken is involving the users and asking about their problems concerning the traffic and in their point of view, how they can be solved. This can be done through a questionnaire that can lead to a better

Figure 3: The lack of mass transportation is obvious in this picture (Source: Google images).

understanding of their needs and problems. This questionnaire can help to identify the major congestions points. After locating these points, they must be studied to identify the cause of the congestion and whether the mass transportation concept can help solving the problem or not. It can also help when deciding which points will be chosen as a parking zone for the people wanting to ride the rail to a certain destination and then come back and pick up their cars and ride for a much shorter distance. This questionnaire will also prove if the theory of most families owning one car per member as is true or false.

As mentioned before, one of the main causes of the congestion is the increase of private vehicles and this increase is caused mainly by the lack of public transportation. So, the conclusion is that this railway will be mainly oriented towards the middle and upper class who own private vehicles. Therefore, the questionnaire will also be oriented towards this class.

Based on the analysis of the questionnaire, only 20% of the females who took this questionnaire use the available public transportation while 25% of the males do. The rest rarely or almost never uses it. The percentage of the males using public transportation was expected to be a lot higher than the percentage of the females. Surprisingly, they were almost the same percentage which is even more alarming. When asked about the reasons why they don't use public transportation, most of the females' answers were safety issues and sexual harassment, while both genders complained about people's behavior, lack of cleanliness, lack of availability, the transportation methods being too crowded, lack of seats, lack of scheduling and lack of speed limit respect and therefore being a serious safety issue. Some summed it up in saying "I'd rather use my car than deal with the drivers of public transportation". When asked about their opinion of causes of traffic congestion, most answers were the increased haphazard number of the mini- and micro buses and toktok, poor urban design, and lack of traffic management. Many agreed that the increased ownership of cars was also a factor, even though they are a part of the problem.

98% of the families of the people who took the questionnaire own at least one car. The average number of the family members was 4 people, so if we calculate the number of the family members and the number of cars owned by them we'll find that 106 people of 172 own an individual car used only by this person (62%). The percentage is alarming and should be considered as an alert for a coming sooner than the government expects it to. When asked if they are willing to use a railway as a transportation method instead of using their car, 98% answered YES. Some added that they prefer using public transportation and wish it was available, safe and comfortable and that this is their only method of transportation when travelling abroad. This acceptance of the idea is very encouraging and should motivate the government to taking action as people are willing to cooperate and give up using these private vehicles. The users' acceptance of the project is the first step towards its success.

The second step is carefully studying the road network infrastructure leading to the railway. The railway can be considered to be an attraction like any other attraction that leads to the increase of traffic at certain times which are called "rush hour". Therefore the network of street must be improved and upgraded as well, or else the railway stations are going to become a cause of traffic congestion rather than the solution. The suggested method is to divide the railway into sectors and dealing with one sector at a time. This method makes it possible to study these sectors in detail and cover all the points of study that are needed to get the optimum results. It will make it possible to identify each area's problems and causes of congestion and therefore find the suitable locations of the stops and also deal with the poor urban design and the lack of traffic management .This method can be applied only if the idea is supported by the government and is essential before taking any final design decisions.

When starting to think about upgrading the railway one of the first questions that come to mind will be where will the people wanting to ride the railway park? Therefore, a parking lot will be included in every train stop design. If there is no enough space for a parking lot it can be an underground- or a multi story-garage. The park and ride concept is a suitable compromise for both sides – the user and the government. It would not eliminate the problem of increased private vehicle ownership but it will decrease its negative effect.

Another issue is the cost. The government often avoids these kinds of projects because of the increased cost. Therefore, there has to be an alternative source to finance mega projects like this one. Marketing the project among the private sector of investors might be a wise decision. The government could be a partner so there would be supervision on the tickets' cost to avoid the possibility of exploitation of customers.

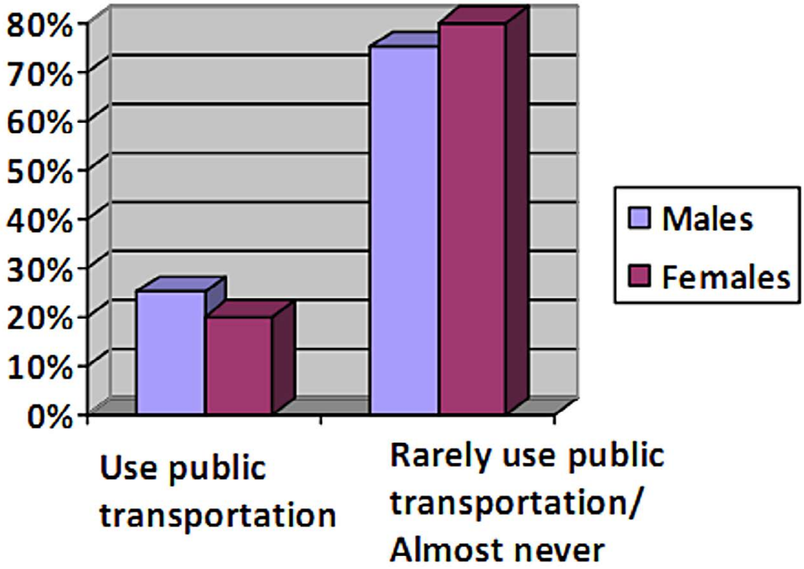

Figure 4: The percentage of males and females using public transportation in Alexandria.

The next step is to suggest where the train stops will be. In order to decide the train stops spots there has to be a certain criteria. First, the distance between the stations has to be suitable, the stations should be close to major attractions, there has to be an appropriate space for parking if possible.

According to Christopher MacKechnie, the appropriate distance between the stops is 1.5 kilometers and in some cases, 0.75 kilometers.

4. Case Study

In our case the stations are placed every 1.5 kilometers. There are five existing stations that will be upgraded and used as stops (Masr Station, El Hadara Elbahareya Station, Sidi Gaber Station,El Souk Station and Abu Quir Station) and seven other additional stops will be added to the railway line.

These stations can be the link to the uses round it. For example, Masr Station is close to the Alexandria stadium, so the railway can serve this area especially in the time of football matches where masses of people need transport to this area. El Hadara station is a 5 minute walk away from the College of Engineering, Alexandria University, the College of Science, English Girls School and the English Boys School. This station can serve an enormous number of students needing transportation to college. As for the Sidi Gaber Station, it's close to Sporting Club and Somuha Club. These are all existing stations; the proposed stations are also close to congested attractions like El Montazah, which is a major touristis attraction and also an entertainment spot especially during the summer time, El Mamoura, and the Arab Academy for Science and Technology (AAST) which is a major congestion cause in the area of Abu Quir, especially during the fall semester when the college operates at full capacity. The number of students and staff trying to reach the college every morning compared to the size of the street network and its capacity is unimaginable. All the places mentioned above are a cause of traffic congestion at some point of the day or at a certain season of the year, according to their use.

The Abu Quir Station leads to El Tabya, which could be a touristic attraction if upgraded and renovated. So, the railway can also be reason certain spots are being revived and reused instead of being ignored and disregarded despite its potential and importance.

These stops are a suggestion based on general study of the railway line. The detailed study of the each sector as mentioned above might, and most probably will, affect those decisions and may result into some changes of the locations when taking the design decisions

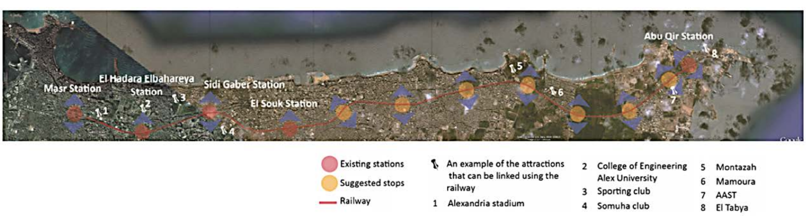

Figure 5: A map of the locations of existing and proposed stations.

5. Conclusions

According to the analysis and discussions above, this paper's conclusions may be summarized as follows: Alexandria is a developing mega-city with a major congestion problem. Therefore, it's caught up in an endless cycle of CO_2 emissions production and non renewable energy waste.

After studying the case in Alexandria through a questionnaire, the experiment proved that the increased ownership of private vehicles is one of the main causes of the congestion. The study of the physical aspects will clarify the problem furthermore.

The plan to decrease the problem is to AVOID the construction of new roads, which can only be done with the cooperation of the government and the reconsidering of its policies to solve the congestion problem; SHIFT to low carbon mode, which in this case is the railway, could decrease the number of vehicles used thus lowering CO_2 emissions; and IMPROVE the mode through technology and policy, which is also the role of the government (Hayatashi, 2010)

Raising people's awareness to the importance of public transportation and its benefits on their lives financially and physiologically is important for the plan to work properly. The railway must be managed properly and maintained on a regular basis to avoid future failure of the project.

The financing system for rail transit infrastructure construction may also avert catastrophe for mega-cities on the verge of chaotic traffic congestion and thus emitting unacceptable amounts of CO_2. It should be reformed to allow proper reclamation of benefits from the construction of rail transit systems, making invisible windfall benefits to be visibly reclaimed to encourage more investors to fund rail transit spontaneously.

Value capture should be effectively applied in rail transit infrastructure construction and operation projects in domestic financing (Hayashi, 2010).

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PAPER 21

Maintaining the Cultural Sustainability of Canada and Prince Edward Island: Examples of the Role of Performing and Visual Arts in Sustainable Development

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Abstract: Cultural sustainability is an interdisciplinary approach aimed at raising the significance of culture in local, regional and global sustainable development. It has been argued by UNESCO and other international groups that culture should be the "fourth and central pillar" of sustainable development, joining the original economic, social and environmental pillars, as culture underpins all of these. At the same time, in an increasingly globalized society, to ensure cultural diversity it is important that these be maintained at the local level as well. Prince Edward Island's Confederation Centre of the Arts is an example of how cultural sustainability works across all pillars of sustainability. Through the performing and visual arts, the Centre contributes to the climate change, biodiversity and sustainable development discourse using the language of art and culture. This paper highlights some of the Centre's programming that contributes to the conversation, and demonstrates how art and culture can educate Islanders – and Canadians – in creative ways about the pressing challenges we face on a local and global scale.

Keywords: Culture, sustainable development, heritage, performing arts, visual arts, Canada, Prince Edward Island, Confederation Centre of the Arts.

1. Introduction

"Climate Change, Biodiversity and Sustainable Development…are the greatest challenges of our time. Recognizing that the well-being of humankind is severely affected by climate change and biodiversity loss, and that it depends on healthy and resilient ecosystems, the integration of these issues is imperative." (GCCBS, 2013)

For some people, the term "sustainable development" conjures certain images: conservation, recycling, renewable energy, green technology, organic farming, ecological footprint, biodiversity – all words that help lead the current generation to believe that they are lessening their impact on the planet so future generations can enjoy it, too. For others, sustainable development is an oxymoron, a contradiction in terms. As one critic has asked, "Are we able to increase human wellbeing and quality of life, without using more resources than the Earth can produce for us?" (Nash, 2012).

In the decades since the Brundtland Commission coined the term, "sustainable development," built on three pillars – economic, social and the environment – people and organizations the world over have lobbied to have culture recognized as the fourth and central pillar that underpins the other three. Leading the charge are the United Nations Educational, Scientific and Cultural Organization (UNESCO), dedicated to establishing world peace based on humanity's moral and intellectual solidarity; the United Cities and Local Governments (UCLG), arguably the world's largest local government organization, representing over half the world's population; and Small Island Developing States (SIDS), a distinct group of the UN dedicated to small island developing countries. They, along with Indigenous peoples and countless others, recognize the interconnectedness of culture in ensuring healthy societies remain free to appreciate, understand and celebrate their cultural heritage, while contributing to larger global efforts to create a sustainable future.

At the same time, in an effort to combat the flattening of culture brought about by globalization, national, sub-national and local institutions – including governments and NGOs – have mirrored these basic tenets of sustainability at the local level. As they work to "think global, act local," they strive to ensure their own cultures maintain their distinctive features, adopting strategies that contribute to the economic, social and environmental health of their regions, and thus the planet as a whole. One such organization is the Confederation Centre of the Arts, located in Charlottetown, Prince Edward Island, Canada, which is dedicated to expressing culture through heritage, the visual and performing arts at its several theatres, art gallery and education centres.

To provide some geographical context, Prince Edward Island is Canada's smallest province, an island cradled in the Gulf of St. Lawrence, with a population of only 143,000 people. It has 1,100 kilometres of shoreline, much of it pristine sandy beaches; many first-class golf courses; a fine culinary industry; a huge number of cultural offerings specifically resulting from its heritage and focus on development of the arts; as well as tertiary education institutions such as the University of Prince Edward Island and Holland College, which boasts an increasingly international student population. Over a million tourists visit the Island each year, predominantly in the summer and fall months from June to October.

By looking at the rationale to have policy-makers officially recognize culture as integral to sustainable development, then focusing on the Confederation Centre of the Arts and specific examples of its programming, this paper explores how the arts on a small island can have a big impact on the economic, social, and environmental challenges facing the world today.

2. Culture as Central to Sustainable Development

Over the years, the word "culture" has taken on several meanings and connotations. In 21st-century Canada, the definition, "total way of life of a people," encompasses such basics as language, literacy, food, dress, religion, sport, leisure, heritage, and, of course, the arts. A common misconception is that culture means "the arts" or "high arts"; rather, the arts are a subset of culture. In recent times, culture has also come to encompass cultural or creative industries, defined by UNESCO as "those industries that combine the creation, production and commercialization of contents which are intangible and cultural in nature. These contents are typically protected by copyright and can take the form of goods and services" (UNESCO, in Dunne, 2004: 3). They might include such modes of production as publishing, multimedia, audiovisual, cinematic, craft, design, architecture, visual and performing arts, advertising and cultural tourism.

The term "sustainable development" is most often defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987: 37), and was originally built on three pillars: economic, social and environment. How culture intersects with, or underpins, sustainable development has been taken on by the group United Cities and Local Governments (or UCLG):

> A Development Agenda cannot be successfully implemented if only three pillars (economy, social inclusion and environment) are considered. This approach is not useful to read the world, and is not useful to provide operational tools to transform the world. It is an old fragmented approach that has failed because it lacks the soul, the glue providing coherence and meaning to development in cities, nations and our existence as human beings. It lacks culture (2013: np).

The UCLG goes on to describe the contribution culture makes to the sustainability of the planet:

- Culture boosts the economic dimension: it generates income and employment, it is the engine of many development processes and it has impact on entrepreneurship, new technologies and tourism. Culture brings creativity and innovation to the economy.
- Culture is linked to the social dimension: it is the accelerator of resilience and rootedness, it gives tools to fight against poverty, and it facilitates participation of citizens, intercultural dialogue and equality of rights.
- Culture embraces the environmental dimension: it is integrated with issues of identity and can be used to raise awareness about ecological responsibility.
- Key values for development like creativity, heritage, knowledge and diversity must shape culture as the fourth pillar of development. A holistic and integrated approach to development will only be achieved when these values are explicit and operationalized (UCLG, 2013: np).

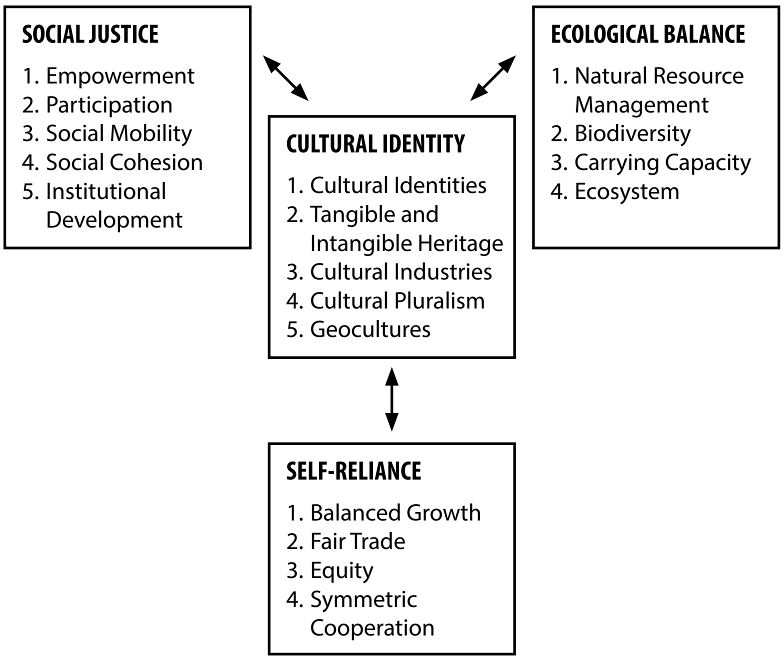

Figure 1: Pillars of Sustainable Development (Nurse, 2006).

Since the Earth Summit in Rio de Janeiro in 1992, UCLG has tried repeatedly to have culture become part of the official strategy for various international sustainable development efforts. In 2004 UCLG adopted Agenda 21 for culture, a declaration with 67 articles that describes the relationship between local cultural policies and human rights, governance, sustainable development, participatory democracy and peace. With over 450 cities, local governments and organizations from all over the world participating, Agenda 21 for culture was the first document to establish cultural development principles and commitments by cities and local governments.

In 2010, UCLG approved the document, *Culture: Fourth Pillar of Sustainable Development* at its World Congress held in Mexico City. This document engages local governments to explicitly include culture in the model of development that "meets the needs of the present without compromising the ability of future generations to meet their own needs," as well as ensuring the enjoyment of culture and its components by all inhabitants, while protecting and enhancing the rights of citizens to freedom of expression and access to information and cultural resources. The document points to the relation between culture and sustainable development through a dual approach: developing a solid cultural policy (culture as a driver of development) and advocating a cultural dimension in all public policies (culture as an enabler of development). The Policy Statement also recommends to cities, nations and the international organizations to explicitly integrate this vision into local, national and international programs on sustainable development.

UCLG made some inroads at the UN Conference on Sustainable Development in Rio de Janeiro in June 2012, and is now focusing its efforts on being part of the post-2015 UN Development Agenda discussions, as well as Habitat III, the third United Nations conference on housing and sustainable urban development scheduled for 2016.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) has made sustainable development part of their raison d'être (or their reason to exist), creating "holistic policies that are capable of addressing the social, environmental and economic dimensions of sustainable development" (UNESCO). They see the imperative of integrating this with their founding principles: to maintain local, regional and national cultures and subcultures that give societies a uniqueness that sustains them and provides a basis upon which they identify themselves and their environment. Working in partnership with governments, sister UN Agencies, the private sector and civil society, UNESCO is promoting a new agenda for development that integrates consideration for culture, found in its "thematic think piece," "Culture: a Driver as an Enabler of Sustainable Development" (UNESCO, 2012). Included are commitments to

> integrate the cultural dimension in the conception, measurement, and practice of sustainable development; integrate traditional scientific knowledge and practices in sustainable development policies; underline the importance of the conservation of natural and cultural heritage and the strengthening of international co-operation; recognize the important role of cultural as well as creative industries, sustainable tourism, and heritage-based urban revitalization; and recognize that cultural factors influence lifestyles, individual behaviour, consumption patterns, values related to environmental stewardship, and the ways in which we interact with our natural environment (UNESCO, 2012).

Indeed, these topics are the focus of discussion at UNESCO's upcoming International Congress, "Culture: Key to Sustainable Development" in China in May.

Finally, the UN sub-group Small Island Developing States (SIDS), a group of the world's most vulnerable developing countries, has added its voice to the need to have culture recognized as a fourth pillar of sustainable development. Created in response to the Earth Summit in 1992, SIDS was a direct outcome of a UN Conference held in Barbados in 2004 which recognized these small island developing states for their "high degree of economic vulnerability, geographical isolation and extreme susceptibility to environmental change" (Nurse, 2006: 39). On these islands, cultural production "is an important area for investment and a means of bolstering cultural identity" and "aid[s] the diversification effort in mono-cultural economies that are overly reliant on a narrow base of traditional and non-traditional exports" (Nurse, 2006: 41). Culture and its by-products (e.g., tourism) are thus seen as a crucial part of making these small islands economically viable and sustainable.

3. Cultural Sustainability Closer to Home

In 2008, the Conference Board of Canada, one of Canada's top economic think tanks, surveyed culture's contribution to the Canadian economy in their report, *Valuing Culture: Measuring and Understanding Canada's Creative Economy*. For the Board, cultural sustainability has to do with harnessing human creativity. Epcor Centre CEO Colin Jackson, who chaired a panel at a Conference Board of Canada meeting in 2008, says the contribution of culture to Canada's economy is based on the notion in economic theory that holds that "the sustainable source of wealth and prosperity is human ingenuity – the ability (within the cultural industries sector) to innovate, to take ideas and make them real in the world. That's really where the economy lives" (Akin & Clark, 2008).

Taking ideas and making them real in the world, through the language of the arts and culture, is what the Confederation Centre of the Arts has been doing since 1964 when the massive 150,000-square-foot facility was built as a "living memorial" to the "Fathers of Confederation." In 1864, representatives from Upper and Lower Canada (now the provinces of Ontario and Quebec), as well as what are now the provinces of Nova Scotia and New Brunswick, met in Charlottetown to discuss the idea of a Canadian confederation. The meeting is now known as the Charlottetown Conference, while the city is "Canada's Birthplace" and its original attendees are the "Fathers." Representatives of the Province of Prince Edward Island were also present at this historical Conference, with Newfoundland participating as observers. Named a National Historic Site in 2003, the Confederation Centre is situated in downtown Charlottetown. Its main entrance looks out onto Province House where the Fathers of Confederation first met in September 1864 and where the province's legislature still meets today. The Government of Canada designated Charlottetown as one of three Cultural Capitals of Canada in 2011 and the City of Charlottetown, under the leadership of Mayor Clifford Lee, subsequently established a Task Force on cultural policy for the City.

Each and every Canadian played a part in the establishment of the Centre; it was the first time that all provinces agreed to provide funding for an institution outside their own jurisdictions. The Centre is the result of a dream shared by all Canadians: to create a place where our country's history, multicultural and bilingual character are celebrated, and where the talents of its people are nurtured and showcased. It is home to several theatres, including a Class A, 1,100-seat indoor theatre, and a 1,000-seat outdoor amphitheatre. It also houses the largest art gallery east of Montreal, several venues for visual arts, dance and music education, and operates a dynamic restaurant and catering business, as well as a high-end gift shop.

Along with the Fathers of Confederation Memorial Citizens Foundation, Canadian Prime Minister John G. Diefenbaker was Canada's leader who was responsible for ensuring the Centre was constructed, but Prime Minister Lester B. Pearson officiated at the opening with Her Majesty Queen Elizabeth II, and he said:

> "The Fathers of Confederation Memorial Building is a tribute to those famous men who founded our Confederation. But it is dedicated also to the fostering of those things that enrich the mind and delight the heart, those intangible but precious things that give meaning to a society and help create from it a civilization and a culture."

The Centre is a dynamic facility teeming with talent, with extensive programming in heritage and the visual and performing arts, and a strong educational component, bringing in hundreds of children and youth a year through Dance Umbrella, the Young Company, the Youth Chorus, spring break and summer camps, and through ongoing collaborations with the province's schools. In partnership with Holland College, the Centre delivers School of Performing Arts programming; in addition, the School has articulation agreements with other Canadian universities. Over its fifty-year history, the challenge has been to ensure all visitors (both Canadians and visitors from other countries) and all levels of government are aware of the historical significance of the complex while enjoying and participating in the visual and performing arts.

Following Keith Nurse's diagram for four pillars of sustainable development (Figure 1), the Confederation Centre of the Arts contributes to the three pillars of sustainable development through:

- economics: the very tangible generation of capital based on the knowledge and creative economies;
- social: addressing issues of empowerment, inclusion, diversity, multiculturalism, and education
- environmental: specific exhibitions, shows and educational programming that focus on ecology, biodiversity, and climate change

The Centre fulfils the fourth or "central" pillar of cultural identity through its commitment to:

- celebrating place: by being a living monument to the Fathers of Confederation, and by being an integral and dynamic part of the cultural fabric of Prince Edward Island and Canada
- heritage, both tangible and intangible: through the telling of Canadian and Island stories, historical and contemporary

- cultural industries: through the box office, restaurant, gift shop, art gallery purchases, exhibition catalogues and books, and the hundreds of people who are involved in the work of the Centre each year (e.g., playwrights; composers; actors; musicians; directors; choreographers; set and costume designers; front of house staff)
- cultural pluralism: focusing on ethnic and cultural diversity, as immigration and migration of people to and from countries all over the world continues to grow
- geocultures: through cultural tourism, as visitors come from all over the world to experience culture on Prince Edward Island, or "The Land of Anne," as it is sometimes called.

4. Commitment to Heritage

The complex itself commemorates Canada's heritage as a memorial to Canadian Confederation. Most memorials are static, but this one is quite the opposite: it is a living memorial. Indeed, each September the Centre celebrates this specific part of its mandate by hosting the Symons Medal and Lecture on the State of Canadian Confederation, providing a national platform for a distinguished Canadian to discuss the current state and future prospects of Confederation, and giving all Canadians an opportunity to reflect upon their country and its future.

The Confederation Players Walking Tours and Historical Reenactments is an example of the Centre being a "living memorial." History comes alive when you stroll through "Olde Charlottetown" with the Confederation Players, a troupe of young bilingual Canadians, in costume and trained as living Fathers and Ladies of Confederation. Visitors join the Players for a guided walking tour or attend their historic vignette outside Province House, the site of the 1864 Charlottetown Conference.

Through their portrayal of some of the key Fathers of Canadian Confederation, such as Sir John A. Macdonald, George Coles, and Sir George-Étienne Cartier, the Confederation Players provide a glimpse into the cultural and historical context of the Charlottetown Conference of 1864. Guided walking tours cover Island history, British North American history, Victoriana, local architecture, folk stories and even ghostly tales of Charlottetown.

As the province and the country gear up to recognize the 50th anniversary of the memorial and the 150th anniversary of the Charlottetown Conference in 2014, reminding Canadians that "PEI is where great ideas are born" (PEI 2014), the Confederation Centre of the Arts is committed to being an integral part of the year-long celebration. Through visual arts and theatre programming honouring the beginning moments in September 1864 that led to Canada's creation in 1867, the Centre celebrates "the rich diversity Islanders, and indeed all Canadians, bring to nation-building" (PEI 2014).

Recognition for the Centre's efforts in promoting the Island's heritage came recently with an award from the PEI Museum and Heritage Foundation. In the summers of 2011 and 2012, the Centre mounted the popular show *Come-all-ye*, a review in comedy, music and multimedia that provided an overview of Prince Edward Island history. For its efforts it received in 2013 the prestigious Wendell Boyle Award, given to a group or individual for an outstanding contribution in a performance medium - for instance, music or theatre – that highlights or interprets the history of Prince Edward Island.

5. The Visual Arts

The Confederation Centre Art Gallery has for a number of years researched and presented contemporary visual art that addresses aspects of the cultural impact on the Island's landscape. Landscape is a long tradition in Canadian Art History – no surprise given the expanse of the country and the variety of geographic regions it encompasses. The Confederation Centre Art Gallery holds a significant collection of Canadian historical, modern, and contemporary art, artifacts, and archival records.

Since the gallery began collecting in 1964, its holdings have grown to over 16,500 items, including a comprehensive research collection on the works of Charlottetown-raised Robert Harris (1849-1919), painter of the iconic group portrait, *The Fathers of Confederation*, as well as dozens of 19th- and early 20th-century holdings. Quebec painter Jean Paul Lemieux's commissioned mural, *Charlottetown Revisited*, 1964, is a highlight of the Confederation Mural Collection, as is the 1997 painting, *Those Who Share Together Stay Together*, by First Nations artist Jane Ash Poitras. The Expo '67 Collection of fine craft, while slightly out of scope, is a fascinating time capsule of that centennial year. Similarly, the L.M. Montgomery Collection of sixteen novel manuscripts is a delightful anomaly, with international cultural resonance.

Catherine Miller's Changing Environs

The Confederation Centre Art Gallery seeks to contribute to sustainable development by increasing public awareness of environmental issues linked to human activities. In *Changing Environs*, an exhibition running from February to June 2013, Prince Edward Island (PEI) artist Catherine Miller presents her investigation of the entwined and often conflicting pressures of landscape, land use, environmental protection and climate change. Given the polarized debate around environmental and economic systems, and balances locally and globally, Miller has contributed accessible images to infill gaps in the climate change conversation in PEI. Miller relies on the comforting and expressive nature of textiles and uses traditional quilting, weaving and sewing techniques as a departure point for her work. Miller's long engagement in craft practices, as well as her interest in climate change research, provides a rich vocabulary for timely and socially engaged works originating on the Island – works of art that clearly link climate change and culture.

Miller's work makes a very tangible contribution to discussions and consultations on sustainability now under way. The government of PEI recently published Planning for a Sustainable Future, which is intended to assist its Environmental Advisory Council in promoting a dialogue on a new sustainable development strategy for the province.

Some of Miller's works have a pictorial straightforwardness, such as *Water Qualities*, 2011, which addresses the issue of water on Prince Edward Island; *Abandoned House*, 2012, which is a poetic metaphor for the decline of rural populations; *Wave*, 2011, which is a call for creative long-term solutions rather than costly short-term fixes; and *Rising Sea Level*, 2010, is comprised of a series of five woven wall hangings that forecast the effects of rising sea levels on the shape of the island(s).

Miller's interests reflect the interrelated range of environmental issues at the core of reports on land use and land protection in PEI In conjunction with the exhibition, the Confederation Centre Art Gallery will host a public panel discussion on Earth Day, April 22. The key objective for the panel is to engage Miller's visual art in a conversation that includes other environmental professionals and scientists studying climate change in PEI and to make these various forms of research accessible to the public at a time when several rounds of consultations on land use and environmental sustainability are under way in the province.

Edward Burtynsky: Material Matters

In the 2012 season, the Gallery presented photographic work by Canadian artist Edward Burtynsky. The large colour photographs represent decades of photographic exploration of the transfigured landscape. His images of farmland in Spain, stone quarries in Vermont, a tailings pond in Ontario, oil pipelines in Alberta and the 2010 oil spill in the Gulf of Mexico were selected to highlight Burtynsky's career and his interest in how we interact with our planet.

Says Burtynsky in his book *Oil*:

> In 1997, I had what I refer to as my oil epiphany. It occurred to me that the vast, human-altered landscapes that I pursued and photographed for over twenty years were only made possible by the discovery of oil and the mechanical advantage of the internal combustion engine… It was then that I began the oil project. These images can be seen as notations by one artist contemplating the world as it is made possible through this vital energy resource and the cumulative effects of industrial evolution (2011).

Material Matters includes landscapes that have a distinct horizon line, as well as those that frame carefully composed and abstracted details found in various stone quarries. In *Dryland Farming #32, Aragon, Spain*, 2010, Burtynsky has made aerial photographs from 600 metres above ground, capturing the patterns resulting from a tradition of dryland farming over many generations in the Monegros region of northeast Spain. In his artist's statement, Burtynsky explains: "I am always interested in how humans shape the landscape. All my work is really about the pristine landscape being pushed back as a result of the expanding human footprint. And I kept thinking of farming as one of the largest terraforming events that humans have exercised on the planet."

Water is one of Burtynsky's key ongoing themes and he references both the horizon and the careful framing of water surfaces in the beautiful and simultaneously troubling image, *Oil Spill #10, Oil Slick, Gulf of Mexico, June 24, 2010*, with its emerald-green expanse of ocean streaked with black.

The photographer has employed scale, pattern, colour and composition for compelling aesthetic impact—even when tackling environmental disasters. But the works are also informative; they provide a revealing link to the industrial supply line so often originating in the landscape and so often divorced from the materials of consumer culture. They often offer compelling and unique points of view on the subjects.

Aganetha Dyck: Guest Workers

During the 2011 season, the Gallery presented the work of Winnipeg-based Canadian artist Aganetha Dyck, entitled *Guest Workers*. Centred around a living beehive, this exhibition featured sculptural and two-dimensional art works based on collaboration between the artist and honeybees. Dyck is interested in environmental issues, and specifically in the power of the small and inter-species communication and collaboration. Her recent research asked the question about the ramifications all living beings would experience should honeybees disappear from the earth. Her work is in public and private collections internationally.

The work of the artist is intertwined with an ongoing project, an architecture of honeycomb that, though threatened, continues incessantly and offers its own constantly evolving model of perfection. The bees and their work were guests in the gallery. This places them (and their impresario) in a special position as dependent, on the one hand, and as subtle transformers on the other. Free to come and go, they offer from their temporary home an encounter with a different state of being – collectively organized, following its own time, instructing and reminding us of the humble labour that keeps plants growing and nature's cycles in play. The honeybees are, of course, workers, a category artists have often taken great pains to distance themselves from; Aganetha Dyck proposes through her work with bees that art and labour be thought together, as essentially parallel processes. Dyck calls her interactions with bees experiments in "interspecies communication." The insects are passing us a message from elsewhere, their temporary platform as full of transformative potential as an altarpiece. It remains to be seen whether or not we will grasp it.

6. Performing Arts

Since the Confederation Centre opened its doors in 1964, the Charlottetown Festival has continued to attract thousands of visitors to the theatre each year to enjoy primarily Canadian musical theatre productions. Over the years, hundreds of productions have been mounted, including many premieres. But its centerpiece, *Anne of Green Gables, The Musical*™, is the heart of the Festival. Next year, 2014, will mark the 50th consecutive season for this musical to be produced and presented by the Centre on its Class A theatre main stage.

Anne of Green Gables, The Musical™

The novel *Anne of Green Gables*, written by Prince Edward Island's L. M. Montgomery, one of Canada's most famous and beloved authors, was first published in 1908. Since then, it and many of the subsequent Anne books have sold over 50 million copies in 30 languages, and have been adapted to various formats for screen and stage. But never has a movie, TV show, play or musical been so successful as the musical produced by the Confederation Centre of the Arts, which is based upon the first book depicting Anne's early years. This stage musical, *Anne of Green Gables, The Musical*™, was a collaboration between Don Harron (book and lyrics), Norman Campbell (music and lyrics), and Mavor Moore and Elaine Campbell (who wrote additional lyrics).

Anne of Green Gables is an endearing story that presents early 20th-century Prince Edward Island through the eyes of the red-headed orphan girl who comes to the Island to be adopted by an elderly brother and sister who expect they're getting a boy who will help out on the farm. How Anne Shirley works her way into the hearts and minds of the people of Avonlea is a tale of creativity and courage, spiritedness and determination, resistance and resilience which has inspired generations the world over with spunk, mischievousness, wit and an open heart. "In the character and experience of Anne Shirley," scholars Jane Ledwell and Jean Mitchell (2013: 4) write in the Introduction to their new book, *Anne Around the World*, "readers have discovered experiences they relate to, identify with, and are moved by. This girl-child heroine, born of L.M. Montgomery's imagination and inflected with aspects of her experience, has been adopted as an icon of childhood across time and across cultures.".

The enduring popularity of "Anne" is an excellent example of how culture can be expressed, with a resonance that extends beyond the local to the universal. Indeed, in her book *Anne's World*, scholar Carole Gerson has mapped

Anne's trajectory: "from fictional character to Canadian icon and commodity, naming seven milestones in the creation of a classic: the book's publication by L.C. Page; Anne entering Hollywood; the intervention of government and Canada's National Parks; Anne's travel to Japan; the advent of Anne of Green Gables: The Musical, the emergence of the miniseries for television, and the publication of the Selected Journals; the launch of L.M. Montgomery Studies; and, finally, centennial commemoration" (ibid., 7). "Anne" has arguably contributed more to the sustainability of the Prince Edward Island economy through local pride and a deep connection to place – as well as tourism – than any other "commodity." Anne's interactions with the world around her – through scenes where Anne describes a tree-lined lane as "the white way of delight," for instance, or joins her teacher and classmates outside to learn lessons from nature – reflect Montgomery's connection and deep respect for of the natural world. Indeed, Montgomery's writings are recognized as some of Canada's finest nature-writing. Writes Cecily Devereux (2001), "Anne the character has become globalized, her local specificity and original nationalism transposed and reshaped in every location, her function as icon and value as commodity shifting endlessly between cultural and economic, local and global". *Anne of Green Gables, The Musical*™ is no exception: the Centre has toured this musical across Canada, the United States and Japan to rave reviews.

Evangeline

As most people know, Canada has two official languages that reflect its two principal founding communities, English and French. As Canada, Prince Edward Island and the Confederation Centre prepare for the 150th anniversary of Canada's founding conferences in 2014, the Centre will present an important story on its main stage during the Charlottetown Festival this year. This new musical, a world premiere, will tell the story of Evangeline and the expulsion of the Acadian French from Canada's Maritime region in the mid-1700s, based on Longfellow's epic poem, *Evangeline: A Tale of Acadie*, originally published in 1847. The story of *Evangeline* follows the story of the betrothed young couple, Evangeline and Gabriel, separated during what is now known as one of the country's great tragedies, *Le Grand Dérangement*, or Expulsion of the Acadians (1755–1763). *Evangeline* is a significant contribution to Canadian's narrative, demonstrating how local populations are so often at the mercy of global powers, over which they have no control. On a larger scale, the musical speaks to the universal themes of displacement and loss, as even today people continue to be exiled from their homelands. At the same time, the story highlights the resilience of the Acadian people and culture – in no small measure due to the welcome and practical assistance they received from the Mi'kmaq, the region's First Nations peoples, when they first arrived to what is now Canada's east coast.

The story is testament to the unrelenting human spirit and the enduring love of Evangeline and Gabriel.

The artistic interpretation of this story can inspire community engagement in creating healthy and resilient eco-systems. The performance ends on a high note, leaving the audience feeling educated, invigorated and happy that the Acadian people, the early settlers of Canada, have overcome this tragic event to survive and thrive over the last two centuries, and that the spirit of reconciliation following the wars between France and Britain lives on as Anglophones and Francophones continue to work together to forge a dynamic and uniquely Canadian pluralism. With this production, the Confederation Centre of the Arts contributes to building bridges of understanding between cultures, and it is hoped that this type of presentation will foster the development of a nation-building model that can address today's cultural diversity and intercultural dialogue challenges, particularly as we continue to welcome the new immigrants who will keep our country sustainable for generations to come.

Interestingly, the story of the Acadian expulsion was recognized internationally by UNESCO itself when, in 2012, the National Historic Site of Grand Pré, in Nova Scotia's Annapolis Valley, was designated a UNESCO World Heritage Site, given to preserve cultural and environmental heritage in sites around the world. The designation honours Grand Pré as the centre of Acadian settlement from 1682 to 1755, and commemorates the deportation. The site is "tangibly associated with living traditions and ideas of outstanding universal significance. Through its evocative memorials to a people who overcame a tragedy of a forced migration, the Acadian Deportation, Grand Pré is a symbol of hope, perseverance and pride for all humanity" (Nomination Grand Pré, 2012: np). This, in concert with the worldwide premiere of the musical, contributes to cultural sustainability in the Maritimes on a significant scale, by nurturing collective identities and social cohesion of the English, the Acadians and the Mi'kmaq while setting the stage for development for future generations.

RiviR

Since May 2012, the artistic team of Wade Lynch, Anne Allan, and Marek Norman has been vigorously engaged in creating an exciting new original Canadian musical entitled *RiviR*. Poised to redefine the precepts of musical theatre, *RiviR* is a theatrical adventure, and will play a significant role in ensuring the performing arts – a process of culture – contributes to the sustainable development discourse. It will use the best of traditional theatrical storytelling in concert with the latest technological advances in live theatre production. It is a gravity-defying, visually stunning, choreographically challenging, musically innovative, humorously witty, and ultimately empowering fable.

After several revisions to the original story synopsis, Wade Lynch and the team have signed on the award-winning Ojibway playwright, author, columnist, filmmaker and lecturer Drew Hayden Taylor to write the original RiviR book. The Confederation Centre's artistic director Anne Allan is consulting with innovators in theatrical design and with leading choreographers from all over the theatrical world. And, in an effort to produce a show that celebrates excellence in existing and original music, musical director Marek Norman is collecting and securing performance rights for extant songs in the Canadian musical canon, and has contacted several composers whom he will engage for new music for RiviR.

RiviR is an evolutionary tale of a world called Kanata, inspired by the stories of Canada's First Nations, the cautionary tales of the consequences of the destruction of the natural world, the seeming inclination of humans to engage in conflict, and the possibility of positive change through accountability and cooperation. On Kanata only two peoples exist: the Cotterans, and the Celainors. Though they share the same sphere, they are completely unaware of each other's existence. They are separated by a great ribbon of water, the RiviR, which serves as a crucial life source for both populations. On Cottera, the RiviR provides life-sustaining food. Cottera is a lush world of natural splendor where its people live in harmony with nature, fishing and farming for their existence. On Celainor, the RiviR is the primary source of energy. Celainor is a world of technological majesty where its people have created a vast empire of machinery and industry.

A crisis erupts – the RiviR has become compromised by the actions of humans on both Cottera and Celainor. The RiviR, and thus Kanata, is in peril. This common threat to their existence pits the Cotterans and the Celainors against each other and a great war erupts. As their conflict rages, the plight of the RiviR is ignored until it stops flowing altogether. In short order, the opponents realize that the only way to ensure future survival of the whole planet is to work together, to merge their resources and heal the RiviR.

An innovative, sometimes humorous, creative, artistic response to energy and the environment, their uses and their sustainability, RiviR's purpose is to educate and inform the public about Energy Literacy. Developed for the medium of musical theatre, perhaps one of the most popular means to challenge, entertain and enlighten mass audiences, RiviR will create a public forum for how we, as a citizenry, must be better educated and informed about science, research and development, economics, and, indeed, our own personal consumption habits to understand our role in the sustainability of our natural resources.

7. Concluding Thoughts

To sustain Canada's cultural fabric, the Confederation Centre of the Arts facilitates intercultural dialogue and public education while reflecting Canada's national character in terms of the country's official languages and with respect to the diversity of its citizens. In addition to the instrumental role that the cultural sector plays in strengthening social cohesion, it has been Canada's experience that creative communities also play a significant sustainable development role in generating economic prosperity and a better quality of life for all Canadians. Canadians need to expose themselves to new ideas to be creative, innovative and imaginative citizens who contribute to our country's health and wealth. One of the best ways to make this happen is through arts and culture – by seeing funds as an investment that sustains and generates new income, rather than the commonly held view that "the arts are a luxury expense to be enjoyed when times are good and eliminated when other programs need the funds" (Wenner, 2010: 3). Indeed, a 2010 U.S. study claims while its governments allocated less than $4 billion to support arts organizations, they "directly create over 5.7 million jobs, while providing $29.6 billion in annual federal, state and local tax revenue," making for a sevenfold return on investment (Wenner, 2010:3). In a presentation to the Standing Committee on Canadian Heritage in November 2012, the Hon. James Moore, Canada's Minister of Canadian Heritage and Official Languages, said:

> Arts and culture represents $46 billion dollars in the Canadian economy, 630,000 jobs in Canada. It's three times the size of Canada's insurance industry, twice the size of Canada's forest industry. Any government who has a plan for economic growth, but doesn't have a strong plan for supporting the arts, is a government that doesn't have plan for economic growth (House of Commons, 2012, np).

Underpinning his words are the voices of cultural organizations across the country, from the national Canadian Conference of the Arts, Cultural Capitals of Canada, and the Canada Council for the Arts, to the local PEI Council of the Arts, the PEI Museum and Heritage Foundation, and Canada's living memorial to its founding, Confederation Centre of the Arts, who believe strongly that a vibrant cultural community is the basis for a vibrant economy, with "cultural diversity equivalent to that of genetic diversity in the sustainable development debate" (Nurse, 2006: 46). With culture shaping the fabric of a society, contributing to and communicating the "identity, values and hopes of a society" (Nurse, 2006: 46), as well as the returns it brings in terms of employment, production and exports, it is crucial that culture be included as part of a jurisdiction's sustainable development plan. The rootedness and connectedness of Prince Edward Island, with its small population located within a bounded space, is in itself an expression of its culture, resulting ultimately in a society that cares deeply about its natural resources, quality of life, indigenous knowledge, and culture. Communicated through the language of heritage and the arts, our culture allows its people to learn about and tackle the ecological challenges it faces as a vulnerable Island looking ahead to the challenges and effects of climate change, biodiversity and sustainable development in years to come.

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PAPER 22

Environment Impact on Seafront Reinforced Concrete Structures in Egypt

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Abstract: Rapid deterioration of reinforced concrete buildings in Alexandria, Egypt has become a major problem for seafront buildings' dwellers. Much evidence of deteriorations has been collected, evaluated and some has been practically tested. The effect of steel corrosion on durability of seafront reinforced concrete structures is currently investigated using a comprehensive experimental program and detailed numerical analysis at the Arab Academy. The corrosion of different types of carbon steel bars has been evaluated for plain bars, un-coated deformed bars and epoxy coated deformed bars. The result of this research confirms the major effect of saline environment on increasing the rate of deterioration in such buildings. Also, the results of the experimental program show that low concrete strength due to either bad design of concrete mix or low quality of construction lead to a higher rate of steel corrosion and can lead to the collapse of these buildings.

Keywords: Environmental impacts, seafront buildings, deterioration of concrete, steel corrosion.

1. Introduction

Often, the durability of concrete structures is considered to be implicitly acquired as long as the concrete strength satisfies the design requirements. It is assumed that high strength concrete is more durable than low strength. Although there is a good correlation between strength of concrete and its durability under normal loading conditions, this vague assumption may not be valid during the full lifespan of a building or under different exposure conditions. As such, both strength and durability has to be considered explicitly at the design stage.

Deterioration of reinforced concrete structures results from external factors or internal causes within the concrete itself. Weakening can result from physical and chemical aggression, or from mechanical damage caused by impact, abrasion, erosion or cavitation. The chemical causes include alkali-silica and alkali-carbonate reactions. External chemical attack occurs mainly through the action of aggressive ions, such as chlorides, sulfates or carbon dioxide, as well as many natural or industrial liquids and gases. Physical causes of deterioration include the effects of high temperature or the differences in thermal expansion of aggregate and the hardened cement paste

(Neville, 2002). Recently the aspects of concrete durability and performance have become a major subject of discussion, especially when the concrete is subjected to severe environmental conditions (Lee and Chisholm, 2005). Corrosion of steel bars is a main factor affecting both the concrete durability and strength. The corrosion of steel develops high pressure within the concrete, which causes cracking and spilling of the concrete cover and the exposure the rebar to further corrosion activity.

Damage attributed to steel corrosion are identified as one of the most costly losses to the construction industry worldwide. In the United States, according to the Federal Highway Association and based on 1995 prices, infrastructure deficiencies due to corrosion has jumped from \$300 billion in 1995 (Neville, 2002) to \$1.3 trillion in 2000 (Roberge, 1999). In Canada, although there is no precise value for infrastructure deficiency, some studies found that rehabilitation cost for corrosion of reinforcing steel is estimated to be about \$3.0 billion per year (Elsener, 2001).

2. Building Collapse in Egypt

In Egypt, the disaster from infrastructure deficiencies exceeds the value of money and extends to include human lives. In the last decade, many reinforced concrete building collapsed with a majority of them located within seafront zones (Figure 1). Over eighty percent of these collapses were in Alexandria and Damietta, as shown in Table 1. This high percentage highlights the importance of studying the common factors that led to the collapse of those buildings.

Figure 1: Collapses in Alexandria, Egypt (Source: El-Masry El-Youm Journal, July 2012). *(a) Collapse of four apartment buildings, July 2012. (b) Rubble from the collapse of an eight story building, January 16, 2013.*

Table 1: Buildings collapses in Egypt.

Date	Description
March 2002	Two buildings collapsed within 24 hours in the industrial city of Damietta, killing a total of 27 people and 25 people were seriously injured.
December 2007	Twenty five years old 12 story building collapsed in Alexandria with 23 people killed
October 2008	Twelve people were killed and six were injured after an old apartment building collapsed in Alexandria.
December 2010	Seven people killed and ten wounded in a factory building collapse in Alexandria
December 2011	Three story residential building collapsed in Alexandria. One person was killed and three were severely wounded.
July 2012	Nine people killed and tens wounded in collapse of four buildings in Alexandria.
September 2012	Five story building collapsed with at least five people injured.
September 2012	Four story building collapsed in downtown Assiut with nine person killed.
October 2012	Collapse of three story building located on Mahmoudeya water channel, Alexandria.
January 2013	Collapse of five years old, eight story building in Mamora, Alexandria. Twenty eight dead and twelve injured.
February 2013	One killed and five injured in a building collapse in Moharam Bek, Alexandria.

Alexandria and Damietta are considered coastal cities and are located on the Mediterranean Sea as shown in Figure 2. The climate in these two cities has the characteristics of mild weather, with variable rainy winters and hot summers that at times can be very humid. Alexandria experiences violent storms, rain and sometimes hail during the cooler months. The average annual rainfall is around 200 millimeters but can be as high as 417 millimeters (Tutiempo.net). Table 2 shows the monthly climatic data for Alexandria as reported by the World Meteorological Organization (Hong Kong Observatory).

Figure 2: Alexandria and Damietta location on Egypt map.

Table 2: Climate data for Alexandria.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C	29	33	40	41	45	44	43	39	41	38	36	29	
Average high °C	18.4	19.3	20.9	24.0	26.5	28.6	29.7	30.4	29.6	27.6	24.1	20.1	24.9
Daily mean °C	13.4	13.9	15.7	18.5	21.2	24.3	25.9	26.3	25.1	22.0	18.7	14.9	20.0
Average low °C	9.1	9.3	10.8	13.4	16.6	20.3	22.8	23.1	21.3	17.8	14.3	10.6	15.8
Record low °C			2	4	7	12	17	18	14	11	1	1	
Rainfall mm (inches)	52.8	29.2	14.3	3.6	1.3	0.01	0.03	0.1	0.8	9.4	31.7	52.7	195.9
Avg. rainy days (≥ 0.01 mm)	11.0	8.9	6.0	1.9	1.0	0.04	0.04	0.04	0.2	2.9	5.4	9.5	46.92
Mean monthly sunshine hours	192	217	248.0	273	316.2	354	362.7	344	297	282	225	195	3,307
Relative Humidity (%)	70	68	66	66	68	71	73	72	68	68	69	72	69.3

3. Impact of Salt-laden Environment in Coastal Regions

The marine atmosphere is laden with fine particles of sea mist carried by the wind to settle on exposed surfaces as salt crystals. The quantity of salt deposited can vary greatly with wind velocity and it may, in extreme weather conditions, form a very corrosive salt crust. The level of salt contamination decreases with distance from the ocean, and is greatly affected by wind currents. The marine atmosphere also includes seafront zones where splashing and heavy sea spray are encountered. The buildings exposed to these splash zones are indeed subjected to the worst conditions of intermittent immersion with wet and dry cycling of the corrosive agent. Coastal regions like Alexandria and Damietta are salt-laden environments with high relative humidity that reaches 73 percent in some months of the year. The environmental impacts in these regions are extremely high compared to other places in Egypt. Usually under such conditions, a special design for concrete mix and good quality control during the building construction stage would control the effect of those environmental impacts.

Previous studies have examined the collapse of buildings in Egypt, particularly those subjected to saline weather in Alexandria (Hassan, 2003). They concluded that two main factors must be studied in detail to determine the extent of their impact on concrete deterioration. The first factor is the type of steel reinforcement used and the second factor is the type of cement and its quantity in the concrete mix. In Egypt, the reinforcement bars used are composed of carbon steel with a high percentage of carbon. The standard percentage of carbon ranges from 3 to 4 percent, and according to this study, the rate of corrosion is directly proportional to the percentage of carbon used. In practice, another major reason for concrete vulnerability to the saline environment is related to poor design of the concrete mix, without consideration for the saline sea environment, as well as low quality control of concrete mix itself.

4. Factors Affecting Concrete Durability

Concrete is a composite material made of aggregates and the reaction product of the cement mixed with water. The structure and composition of the cement paste determines the durability and long term performance of concrete; it also determines the efficiency of the protection that concrete provides to the embedded steel.

The environmental attack on reinforced concrete buildings in coastal zones starts with erosion to the buildings' frontage, followed by intrusion of chlorides to the concrete matrix and eventually reaching the reinforcing steel bars as shown in Figure 3. The question is how these attackers are able to enter the concrete matrix and what are the factors that weaken the concrete against the intrusion of salts and chlorides? Recent research has demonstrated that concrete with a low void ratio and high strength plays an important role in delaying steel corrosion. As the void ratio decreases and cement content increases, permeability decreases and this increases the concrete resistance to water and chlorides intrusion.

Figure 3: Signs of environmental attack on reinforced concrete buildings in Alexandria, Egypt. *(a) Erosion of old building frontage. (b) Development of cracks in columns and slabs. (c) Total concrete cover spalling.*

Structural and Concrete Mix Design

During the structural design stage, care must be taken to choose adequate concrete cover for the steel reinforcing bars according to the exposure conditions of each building. Also eliminating cracks within buildings reduces the chances of chloride intrusion or in other words, to decrease the rate by which chlorides reach the steel bars. However, the main problem is that many engineers disregard the concrete mix composition when designing buildings in coastal areas. The composition of concrete is very important to achieve the designed strength and durability. Also, when consultants assess fabricated concrete, they only perform the compressive strength test and disregard the durability aspect of concrete.

Water Content and Water/Cement Ratio

In Egypt, 80 percent of the laborers are not trained, resulting in poor quality of concrete building construction. One of the issues is associated with excess water added to the concrete. For in-situ concrete, laborers add water to increase the concrete workability and make it easy for placing. It is well known that excess water negatively affects the strength of concrete (see Figure 4). In terms of concrete durability, excess water in the fresh mix results in an increase in the void ratio of the hardened concrete matrix. The Egyptian Code of Practice (ECP 203-2007, 2007) provides maximum limits for the water to cement ratio to ensure good concrete durability and sufficient protection to the embedded steel bars. The code limits are (w/c=0.50) for concrete secured from any harmful environmental impacts and (w/c=0.40) for concrete surrounded by harmful environmental effects and subject to cycles of freezing and thawing.

Using Unclean Fine Aggregate

Samples of sand used in construction and in situ concrete mixers used by contractors were tested. All samples contained a high percentage of clay and fine materials which varied from 12 to 20 percent. Egyptian specifications limit this percentage to 3 percent (ESS, 2009). The presence of fine materials first affects the bond between the aggregates with each other and between the steel reinforcement and the concrete matrix, which decreases the strength of the concrete. The durability may also be affected since these materials form a strong coating covering the aggregate surface. When this coating is chemically stable and has no deleterious effect, there is no harm in using aggregate with such a coating. However, aggregates with chemically reactive coatings, even if physically stable, can lead to serious trouble (Neville, 2002).

Deficiencies in Concrete Curing

Another concern related to concrete strength and durability is the issue of untrained laborers who use inadequate systems for concrete curing. In practice, workers mainly cure the concrete only one day after setting, disregarding the

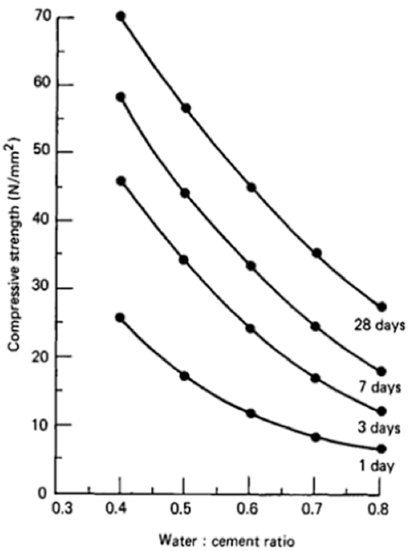

Figure 4: Effect of water/cement ratio on concrete strength.

need to cure it for at least seven days after setting. The curing process does not only affect the concrete strength, but it also affects its durability. The resistance of concrete to corrosion is highly affected by the duration of curing (Figure 5). The time to initiation of corrosion is substantially increased by prolonged curing (Rasheeduzzafar *et al.*, 1989). Once the corrosion is initiated, its continuation is not inevitable.

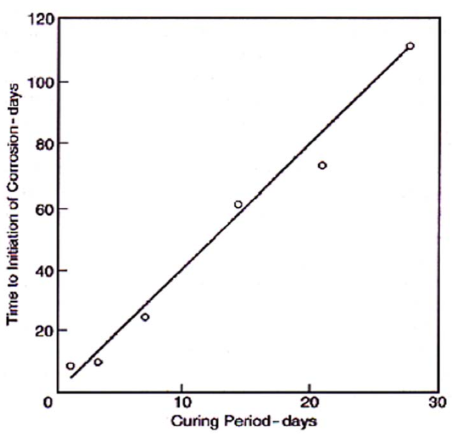

Figure 5: Influence of the length of curing on the time to initiation of corrosion of reinforcement (Source: Neville, 2002).

Use of Non-Standardized Setting Accelerators

Problems in concrete mixtures can also be found in different construction projects, where contractors use admixtures to accelerate the time it takes to set concrete in order to increase the rate of production and form removal (El-Baltimy, 2013). Hazardous admixture types are used in the rapid construction of illegal stories, especially after the Egyptian revolution (Seif, 2013).

Use of Inadequate Cement type

One of the most dangerous risks in the Egyptian construction field is related to the use of inadequate types of cement. In coastal regions, the Egyptian code of practice requires building contractors to use sulfate resistance Portland cement, which contains a low percentage of C3A (tetra calcium alumina ferrite)which reduces the ability of cement components to react with sulphates in coastal environments. However, in practice, cement used in such regions is the ordinary Portland cement, which is 20 percent less costly than cement required by code.

Repair and Maintenance of Older Residential Buildings

The cost of repair and maintenance in older residential buildings is not economically feasible when compared against the low rental income they generate. Owners disregard the repair or maintenance requirements of these buildings where the revenue from tenants does not cover the costs of repair. Building deterioration problems appear mainly in the rainy seasons where heavy rains and environmental risks arise. This unsustainable situation is an example of the shortcomings of rental laws that result in a broader legislation dilemma in the country.

5. Experimental Program Results

The effect of steel corrosion on the durability of seafront reinforced concrete structures was investigated experimentally at AASTMT Labs (Hassan, 2012). Four types of concrete were considered with variable strengths and water to cement ratios as shown in Table 3. The effect of corrosion in different types of regular carbon steel bars was evaluated for plain bars, un-coated deformed bars and epoxy coated deformed bars.

Figure 6 shows the relationship between the current readings in mA and the immersion time in days for different concrete strengths surrounding uncoated deformed steel bar. All concrete mixes had the same water to cement ratio (0.32). The results obtained from a study by Hassan (2003) are also represented on the graph. As expected, the 30MPa concrete mix demonstrated the lowest protection for steel bars and showed the higher rate of corrosion through the current values that increases from 200mA at the beginning of the test to 500mA after 2 months. This result was followed by the 44MPa mix, which measured approximately 130mA and the 60MPa mix, which had the lowest initial current reading of approximately 110mA.

Table 3: Properties of concrete mixtures.

Mixture Type	Concrete Density (kN/m^3)	Slump (mm)	Test Type	Average Stress of three samples (after 56 days) (MPa)
30 MPa, w/c=0.32	23.1	29	Compressive Strength	33.74
			Splitting Tensile Strength	3.69
44 MPa, w/c=0.32	23.3	30	Compressive Strength	48.58
			Splitting Tensile Strength	4.604
60 MPa, w/c=0.32	23.3	33	Compressive Strength	62.904
			Splitting Tensile Strength	4.397
44 MPa, w/c=0.52	24.2	32	Compressive Strength	49.88
			Splitting Tensile Strength	3.98

As void ratio decreases, permeability decreases and this increases the concrete resistance to water and chlorides intrusion. The concrete void ratio is inversely proportional to the concrete cement content; this means that the lowest permeability and highest chlorides resistivity concrete samples are those of the 60MPa concrete mixes.

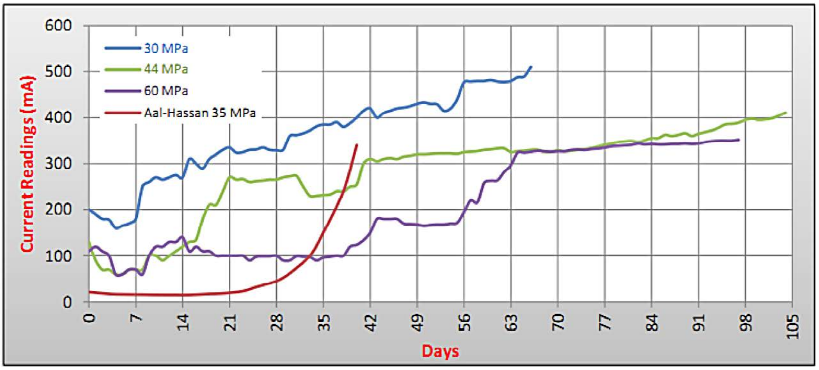

Figure 6: Current readings for uncoated deformed steel bars in different concrete strength (w/c =0.32).

To differentiate between the durability of concrete and its strength, another comparison is presented in Figure 7. It shows the relationship between current readings and immersion time for a fixed concrete strength (44MPa) and using variable water/cement ratios (0.52 and 0.32).

The results demonstrate that a higher water to cement ratio increases the corrosion rate of embedded steel in the reinforced concrete element and is less durable then mixed with lower ratio. A higher water to cement ratio in the mix results in a higher permeability of concrete, since the excess water in the concrete matrix occupies more voids (Neville, 2002). On the other hand, the concrete with lower water to cement ratio and using workability admixtures exhibit lower permeability and produce higher protection for steel bars.

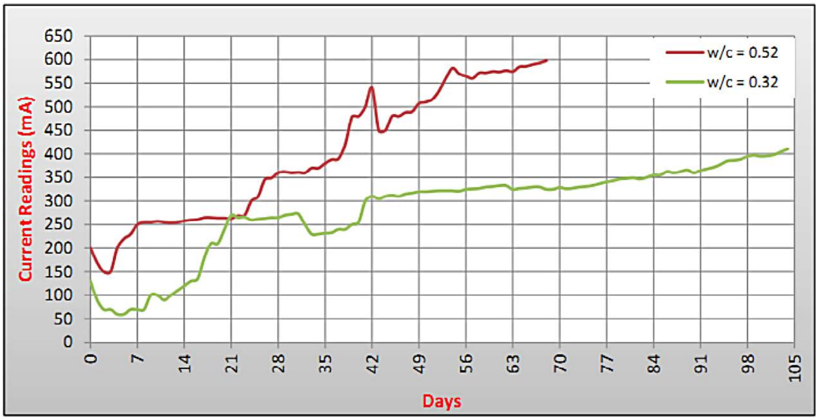

Figure 7: Current readings for un-coated deformed steel bars in 44MPa concrete cylinders.

6. Conclusions

The performance of reinforced concrete members under different degrees of steel corrosion is studied experimentally. The purpose of this study is to determine the effect of salt-laden weather conditions on reinforced concrete structures, especially those located at seafront in Egypt. The paper shows the vulnerability of such structures and identifies several factors that are vital for preserving these buildings based on expert survey from architectural and construction field and validated with experimental results. The effect of concrete strength and concrete durability in protecting the steel bars and reduce the rate of corrosion is described. The following conclusions are based on the data and analysis presented in this paper.

1) Salt-laden weather has a severe negative effect on reinforced concrete buildings.
2) The low quality control of concrete in construction is a major factor affecting the vulnerability of residential buildings in Egypt.
3) High water content in concrete mix increases the voids and facilitates the intrusion of environmental risk to the steel bars.

4) Carbon steel, the most commonly used reinforcement, corrodes in outdoor atmospheres. When comparing the uncoated plain and deformed bars, the deformed bars showed faster rate of corrosion due to their greater surface area.
5) Concrete with high strength provides higher protection to reinforcement and reduces the corrosion rate. However, after cracking, the highest strength concrete deteriorates faster than others.
6) The decrease of water to cement ratio increases concrete durability and has a positive effect on slowing the corrosion rate of embedded reinforcement.

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PAPER 23

Green Urbanism: A Vision for Sustainable Urban Renewal in Alexandria

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Abstract: Today mainstream studies articulate the two words ***environment*** and ***respect*** together when applied to urban planning and development. In fact, the close of the twentieth century saw a global approach arising: sustainable development, green building, reduction of energy consumption to a minimum. Therefore, planning methods and decision-making tools that promote green urbanism must be analyzed and urgent issues that are facing cities in developing countries must be understood. Despite the fact that today every planner and architect is aware of the definition of sustainability, it is not at all clear how sustainability can be mapped into actual decisions especially regarding deteriorated urban contexts. This problem is particularly evident in Egypt where recent civil unrest and an unstable political situation has provoked intensive illegal construction practices, aggressive transformation of the natural and built environment as well as irreversible ecological transgressions. In addition, most decisions of local authorities are hastily taken and urban development projects are not carefully studied. This paper will shed light on the French experience with green urbanism policies to draw lessons from urban renewal methods. It will describe environmental strategies and projects that must be promoted in Alexandria in order to achieve sustainable development. The methodology will include a review of existing urban development and associated opportunities in Alexandria, as well as its significant environmental problems and challenges. In conclusion, guidelines will be proposed to develop an integrated framework that can be implemented, which is reflective of environmental local issues and priorities with particular emphasis on the urban regeneration of aging inner city areas.. The synthesis of this research highlights the essential synergy between all actors involved in the planning process and determines the necessary mechanisms to build that synergy.

Keywords: green urbanism, urban renewal, planning process, Alexandria.

1. Sustainable Development: International Plans of Action and Agreements

The early 1990s witnessed widespread and diverse concerns about environmental quality in all developed countries. Due to rising greenhouse gas emissions, water, soil and air pollution, the destruction of ecosystems under the guise of development and wide-ranging aggressive patterns of conduct vis-à-vis nature, a new focus of sustainability on cities has emerged. The recognition of the urgent need for a paradigm shift to achieve sustainable development is now embedded in the political agenda worldwide.

This growing awareness of the ecological impact of buildings and cities has put architects and planners in a forefront position to lead the way in developing climate change mitigation strategies. Much of the recent debate that has circled around ideas for reducing greenhouse gas emissions includes four issues (Williams, 2007; Halliday, 2008; Kibert, 2008):

- energy efficiency and conservation;
- transport;
- urban planning; and
- building design.

Sustainable Development was first developed as a concept in 1987 with the publication of the Brundtland Report. Many of the sustainability principles now embodied in national and international agreements stem from this report, including:

- the precautionary principle;
- intergenerational equity;
- intragenerational equity;
- conservation of biodiversity; and
- internalized environmental costs.

However, it was not until 1992 at the Rio Earth Summit that nations around the world came together to push for concerted action to try and reach an agreement on the best way to slow down, halt and reverse environmental deterioration (Halliday, 2008). Out of Rio came Agenda 21, the Framework Convention on Climate Change and the Convention on Biological Diversity. Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which humans impact upon the environment. The Commission on Sustainable Development was set up to monitor and ensure effective implementation of the agreement. Agenda 21 is widely recognized for putting 'bottom-up', participatory and community-based approaches into the forefront of policy-making in many areas (Halliday, 2008).

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. Recognizing that developed countries are principally responsible for the current high levels of greenhouse gas (GHG) emissions in the atmosphere as a result of more than 150 years of industrial activity, the Kyoto Protocol, which entered into force in 2005, committed its Parties by setting internationally binding emission reduction targets.

In 2012, the UN Conference on Sustainable Development identified the Institutional Framework for Sustainable Development as one of its core themes. The aim was to advance sustainable development at the global level. The report argued that environmental objectives have too often been compartmentalized from economic development priorities, so balance between three pillars of sustainable development (environment, economy and social progress) had to be a priority in development plans and identification of best practice (Cruickshank *et al.*, 2012).

2. Green Urbanism: A Paradigm Shift Much Needed After Decades of Environmental Degradation

To understand Green Urbanism implies understanding Green Design. Actually, the whole idea of the "Green Revolution" is that individuals are encouraged to feel responsible not only for their fate, by that of others, but also for other life forms: plants, animals or insect life. The term "Biourbanism" is also employed to designate eco-city and eco-district, where urban systems are designed to work as biology, combining economic, community, and environmental elements all powered by renewable energy and place-based resources (Williams, 2007).

Too often the scope of concerns and complexity of issues regarding sustainability are over-simplified. The problem is that this oversimplification diverts attention from a broader understanding and excludes actors and institutions that need to be engaged. It is well established that sustainability involves environmental, economic and social aspects but it is of importance to actively make and demonstrate those links. The lack of genuine belief in the triple bottom line prevents politicians from providing long-term solutions to development issues (Halliday, 2008).

Figure 1: The three pillars of Green Urbanism and the interaction between these pillars, based upon the framework of Lehmann (Source: Lehmann, 2010).

According to Lehmann, the aim of green urbanism is to minimize the use of energy, water and materials at each stage of a City or district's life-cycle, including the building and the ease and value of recycling when the life of the building is over. Planners and architects must also consider the use of energy in the buildings' maintenance, renewal and operation (Lehmann, 2010). Hence, the pillars of Green Urbanism are classified as in Figure 1.

3. The French Experience

This paper deals specifically with the renewal of older inner city areas, which has recently been at the heart of urban planning policies in France. Additionally, the National Strategy for Biodiversity is one of the main commitments of France's policies. The aim is to restore natural environments and ecological corridors. Consequently, this paper will provide an overview of the French experience and its green urbanism policies to draw lessons from urban renewal methods and strategies.

Regarding sustainable development in construction, France initiated the HQE (High Environmental Quality) to adapt building standards to European norms. This rating system, along with LEED, BREAM and others, promote the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout the building's life cycle. With regard to urban sustainable development, there are four main scales: the scale of housing, the scale of the commune, the scale of inter-communality and the scale of the metropolis. Within the framework of eco-district, the application is illustrated by the layout of green spaces at the proximity of residential areas, the development of the tram and mass transport links in separate lanes, and photovoltaic energy produced for some buildings (Hamman, 2008).

3.1 STRONG POLITICAL WILL

The issue of 'integrated urban development' is considered at the core of the European Urban Policy, as local political and administrative systems are joined in a common urban agenda. The management and planning process of this framework is guided by the Local Agenda 21. The 'Green and Blue Grid' is a new policy that stems from the round table named Grenelle de l'environnement. The Green Grid refers to all green open spaces (public and private), parks, rivers and floodplains. The 'blue' part of the Grid covers the network of wetlands, ponds and lakes. Besides providing valuable habitat for fish and other species, this network is essential to the hydrological function of Alexandria and its region. Ecosystem management and watershed planning simultaneously address the complex issues of urban quality of life and preservation of ecosystem (Williams, 2007). The aim of the Environment Round Table, founded by the President of France, Nicolas Sarkozy, in 2007 was to define key points of government policy on ecological and sustainable development issues for five years. For the first time, the Round Table brought all civilian and public service representatives together around the discussion table. During discussions, it was crucial to look at the technical, legal and administrative aspects of sustainable development, which will serve to assess how best to implement all the measures decided upon.

The aim of the Green and Blue Grid is to integrate biodiversity in the decisions related to town planning and the conservation and to restore of natural environments and ecological networks (MEDDE, Centre de Ressources Trame Verte et Bleue). It was created as a decentralized instrument of sustainable development and for consultation and coordination to encourage urban densification and integrated land management that preserves biodiversity, the ecosystems functions and the capacity of nature to adapt (MEDDE, Trame Verte et Bleue).

3.2 LEGAL FRAME RELATED TO URBAN PLANNING

In France, the decentralization laws of 1982, and the following years, have profoundly modified the allocation of power between the different levels of France's local authorities: state, region, department, and commune (municipality); and even more so, the way in which these powers are exercised. Decentralization laws outlined the division of responsibilities to promote democracy and a better functioning of public services (Merlin, 2007).

State intervention in urban management can be more direct and concrete, within the framework of a partnership with local authorities. The State intervenes by way of methodological and financial support; and in actions to improve quality of life and for that matter protect and enhance architectural and urban heritage (Lacaze, 2012). In order to understand the process by which the development process is managed, it is important to review the main laws regarding urban planning.

French planning rules are set out in the 'Code de l 'Urbanisme' which states whether or not construction is allowed on specific land, as it gives details about national principles and the tools and procedures which regulate planning and construction. The code concerns economic management of space, preservation of heritage and landscape, equilibrium by mix and diversity of use, security, sanitation and, of most relevance to the current study, the rules related to the appearance of buildings (Lacaze, 2012).

The SRU Law of 2000 (Solidarity and Renewal Urban law) is a refinement added to the legal body concerning the area around historic monuments as it has bought improvements to the functioning of housing projects and set up a public intervention mechanism. New funding was provided to increase control of future development and promote cohesion of urban areas and their hinterlands and encourage sustainable developments. The SRU law mainly concerns the local planning documents, which include the SCOT (Territorial Cohesion Scheme) and the Local Urban Planning Scheme (PLU) (Lacaze, 2012).

The SCOT is a long term planning document, which determines orientations; it aims to achieve equilibrium between preservation of natural landscapes and creation of new economic activities. The PLU (Local Urban Planning Scheme), on the other hand, is prepared to cover the municipality (commune) on a plot-by-plot basis and to define protected areas and land use. The PLU carries projects for the implementation of sustainable development according to the vision of the SCOT.

The French experience in urbanism exemplifies the importance of plans in defining and conferring rights to development. Urban planning powers are principally exercised according to procedures established in terms of sets of zoning plans, maps and documents.

Like the department and region, the municipality (commune) which is the smallest political level, has a deliberative or decision-making body (the municipal council) and an executive (the mayor), elected by the municipal council .The council has statutory powers, which can be used to prevent loss of the character of its historic core and its natural environment and biodiversity.

Periods of economic crisis and the spread of unemployment were characterized by poorly-maintained housing estates of historic cores in towns. Several laws were enacted to bring improvements to the functioning of under-privileged and old housing stock and public intervention mechanism was set up to take care of remodeling and rehabilitation. Planning projects shifted towards urban renewal and sustainable development in a way that ensured that alterations would not betray the original spirit of traditional districts (Merlin, 2007).

Despite the many potential overlapping jurisdictions of the French government, effective coordination enabled detailed planning to become an essential instrument for sustainable development. It gave far greater autonomy in decision-making by sharing administrative and budgetary tasks between central and local authorities. For renewal projects, the emphasis was on special programs for the improvement of the social capital, education and housing (Lacaze, 2012).

Now, how can the French experience be transposed? There must be a determination to combat any arbitrary oversimplified tendency to the adoption of general concepts and stereotypes, which exert their influence regardless of their relevance, or adaptability to a different context. Instead, a practical inductive method is needed to manage action according to real situations. The present research will deal with important issues related to urban planning and environmental resource management with special emphasis on renewal and sustainable development of the city of Alexandria.

4. Alexandria's Current Situation: Opportunities and Serious Environmental Problems

Alexandria is located at the western extremity of the Nile River delta on a narrow isthmus between the Mediterranean Sea and Lake Mariout. It is the second largest city in Egypt and one of the major urban agglomerations of the Mediterranean. The city is Egypt's principal port and a key commercial and transportation center. It also comprises main industrial areas where natural gas and oil pipelines pass from Suez and where refined petroleum, asphalt, cotton textiles, processed food, paper, and plastics are produced.

Like most coastal cities of the Mediterranean, Alexandria's climate is pleasant during most months of the year as it is temperate, with variably rainy winters and hot and humid summers. January and February are the coolest months, with daily maximum temperatures ranging from 12 to 18 °C. July and August are the hottest and driest months of the year, with an average daily maximum temperature of 30 °C. The average annual rainfall is around 200 millimeters (Britannica, 2013). Because of its distinctive situation, its temperate climate, its beaches and its past magnificent history – mirrored in its unique archaeological, underwater sites and rich architectural heritage – Alexandria is a valued tourist destination. In 2002, Alexandria revived memories of its past splendor with the opening of the iconic Bibliotheca Alexandrina: the new library.

The city, as is the case with most Egyptian cities, is facing numerous environmental problems due to rapid population growth, unplanned land use distribution, unplanned extension of human activity and urban encroachment over arable lands. As the major port and one of the most important industrial cities of Egypt, Alexandria's factories, transportation sector and energy production are also major contributors to pollution.

According to the Central Agency for Public Mobilization & Statistics, Egypt is expected to grow to 102 million people over the next 20 years (CAPMAS, 2012). Without changes in development policy and practices, the environmental and social costs will be enormous and the impacts will be irreversible. Experiencing similar growth, Alexandria is suffering from acute problems of urban sprawl and irretrievable losses of its natural and built heritage.

Today, Alexandria struggles to regenerate its urban core, resolve traffic and waste management issues and provide appropriate and affordable housing to its growing population. The impacts are worsened by the lack of any overall plan for channelling this urban growth into a coherent, ecologically responsive and integrated scheme.

After the revolution of 25 January 2011, the pace of environmental degradation is increasing, as unrest and unstable political situation have exacerbated the problem. The implementation of urban development plans faces serious hindrances. They range from political to economical, financial to institutional and physical to socio-cultural problems. Research must offer ways to overcome the seemingly insurmountable problems of bureaucracy and economic stagnation to challenge the status quo.

Besides urban sprawl, the challenges of the 21st century for many coastal cities include coastal erosion, wetlands conservation, biodiversity protection, tourism development, waste disposal, artisanal fisheries and port development. A comprehensive and exhaustive discussion of the wide range of environmental problems facing Alexandria is beyond the scope of this paper. However, significant problems related to the human-nature interface will be examined.

4.1 URBAN ENCROACHMENT OVER ARABLE LANDS

The surface area of agricultural land in Egypt remained at about six million acres for a number of years (Alex Med Report – year?). However, in recent years the greatest increase in population and the impact of human activities has led to an alarming decrease in agricultural land since vast areas have been used for urban expansion projects and informal settlements. Since the 25 January 2011 revolution, state control and law enforcement have widely vanished, which has led to a boom of illegal construction. A report received by the Agriculture Minister, Mohamed Reda Ismail, shows that encroachments damaged more than 16,000 acres of valuable agricultural land (Egypt Independent, 2012).

4.2 THE URGENT NEED FOR THE RENEWAL OF OLD QUARTERS OF ALEXANDRIA

In old rundown areas of the city, vacant plots of land represent an opportunity for future residential development. The many commercial activities and workshops are an important asset, with the potential of generating more employment and income. There are obvious concerns about the structural safety and building envelope (damp walls) of the existing buildings but most of them can be restored. The renewal of the area of the Turkish Town, for instance, must include different types of interventions: preservation (preventive maintenance), restoration, refurbishment, adaptive reuse, and infill development. The intervention must also include the removal of illegal additions and encroachment on heritage buildings and urban open space. The political unrest and the consequent laissez-faire attitude of local authorities have exacerbated the situation and the malpractices related to illegal construction have multiplied after the revolution of 2011. Therefore, every pilot project proposed within this area must consider eliminating whole structures or portions of structures that damage the environmental quality and integrity of the existing urban fabric, as well as building entire new structures and remodeling public open spaces in order to improve the provision and quality of housing, community services, and public spaces in the area.

An initial focus on improving the situation in the older areas of Alexandria would provide a catalyst to trigger similar pilot projects in other areas with potential for renewal to encompass all original quarters of the inner city core.

4.3 LAKE MARIOUT

Lake Mariout, or the ancient Mareotis as it was called in Ptolemaic times, was formed as a result of the sea inundating the north coast of the Nile Delta. During Antiquity, the Lake was linked to the Nile through several canals and its lakeside ports were even busier than those on Alexandria's seacoast. Until recently, Lake Mariout was well known for its profusion of wildflowers in spring and for its ducks, geese, quails and many other species of birds.

Fishing villages where huts made of reeds stand along the shore of the Lake, but these communities are now struggling to survive. At present, the water quality of the lake has deteriorated so much as to cause serious disturbance to the biodiversity of its environment. Lake Mariout has become a body of shallow brackish water that experienced a dramatic reduction in its original area and volume. Lake Mariout receives polluted water from three major sources on a daily basis:

- industrial effluents from various industries that discharge their effluents directly into the lake;
- domestic effluents from two wastewater treatment plants that discharge their primary treated effluents into the lake; and
- drainage water from agriculture, bringing pesticides, nutrients along with organic matter from animal farming and domestic wastewater of nearby villages.

Beside pollution, the other major threat to the lake is the rapid urbanization and informal land-filling for real estate development and commercial activities. As a consequence of the environmental degradation, Lake Mariout has changed from being the most productive fisheries resource to the least productive within several decades (Alexandria Integrated Coastal Zone Management Project, 2009). To address this alarming situation, the Government of Egypt, represented by the Egyptian Environmental Affairs Agency (EEAA), prepared the Alexandria Integrated Coastal Zone Management Project (AICZM) in 2009. The project had two main objectives:

- to develop a strategy to lower the amount of land-based sources of pollution entering the Mediterranean Sea via El Mex Bay and Lake Mariout; and
- to support the Government of Egypt's development and implementation of a National Coastal Zone Management Plan, which will protect and/or restore coastal heritage and ecosystem processes that are globally significant.

This proposed project was developed with assistance from the World Bank through a grant from the Global Environment Facility (GEF).

Until now, many factors have hindered the implementation of projects. Successive governments have failed to halt the industrial contamination and the growing sprawl of construction across the lake's shallow marshland waters. Moreover after the 2011 Revolution, hundreds of acres of the lake have been levelled and rubbish and construction site debris has been dumped into the water. Mechanisms for implementation are urgently needed and most importantly, the restoration of Lake Mariout will have to include adequate measures to improve socio-economic conditions of the fishing community.

4.4 THE MAHMOUDIEH CANAL

The renaissance of Alexandria after centuries of decline must be ascribed to the Viceroy Mohamed Ali (1769-1849). The digging of the Mahmoudieh Canal is one of the many ambitious plans he had for the city. His aim was to link the city with its Egyptian hinterland, to improve the fresh water supply and to increase the area of arable land. Under the supervision of the French engineer Pascal Coste, the Canal was completed in 1820 and had a great impact on the growth and prosperity of Alexandria (Yehia, 2005).

In January 2007, the governorate of Alexandria commissioned the Alexandria and Mediterranean Research Center (Alex Med), which is affiliated with the Bibliotheca Alexandrina, to conduct a preliminary study for the improvement and development of the road along the northern bank of the Mahmoudieh Canal. The overall objective was to transform this road into a new route for traffic along the east-west axis of the city, thereby decreasing traffic density within Alexandria. This preliminary study focused on the stretch of road between Antoniadis Gardens and Namoos Bridge. The study included a survey of land use, existing problems and an analysis of the condition of the road. Stretches of the road which could be widened and areas which should be expropriated were identified. The outcome of the study, including recommendations and proposals, was submitted in a report to the governorate of Alexandria (Alex Med Report).

As a large number of businesses and factories are located along its banks, the Canal increasingly suffers from untreated or poorly treated urban and industrial effluents that are discharged into its water. It also experiences eutrophication, dense growth of weeds and the accumulation of pesticides, which in turn lead to the contamination of drinking water. For these reasons, today Mahmoudieh Canal endangers human health and welfare, as well as the environment of Alexandria.

4.5 THE URGENT NEED FOR SUSTAINABLE WASTE MANAGEMENT IN EGYPT

Concerns about environmental degradation, resource shortages, and human health promote the widespread acceptance of the urgent need to address waste management in Egypt. Successful solid waste management must be a vital component of Egyptian cities' sustainable development strategy as it impacts several sectors of the economy and environment.

In an essay entitled "What is Green Design?' the renowned Malaysian architect Ken Yeang explains that ecosystems have no waste and to produce built environments in a benign way, the human diverse interventions and activities (including buildings, infrastructures and others) must be integrated with the natural environment imitating ecosystems (Yeang, 2005). Actually, all ecologies have wastes, but those wastes are part of a cycle. The challenge is thus to continuously reuse, recycle and reintegrate all emissions and products with the natural environment, in tandem with efficient uses of energy and material resources.

In 2000, a study titled "Policies and Institutional Assessment of Solid Waste Management in Egypt" (Bushra, 2000) highlighted the fact that there are many constraints impeding the progress of solid waste management. Regarding the national, regional and local policies, it was noted that laws are not adequately enforced for all violators (waste service providers and waste service recipients).

In 2005, another important study was carried out by the Overseas Environmental Cooperation Center supported by the Ministry of the Environment of Japanese Government. According to the report, the actual status of solid waste management in Egypt faces serious problems that include illegal dumping of municipal waste and unsanitary waste disposal practices such as open dumping. Addressing these problems were already the focus of 'The National Strategy for Integrated Municipal Solid Waste Management' developed by the Egyptian Government in 2002 (Overseas Environmental Cooperation Center 2005). The report – with the aim to implement waste reduction measures, recycling practices and the development of action plans– proposed the formulation of a master plan, action plans and guidelines to promote solid waste minimization (Overseas Environmental Cooperation Center, 2005).

In 2010, the Regional Solid Waste Exchange of Information and Expertise Network (Sweep-Net) in Mashreq (Egypt, Jordan, Lebanon, and Syria) and Maghreb (Algeria, Morocco and Tunisia) countries published a report on solid waste management in Egypt that showed that 9% of total waste are composted, 2.5% are recycled, 5% are landfilled and 83.5% are open dumped. An updated report was published in 2012; it discussed several institutional and financial issues and stressed the importance of cost recovery and the participation of private sector for the sustainability of any project. Moreover, pilot projects for source segregation of household waste were implemented in limited areas of Egypt. These activities will lead to the creation of job opportunities for the urban poor and contribute to general improvement in the living environment for local communities in these cities (Zaki and Khayal, 2012).

All the reports cited above concluded the necessity of coordinating with relevant authorities and the importance of involving the private sector. The need for introducing innovative systems for recycling and composting was also mentioned. In brief, the city will have to embark on greener strategies and reformulate a circular view on waste management.

4.6 INSTITUTIONAL INERTIA AND LACK OF PROPER PENALTIES FOR VIOLATORS IN EGYPT

Key problems in Egypt include a lack of political will to implement strategies; the absence of continuity in the implementation of associated plans; insufficient exploration of the sustainable development concept; difficulty establishing a culture of cooperative management and the lack of a systemic approach to urban development. Fines levied on lawbreakers are, most of the time, too inexpensive to be an impediment, when compared to the gains made by illegal modes of construction and transgressions against the environment. The loss of many villas listed as built heritage in Alexandria, loss of agricultural lands, illegal construction of "slum towers" and prohibited additions of floors above existing apartment buildings, and pollution of Lake Mariout and the Mahmoudieh Canal are direct consequences of this laissez-faire approach adopted by local authorities.

5. Guidelines for an Integrated Holistic Framework for a Substantial Program of Renewal in Alexandria

The French urban planning system has provided a practical and successful framework to advance recommendations for the renewal of Alexandria through systematic evidence-based research. Four main guiding directions can be concluded as instrumental to the French experience and relevant to Alexandria: firstly, the role of political will in enacting the sustainability agenda (Green & Blue Grid); secondly, the focus on developing detailed urban renewal plans in line with a strategic master plan; thirdly, the importance of strengthening the municipalities; and finally, the establishment of objectives for renewal policies, which include housing, social capital, and education programs. The question now is: how to move from multiple instruments and policies to an approach where a reform agenda drives the establishment and use of specific mechanisms to regenerate the city of Alexandria? The next section of this paper attempts to provide an integrated framework that embeds green urbanism principles that reflect local environmental issues and priorities.

Figure 2 illustrates the Green Urbanism framework, derived from the Green Urbanism framework of Lehmann (Figure 1) and adapted to the Alexandrian context and priorities. The synergy between the three pillars – energy and materials; water and biodiversity; and urban planning and transportation – is built on cross-cutting themes across all three pillars which include the support to research sustainability solutions; the improvement of governance; and empowerment of the local community. Each aspect is reviewed in the following section of this paper.

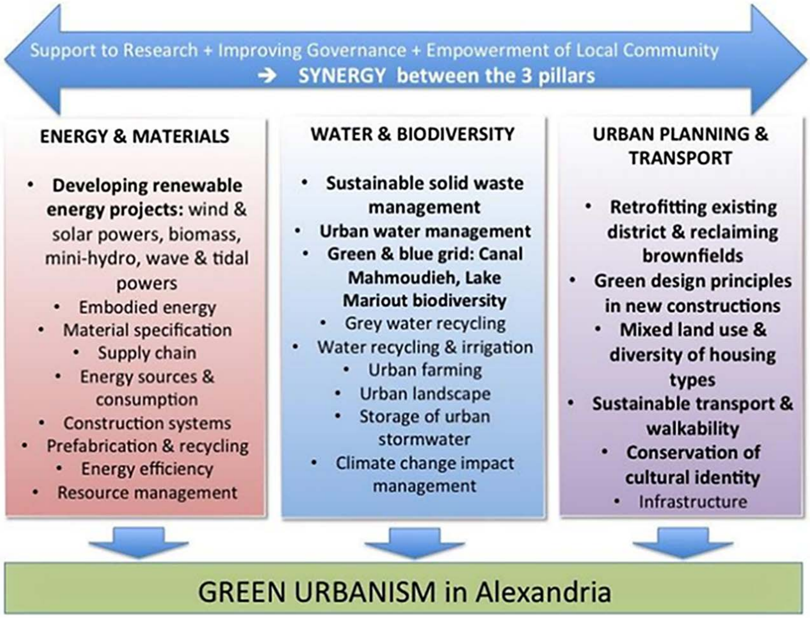

Figure 2: The three pillars – energy & materials, water & biodiversity and urban planning & transport – and the mechanisms of the prerequisite synergy to establish Green Urbanism in Alexandria (Source: the author).

5.1 ENERGY AND MATERIALS

Developing Renewable Energy Projects

Egypt's geography provides significant advantages for the development of several sources of renewable energy on a large scale. By 2020, Egypt plans to produce 12% of its energy from wind. According to a report by the New Renewable Energy Authority, Egypt is also well positioned for solar power resources (Sterman, 2009). Biomass, geothermal power, mini-hydro energy, wave and tidal powers need to be developed to secure future supply of energy and reduce greenhouse gas emissions in Alexandria.

5.2 WATER & BIODIVERSITY

Sustainable Solid Waste Management

Throughout Egypt, the problem of solid waste management has been increasing. The negative impacts of unsustainable waste management practices, as well as direct and indirect harmful and serious, impacts on public health, the environment and the national economy are becoming apparent and acute, particularly in Cairo and Alexandria. It is for this reason, the issue of waste management must be given a high priority within the agenda of sustainable development. Many studies have put forward well-founded scientifically planned approaches to sustainable waste management (Bushra, 2000; Overseas Environmental Cooperation Center, 2005; Zaki and Khayal, 2012). However, building the capacity of various stakeholders including government agencies, NGOs and the general public is critical to the success of sustainable waste management efforts. If managed effectively, waste will be an important asset to the city, by providing energy (biomass and composting) and marketing materials from recycled materials. Moreover, adopting waste separation practices at the source will help to create eco-districts in Alexandria that help to minimize waste to landfill.

Urban Water Management: Efficient Use and Reduction of Pollution

Egypt and most of the arid and semi-arid regions of the world can expect an increase in water stress because of the impacts of climate change, especially on threatened ecosystems in the Mediterranean region. As a result of global warming, population growth, urbanization, and agricultural and industrial expansions, the scarcity of water will increase. The Nile, which is the main source of water in Egypt, is being polluted by the discharge of untreated or partially treated wastewater and industrial effluents. According to recent research, from the institutional standpoint, seven ministries are involved in wastewater treatment and reuse in Egypt, with unclear delineation of responsibilities and limited coordination among them. The situation is further worsened by the absence of clear policies and action plan on wastewater management, making enforcement practically impossible and limiting the effectiveness of pollution control abatement efforts (Loutfy, 2010).

Thus, main considerations for the sustainable management of water resources involve reducing consumption; minimizing organic and chemical discharge into the Nile; developing sustainable methods to treat sewage; harvesting storm water and rainwater for re-use especially in Alexandria; and applying industrial ecology principles where the waste from one process is provided as the input to another.

Protection of Biodiversity: Using the Green and Blue Grid

The development of a Green and Blue Grid enables a city to become more resilient to the effects of climate change and to energy and food shortages.

Natural habitats must be linked, extended and preserved to reverse habitat fragmentation. Wildlife must be managed as a "community" of interrelated species; actions that affect one species affect the other (Ewing, 1996). Environmental issues in Alexandria provide insight into the loss of natural habitat and biodiversity in areas including Lake Mariout and Mahmoudieh Canal, which should be a priority when addressing the impacts of pollution in Alexandria. These two important water bodies can be regenerated as green corridors. Along their banks, integrated networks of parks and wildlife areas can be established to provide safe, pedestrian and cycle routes.

5.3 PLANNING AND TRANSPORT

The Renewal Strategy Between Retrofitting Existing Districts and Reclaiming Brownfields

Redirecting development away from arable productive agricultural land must be a priority of any sustainable development-planning initiative in Alexandria and more broadly within Egypt. Therefore, it is crucial to ensure that formerly contaminated land, brownfields and grayfields are rehabilitated and restored for productive use. Similar to recycling, land restoration is a key imperative in creating sustainable communities and protecting fertile green fields adjacent to urban areas, which have been lost because of urban sprawl. A brownfield site refers to an abandoned or underused industrial or commercial facility where development is complicated by the presence or the potential presence of pollutants. Grayfield sites are areas that are not necessarily contaminated but are comprised of obsolete buildings (Kibert, 2008). Research and best practices in green urbanism recommend adaptive reuse of brownfield sites such as industrial and military sites or docklands, as well as the upgrade of existing buildings rather than their demolition (Lacaze, 2012).

Increasingly, Alexandria lacks appropriate affordable housing. At the same time, its inner city core possesses several underused and brownfield sites. A complete field survey must be carried out to update previous surveys and gather new information needed to formulate regeneration plans. All investigations must be conducted on a plot-by-plot basis to gain a complete understanding of different areas' physical fabric. These include a block survey form, a building survey form and forms documenting building conditions, and streetscape and open space features. In addition, surveys must include interviews with samples individuals living in households in these areas. The findings will have to encompass information on household sizes, employment, tenure, occupancy, schooling and access to public services. Proposals must develop low-cost solutions to contribute in solving the acute issues related to slums' expansion. Finally, there is an urgent need to mobilize local resources by providing poverty-reduction measures, vocational training and employment generation programmes to regenerate the socio-economic capital of local communities (Yehia, 2012).

Integrating Green Design Principles in New Constructions and Infill Projects

The construction industry is constantly making financial decisions that have wide-ranging environmental and social impacts. The problem is that there is a perceived added financial cost to sustainable building and a low perceived value of environmental and social benefits, which have often prevented positive action (Halliday, 2008). This is why whole-life cycle costing must be part of the building design approach when dealing with the use of appropriate local materials and local energy resources.

Passive design that optimizes building orientation to take advantage of climatic conditions (solar energy and wind energy) can significantly reduce heat gain or losses. Additionally, working with the existing landscape, topography and resources particular to the sites can increase of urban vegetation and trees that provide shade for cooling and absorb carbon dioxide. Therefore, building and site layout must consider natural daylight, rainwater, cooling breezes and solar exposure. In Egypt, the public is now aware that there is an urgent need to reduce energy consumption. Solar water heaters, for instance, provide a simple, cost-effective, method now used in several residential units and commercial facilities.

Mixed Land Use and Diversity of Housing Types

There is a consensus that a mixed-use and mixed-income city delivers more social sustainability and social inclusion than segregated zoning (Halliday, 2008; Lehmann, 2010). Decision-makers and planners in Alexandria will have to consider socio-demographic changes of local communities and propose a diverse range of economic activities and avoid mono-functional projects that generate high demand for mobility.

Sustainable Transport and Walkability

Eco-mobility supports socially inclusive, environmentally sustainable transportation options, such as walking, cycling, and wheeling. Enabling citizens and organizations to access goods, services, and information in a sustainable manner can help to reduce traffic volumes and associated greenhouse gas emissions. Access to basic public transportation will help reduce reliance on automobiles and greenhouse gas emissions and will also provide the city an opportunity to reduce its fossil fuel consumption. The regeneration of Mahmoudieh Canal, which stretches along the south side of Alexandria, can include two roads along its banks to carry traffic without disconnecting people from the waterway and the green areas as pedestrian routes can also be integrated.

Conservation of Cultural Identity: Built, Urban and Landscape Heritage

The deteriorated state of architectural heritage in Alexandria is a result of several socio-economic problems including a lack of maintenance and devaluation of rents. The decay of many valuable built heritage buildings has reached a critical stage, where many are classified as structurally unsound (Yehia, 2012). Alexandria, as is the case in Cairo, urgently requires conflict-stabilizing strategies to preserve its built, urban and landscape heritage. Innovative funding is required to provide appropriate compensation to owners of heritage buildings to support their conservation, restoration and adaptive reuse. Public-private partnership can channel investments in rehabilitation processes and yield a cohesive implementation agenda to preserve the unique Alexandrian sense of place and local identity.

6. The Synergy between the Three Pillars

Upon review of the diverse challenges noted above, it is clear that sustainable development is a cross-cutting issue that involves different groups of actors and complex issues that are specific to local conditions and constraints. The successful implementation of the green urbanism framework that include different and diverse interrelated issues such as energy, materials, water management, waste management, biodiversity and transport will be enabled only if planning documents are developed considering three main aspects: research, improving governance and social sustainability.

6.1 RESEARCH AND SUPPORT TO THINK TANKS

Knowledge of the terrain and understanding of the range of opportunities and challenges are both prerequisites to sustainable development. Disseminating information, dissertations and research developed by the University of Alexandria and its colleges of Architecture substantiates the need for integration and coordination to benefit from diverse and scattered studies on the city's environment. The Alexandria and Mediterranean Research Center (Alex Med) established a digital database to collect, archive and analyze all available data related to Alexandria Governorate, covering development sectors such as cultural heritage, transportation, housing, tourism, agriculture, environment, infrastructure and land divisions. Among the important studies, it is noted that slums were identified including those resulting from the illegal appropriation of agricultural lands for the construction of buildings (Alex Med).

There is an urgent need to set up the Alexandria Development Agency (ADA) proposed by Alex Med. This agency is intended to be a think tank for urban development, for qualifying pilot projects and, most importantly, to implement them. The aim is to achieve synergy and involve a wide range of decision makers and stakeholders in the discussions about urban development. In order to implement urban renewal projects in Alexandria, it is crucial to include politicians, business communities, citizens, cultural institutions and milieus, educational institutions, urban and regional planners, as well as NGOs. In 2005, Alex Med prepared the structure of ADA and submitted it to the Governorate and the World Bank. They have both approved the structure (Alex Med).

6.2 URBAN GOVERNANCE: RECONCILIATION BETWEEN CONSERVATION AND ECONOMIC DEVELOPMENT

According to Healey (1995), the determination of how to intervene in and regulate the way land is used and developed is a problematic task for the modern state. Given the range of interests involved in land and property development, development plan-making is a potential area for struggle over strategy, policy and decision rules. Development plans must be designed as a device for a strategic resolution of the tension between the conflicting dynamics of environmental conservation and economics (Healey, 1995). Efforts that are deemed successful are those where institutional structures have been put in place the capacity to stabilize the conflicting dynamics, to identify the forces of global economic change, and to achieve some degree of coherence between economic, social and political relations.

In Egypt, decrees and regulations concerning the Environment exist (Law N. 4 of 1994 for the Protection of The Environment amended by Law 9/2009); the problem is the inefficiency in implementing the law, as legislative and administrative systems are impotent. Each of the Development Plans in Alexandria must be subject to independent specialists and planners, as well as public examination, to determine the Plans' reliability. If found to be sound and feasible, the contents of the Development Plan could complement the detailed master and established principles in demonstrating how best practice for the development and management of green and blue infrastructure can be applied on the ground.

6.3 SOCIAL SUSTAINABILITY: EMPOWERMENT OF LOCAL COMMUNITIES

As stated earlier, to develop a planning document reflecting Green Urbanism, precepts, analysis and synthesis across economic, social and environmental spheres are required. By installing a culture in which sustainability is not an option but an essential part of development, adverse impacts of negative attitudes and unsustainable lifestyle will be minimized. The sooner the cities develop alternatives to their reliance on nonrenewable resources, the sooner those cities will have a competitive advantage over cities that do not offer alternatives (Williams, 2007). Educating the public in water efficiency and raising awareness of the community on the value of waste to encourage reuse, recycling and source segregation is of utmost importance. This is why concerted efforts must be made to install an education renewal in schools and universities to stress that irreversible misconducts are stealing the environmental capital of future generations.

According to the Egyptian Building code n. 119 of 2008, civil society is granted statutory rights to participate and be engaged in decisions related to Strategic Planning Schemes. This law empowers civil society to participate more vigorously as partners in the decision making process. Therefore, priority must be given to heightening the public's awareness so they can take a greater share of responsibility in the conscious management of their environment.

7. Synthesis and Conclusions

Different local issues in Alexandria have demonstrated the intricately intertwined nature of urban physical planning and environmental management. Projects for redressing the actual environmental degradation (such as the waterscapes of Lake Mariout and Mahmoudieh Canal, solid waste management, and others) have been initiated repeatedly and numerous research initiatives have been carried out but lack of coordination, follow up and monitoring have led to stagnation. It is clear that in Egypt, serious hindrance to progress is due to many socio-economic and political actors, the most salient is the lack of political will to initiate dynamics to implement strategies and pilot projects. The inefficiency of local authorities to enforce the laws concerned with the construction industry and the respect of environment has led to a highly critical situation. Overcoming this governmental and institutional inertia is a decisive priority for any reform. Means of improving governance and building capacities of governmental settings and institutional structures must be developed, focusing especially on inter-administrative relations and multilevel governance.

Architects and planners are aware that to realize high ideals, the success depends upon realities and the conditions of implementation. So the precepts of urban sustainable development are materialized by way of systems and tools, operating on various scales. The French experience has shown that the power relations are played out on several territorial scales (housing, district, city and region), where transversal links are relying on interdependencies of action perimeters. Detailed plans were developed to borrow from the registers of nature, transport, housing and quality of life. Within the decentralization policies, the strengthening of the municipalities regarding responsibilities and possibilities of action has been made possible by reliable legal and administrative tools to initiate appropriate measures for sustainable development. A common sense conclusion can be drawn; if key resources are managed sparingly, environmental resilience will be maximized and adaptability to climate change and to the changes generated by extensive new built developments will be possible. Land and water contamination are now almost universally acknowledged to be key social, economic, and political issues and the central focus must be to craft and implement public policy to deal with these issues. Alexandria and all Egyptian large cities need think tanks (similar to the Information and Decision Support Center IDSC affiliated with the Egyptian Cabinet) not only to build local databases but also to support relations with different governmental authorities, local communities, the private sector and NGOs. As stated earlier, suitable participatory channels for urban actors must be created to articulate the three element of sustainable development: environmental, economic and social aspects. The renewal of derelict inner city areas is a complex process, embedded in the whole city's context. However, sound place-based knowledge can enable the development of projects well adapted to current new realities and mounting challenges. Finding the financial resources for renewal will not be so critical if cost recovery of projects is based on well-grounded empirical analysis studies. The World Bank, The European Union, Japan and agencies such as the USAID (United States Agency for International Development) and the AFD (French Development Agency) have contributed to numerous development projects and programs and can finance even more initiatives if the synergy of concerted efforts is built.

The current overall approach opens the architectural fields to other disciplines, calling upon new specialties and expertise. As a result, the alliances between different technological fields will be transformed and architects and planners will take a much more comprehensive overview of the whole construction process, to go beyond the design and building phases, to management, demolition and even the recycling of a building. Today's environmental crisis in Egypt demonstrates the magnitude of the work that needs to be done. A stance needs to be taken between the option of applying insufficient corrective measures and the radical transformation of lifestyle by the creation of greener urban models.

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PAPER 24

A Sustainability Assessment Framework for Waterfront Communities: Increasing the Resilience of the Abu Qir Waterfront Community in Alexandria

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Abstract: It is predicted that the global phenomena of climate change will have far reaching effects and implications on different local urban systems. For instance, average global sea levels are expected to rise between 7 and 36 cm by the 2050s and between 9 and 69 cm by the 2080s. Waterfront communities are the first to be affected by such impacts, putting them at high risk. Planning tools are needed to assist these communities and to increase their adaptive and learning capacities in the face of diverse challenges to their urban sub-systems. This research paper investigates a number of sustainability frameworks and assessment rating systems for buildings, neighbourhoods and communities. It investigates sustainable evaluation criteria specified within three difference assessment rating systems: LEED (Leadership in Energy and Environmental Design, USA), BREEAM (Building Research Establishment Environmental Assessment Method, UK), and Pearl (Estidama PEARL rating system, UAE). Examples of waterfront communities that have applied these rating systems are analysed to determine the applicability and relevance of these systems to waterfront communities in particular. The paper concludes with a proposed framework of indicators for waterfront communities. Similarities and differences among the three noted rating systems, with a particular focus on indicators that pertain to waterfront planning, contributed to the selection of indicators encompassed within the proposed assessment framework. The proposed framework could be an effective tool for the planning and development of a waterfront community in the MENA region. In order to validate the framework, a set of environmental and physical indicators was applied to the case study of the Abu Qir waterfront, Alexandria, Egypt. Conclusions and recommendations that would enhance the resilience of this waterfront community and provide a comprehensive tool for its sustainable planning are provided.

Keywords: waterfront communities, sustainability, rating systems, assessment framework.

1. Introduction

Waterfront regeneration is becoming one of the most celebrated practices of urban renewal in contemporary cities of the North. At the same time, developing regions have suffered prolonged inattention with respect to this practice, which led to a notable gap between the two (Giovinazzi and Moretti, 2010). Urban waterfronts throughout the world have experienced a series of threats related to environmental, social and economic impacts. Some of these impacts include land use changes; large areas of derelict land; lack of services and affordable housing for communities; contaminated air, water and soil; and lack of connectivity and efficient transport. With increasing climate change impacts, cities are faced with environmental conditions that threaten urban systems, coupled with pressures to accommodate rapid growth and development. Planning for long-term growth and increased resilience of urban areas in a manner that addresses the extent of crucial economic, environmental and social conditions arising from resource use and the generation of wastes and pollution is an important endeavour; even more so for developing countries with surging population growth. This paper addresses this challenge by providing a framework of indicators to assess the environmental and physical aspects of waterfront communities.

Following the introduction, this paper explores agreed upon principles for the sustainability of waterfront areas. Three rating systems designed for urban communities are presented, with indicators organised according to common categories, in a manner that critically assesses the importance placed on each theme. International examples of the use of rating systems and any appendages are made. The framework is then applied to the case study area of Abu Quir to reveal priority themes according to inputs from the field survey and interviews conducted, in order to facilitate the sustainable planning of this waterfront community. Lessons learned are outlined in the final section of the paper, with concluding remarks that can benefit other MENA coastal areas.

2. Principles of Sustainable Waterfronts

In the context of the initiatives for the Global Conference on The Urban Future (Urban 21) held in Berlin in July 2000 (Hall and Pfeiffer, 2000) and in the course of the EXPO 2000 World Exhibition (Giovinazzi and Giovinazzi, 2008), 10 Principles for Sustainable Development of Urban Waterfront Areas were approved. These principles are shown in Table 1.

Table 1: Principles of Sustainable Waterfronts

Principles of sustainable waterfronts:
1 - Secure the quality of water and the environment
2 - Waterfronts are part of the existing urban fabric
3 - The historic identity gives character
4 - Mixed use is a priority
5 - Public access is a prerequisite
6 - Public participation is an element of sustainability
7 - Planning in public private partnerships speeds the process
8 - Waterfronts are long term projects
9 - Waterfronts profit from international networking
10 - Re-vitalization is an ongoing process

The set of principles offers general international concepts of sustainability that can be applied to waterfronts, specifically by methods that respect nature and human needs to create a vital waterfront. However, an assessment tool is needed as an evaluative mechanism to measure the degree of sustainability. The following section will describe existing sustainability assessment rating systems; however, it must be noted that the rating systems apply to urban areas generally, and are not particular to waterfront communities. Section 3 will critically evaluate whether or not the assessment tools fully consider the above principles and hence examine their applicability to waterfronts. In addition, the rating systems are applied to examples of waterfront communities in section 4.

3. Sustainability Assessment Rating Systems

Sustainability has become an accepted meta-narrative, almost certain to be integrated into any future development scenario (Campbell, 1996). Many institutions and cities call for the application of sustainable development principles in planning and development. (WCED, 1987; IUCN, 1991; Bell and Morse, 2008). Various sustainability assessment rating and certification approaches have been developed to integrate sustainability in the design, construction, assessment and operation of building and community developments. These approaches include assessment techniques; indicators and guidelines; audits; footprint/impact studies; and ecological accounts (Munda, 2001; Rydin *et al.*, 2003, Tanguay *et al.* 2009). - all viewed as a means to translate a concept that is presumed to be agreed in principle into something workable on the ground (Owens and Cowell, 2002).

Sustainability assessment rating systems are important to promoting sustainable development, and have became popular worldwide. In some jurisdictions, sustainability assessment rating systems are a legislated mandatory requirement to meet or exceed the minimum requirements of sustainability within a particular framework. Examples of these rating systems include LEED (developed in the US and recognized internationally), BREEAM (European system), CASBEE (Japanese system), Green Star (Australian system), and Pearl (United Arab Emirates system).

3.1 RATING SYSTEMS UNDER STUDY

Three rating systems will be analysed in this paper. LEED and BREEAM were selected as they are the most commonly known rating systems and Pearl was selected as it is a rating system used in the Middle East, which is similar to the Egyptian context.

LEED (Leadership in Energy and Environmental Design)

LEED is a green building rating and certification system originally developed in 1998 by the U.S. Green Building Council (USGBC) to provide a recognized standard for the construction industry to assess the environmental sustainability of building designs. LEED for neighborhood development was later developed in 2007 and updated in 2009 (USGBC, 2009).

BREEAM

BREEAM (Building Research Establishment's Environmental Assessment Method) is an environmental assessment method that was launched in 1990 for buildings to set the standard for best practices in sustainable design. In 2002, BREEAM released and published a comprehensive framework for the early stages of development titled "*A sustainability checklist for developments: a common framework for developers and local authorities*". (BREEAM, 2009)

PEARL

The Pearl Rating System for Estidama (which means sustainability in Arabic) is the first government initiative released in the Middle East region by the Estidama program of the Abu Dhabi Urban Planning Council in 2010. The release includes rating systems for buildings, villas and neighborhoods. Its aim is to create more sustainable communities, cities and global enterprises and to balance the four pillars of Estidama: environmental, economic, cultural and social. Estidama itself is also part of Abu Dhabi's 20-year plan, known as Plan Abu Dhabi 2030, which attempts to redefine how a contemporary Arab city should look like to encourage sustainable growth (Abu Dhabi Urban Planning Council, 2010).

3.2 COMPARISON AMONG THE CATEGORIES OF THE 3 RATING SYSTEMS

After analyzing the 3 rating systems chosen for this study, it is observed that there is considerable overlap among the three systems. For example, they all include the same main categories shown in Table 2. Each rating system names the categories differently but the general topic areas of focus include community layout, buildings, transportation, water, energy, materials, waste, environment, and innovation. Each system has distinctive criteria and definitions under its categories. Similarities between the 3 rating systems were identified and the criteria for sustainability to be followed were organized to form a framework. Five categories resulted: communities, buildings, transportation, environmental issues, and innovation. This framework is used to assess the sustainability and resilience of waterfronts, to be applied in the case study of Abu Qir.

Table 2: The common indicators among Pearl, BREEAM, and LEED rating systems (after grouping categories under headings devised by the author).

Category		LEED Indicator		BREEAM Indicator		PEARL Indicator	
Community layout		Smart Location & Linkage	-Smart Location - Proximity to water & waste water infrastructure - Floodplain Avoidance - Brownfields Redevelopment - High Priority Brownfields Redevelopment - Site Design of Habitat /Wetland Conservation -Housing and Jobs Proximity -School Proximity - Conservation Management of Habitat or Wetlands --Open community - Compact Development - Diversity of Uses - Reduced Parking Footprint - Access to Surrounding Vicinity - Access to Public Spaces - Access to Active Spaces - Universal Accessibility - Community Outreach and Involvement	Community / Place Shaping	- Inclusive Communities - Community Consultation - Information / Ownership - Land Use Form of Development - Open Space - Inclusive Design - Mix of Use	Livable communities & Integrated Development	-Integrated Development Strategy - Sustainable Building Guidelines - Community-Dedicated-Infrastructure-Basic Commissioning - Life Cycle Costing - Plan 2030 - Urban Systems Assessment Provision of Amenities and Facilities - Outdoor Thermal Comfort Strategy - Neighborhood Connectivity - Open Space Network - Accessible Community Facilities - Community Walkability - Active Urban Environments - Travel Plan - Safe and Secure Community -Regionally Responsive Planning
Buildings		Green Construction & Technology	- Diversity of Housing Types - Affordable Rental Housing - Affordable For-Sale Housing -Construction Activity Pollution Prevention -LEED Certified Green Buildings - Energy Efficiency in Buildings - Reduced Water Use - Building Reuse and Adaptive Reuse -Reuse of Historic Buildings	Buildings	-Residential Buildings (CSH or EcoHomes) -Non-Domestic Buildings (BREEAM)	Livable communities	- Minimum Pearl Rated Buildings Within Communities -Housing Diversity
Transportation		Neighborhood pattern & Design	-Reduced Automobile Dependence -Walkable streets Street Network -Transit facilities -Transportation demand management	Transport	- Public Transport - Cycling Requirements - Car Parking -Traffic Management	Livablecommunit	- Transit Supportive Practices
Environmental Issues	Ecology	Green Construction & Technology	- Imperiled Species and Ecological Communities - Wetland and Water Body Conservation - Agricultural Land Conservation - Minimize Site Disturbance Through Site Design. Minimize Site Disturbance During Construction. - Contaminant Reduction in Brownfields Remediation - Heat Island Reduction - Solar Orientation	Ecology & Resources	- Ecological Survey - Biodiversity Action Plan - Native Flora - Wildlife Corridor - Pollution Issues - Land Remediation	Natural Systems	-Natural Systems Assessment -Natural Systems Protection -Natural Systems Design &Management Strategy -Reuse of Land -Remediation of Contaminated Land -Ecological Enhancement -Habitat Creation and Restoration Food Systems -Improved Outdoor Thermal Comfort -Construction Environmental Management
	Water	Green Construction & Technology	-Stormwater Management	Resources	- Water Resources Management -Flood Risk Issues -Water Consumption Management	Precious Water	-Community Water Strategy -Building Water Guidelines -Water Monitoring and Leak Detection -Community Water Use Reduction: Landscaping -Community Water Use Reduction: Heat Rejection -Community Water Use Reduction: Water Features -Storm water Management -Water Efficient Buildings
	Energy	Green Construction & Technology	- On-Site Energy Generation - On-Site Renewable Energy Sources - District Heating & Cooling -Infrastructure Energy Efficiency	Climate & Energy	-Passive Design Principles -Energy Consumption Management - Infrastructure	Resourceful Energy	-Community Energy Strategy -Building Energy Guidelines -Energy Monitoring and Reporting -Community Strategies for Passive Cooling -Urban Heat Reduction -Efficient Infrastructure: Lighting -Efficient Infrastructure: District Cooling -Efficient Infrastructure: -Smart Grid Technology -Renewable Energy: Onsite -Renewable Energy:Offsite -Energy EfficientBuildings
	Waste	Green Construction &	-Construction Waste Management -Comprehensive Waste Management	Resources	-Waste Management (Operation and Construction)	StewardingMater	- Basic Construction Waste Management - Basic Operational Waste Management - Improved Construction Waste Management - Improved Operational Waste Management - Organic Waste Management 2 - Hazardous Waste Management
	Materials	Green Constructi	- Recycled Content in Infrastructure	Resources	-Impact of Materials	Stewarding Materials	-CCA Treated Timber Elimination -Modular Pavement & Hardscape Cover -Regional Materials -Recycled Materials -Reused or Certified Timber
Innovation		Innovation	-Innovation and Exemplary Performance -LEED Accredited Professional	Business	-Business Investment -Employment -Business Facilities -Connectivity	Innovating Practice	-Showcase of Regional & Cultural Practices -Innovating Practice -Sustainability Awareness

3.3 COMPARISON AMONG THE WEIGHT OF EACH CATEGORY OF THE 3 RATING SYSTEMS

Table 3 shows the relative weight in each rating system according to five categories resulting from the previous analysis. The weight of each category is measured as a percentage of each system's total credit points.

Table 3: The relative weight in each rating system for the five main categories.

Applying 25% of the weighting | Applying 12.5% of the weighting | Applying 50% of the weighting | Applying 37.5% of the weighting

Categories		LEED	BREEAM	Pearl
Community layout		43.5%	31%	13%
Buildings		16%	4%	10%
Transportation		11.5%	22%	1%
Environmental Issues	Water	8.5%	6.5%	24%
	Energy	5.5%	10.5%	25%
	Materials	1%	3%	7%
	Waste	2%	3%	4.5%
	Ecology	6.5%	15%	14%
Innovation		5.5%	5%	2%

It is shown in Table 3 that each system gives different weights to each category as each region focuses mainly on one category more than the other according to the issues at stake and the region's policies or strategies towards sustainability. LEED's main focus is on community layout reflecting the United States' most common planning problems. BREEAM's main focus is on community layout and transportation. PEARL's main focus is on environmental issues specifically water and energy issues as the very hot weather and the scarce water resources are problems of main concern in the United Arab Emirates. Similarly, a new rating system for neighbourhoods has to be made for the Egyptian context as it is a different region with its own needs and characteristics. Moreover, waterfront neighbourhoods have specific issues reflected in the principles outlined in section 2. The following section will examine examples of waterfront communities which applied the three rating systems to deduce if any aspects had been added and how useful the indicators were.

4. Analytical Examples of Waterfront Communities Applying Sustainability Rating Systems

Three types of waterfront cities which apply the categories of the sustainability rating systems are studied and analyzed. The first example is Toronto, Canada, which applied the guidelines of LEED rating system to the West Don Lands waterfront community. The second is Greater Manchester, United Kingdom, which applied the guidelines of the BREEAM rating system to the MediaC-ityUK waterfront area. The third is Abu Dhabi, United Arab Emirates, which applied the guidelines of the PEARL rating system to the Mina Zayed waterfront community. The framework previously discussed will be used to compare these examples and their implementation of methods of sustainability. Examples from varying locales were chosen for the opportunity to study how different regions deal with their surrounding environments to achieve sustainability.

4.1 WEST DON LANDS, TORONTO, CANADA (TWDI, 2002)

The Toronto waterfront development has received the LEED gold certification for neighborhood development with a total of 61 points. Table 4 presents a summary of the application of LEED standards in the sustainable development of the West Don Lands waterfront community.

Table 4: Summary of Toronto's application of LEED.

Common Categories		Application (Toronto LEED achievement)
Community layout		• smart mixed use neighborhood design • HIGH % Parks & opens spaces connected to the waterfront • 90% within ¼ mile to transit stops, 50% within ½ mile to services, 99% within ½ mile to schools
Buildings		• 60 % LEED certified buildings -20% Affordable renting
Transportation		• Increased % multi modal transport, cycling, reduced car use
Environment	Water	• 15% reduction in water consumption due to Enwave project • New storm water collection system
	Energy	• 27% reduction in energy use • 30% energy supplied renewable sources Enwave deep water technology
	Materials	• Using recycled materials in infrastructure
	Waste	• Recycling 50% of construction waste - Waste diversion
	Ecology	• Preservation of the habitat near the water body by natural parks • Enwave technology reduces tones of CO2 emissions

4.2 MEDIACITYUK, GREATER MANCHESTER, UNITED KINGDOM (BRE GLOBAL, 2006; BREEAM COMMUNITIES, 2009)

MediaCityUK is the first scheme in the world to become a BREEAM approved sustainable community. The project achieved final certification and an 'Excellent' rating with a score of 76%. Table 5 summarizes the application of MediaCityUK waterfront to the BREEAM measures of performance for sustainable development.

Table 5: Summary of MediaCityUK's application of BREEAM.

Common Categories		Application (BREEAM achievement)
Community layout		• Mixed use compact development • Decreased % of industrial sites & increased % of commercial & residential to 96% • Radial planning centered towards waterfront • One Huge open space on the waterfront
Buildings		• 80% BREEAM certified buildings
Transportation		• Using canal in water transportation • Increased % of multi modal transport • Encouraging cycling through providing special lanes
Environment	Water	• Water resources management • Use of water from the canal to create a combined heat & power plant energy system (Tri Gen plant)
	Energy	• Tri Gen plant as a renewable source of energy
	Materials	• 80% of construction timber environmentally friendly
	Waste	• New waste management plan for waste collection and recycling • Production of fuel from waste & using it in a power plant on site
	Ecology	• Reduce air pollution by the tri gen plant & the increased use of public transport • Major Brownfield urban regeneration

4.3 MINA ZAYED COMMUNITY, ABU DHABI, UNITED ARAB EMIRATES (ABU DHABI URBAN PLANNING COUNCIL, 2010B)

The Mina Zayed community is a new mixed-use project developed by ALDAR Corporation on the waterfront of Abu Dhabi. Mina Zayed's ambition is to create an integrated and sustainable new waterfront community that affords a vibrant example for the future development of Abu Dhabi. Table 6 highlights its features in achieving Estidama.

The analysis of the three previous examples in their implementation of the different rating systems reveals that all the previous rating systems are concerned with the environmental factor of sustainability more than the social and economic factors, even though all three are main pillars of sustainable development (WCED, 1987). Another conclusion drawn is that all three systems, when dealing with a waterfront community, only include rating categories like waterfront (water body or wetland) conservation from a pollution or habitat extinction standpoint, which address environmental aspects but neglect ***integration with the waterfront*** and social and economic aspects (the other 2 pillars of sustainability). For example, the rating systems do not specify the percentage of open spaces which must be on the waterfront, the type of land use on the waterfront, or the percentage of recreational facilities which

Table 6: Summary of Abu Dhabi's application of Pearl.

Common Categories		Application (pearl achievement)
Community layout		• Mixed use compact development • 20% open spaces & parks on the waterfront • continuous shaded pedestrian routes that link the center to it's waterfront.
Buildings		• 99% PEARL certified buildings • Housing variety
Transportation		• Multiple transportation options and transit supportive practicesto reduce car use • Street management between car lanes, rails & walking lanes
Environment	Water	• Low water use landscape • Utilize biological water treatment systems with least energy consumption
	Energy	• District cooling strategy • Green roofs & compact development for shading & cooling
	Materials	• Use of local materials, reuse and recycle materials
	Waste	• waste management plan • recycle a large % of the demolition of industrial site
	Ecology	• Conserving the shoreline • Re-introducing nature on a formerindustrial site • High % of parks reinforce the natural systems and help in habitat creation

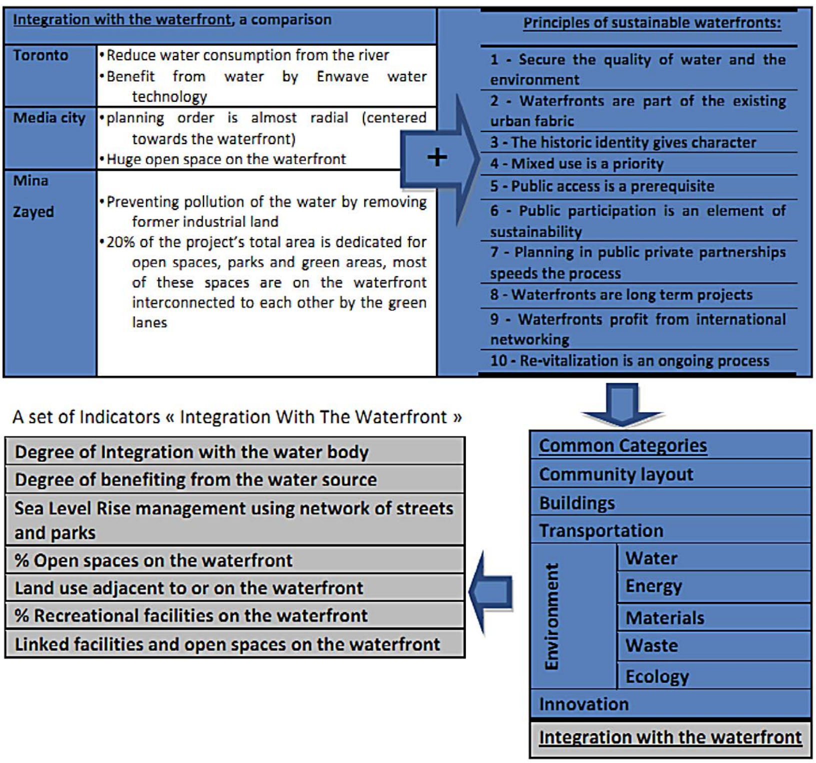

Figure 1: Addition of a sixth category 'Integration With The Waterfront' and its indicators to the rating system.

must be on the waterfront. These principles increase the social and physical interaction between people and the waterfront as well as the economic values of the principles described in section 2. Although these indicators were not required in the rating systems, the examples still succeeded in applying some of them to integrate the waterfront. This signifies the importance of integration in sustainable planning, so it must be considered under any rating system when dealing with a waterfront. Thus, when forming a rating system to implement for the case study at Abu Qir, environmental, social and economic aspects of sustainability should be included in addition to the existing five categories discussed above.

5. Analytical Review of Alexandria's waterfront (Abu Qir as a case study)

The analysis of Abu Qir includes a study of its physical, environmental and historical features. In the following subsections, the problems of the area are identified and organized in order of priority, under the five categories of the framework. This helped in determining the biggest problem which must be considered first and identifying which can be considered afterwards in the urban development of the area. The study was based on a document review of the future comprehensive planning for development strategy of Abu Qir, observations and interviews, site visits, and consultations with experts in urban planning, coastal planning & environmental design.

5.1 ABU QIR REVIEW

Alexandria city is the second largest city in Egypt in population and economic growth. Located on the Mediterranean Sea, its waterfront stretches 93.5 km from Abu Qir Bay on the east to Matrouh city on the west. Abu Qir (shown in Figure 2) is one of the communities within the Montazah District in Alexandria city; it consists of 60 km^2 out of the 81km^2 of the Montazah District (Alexandria Governorate, 1984). Abu Qir has a population of 200,000 and is subdivided into 3 neighborhoods: Abu Qir, Toson, and Mamoura Elbalad. Abu Qir one of the most important historical places in Egypt (Alexandria Comprehensive Plan 2017).

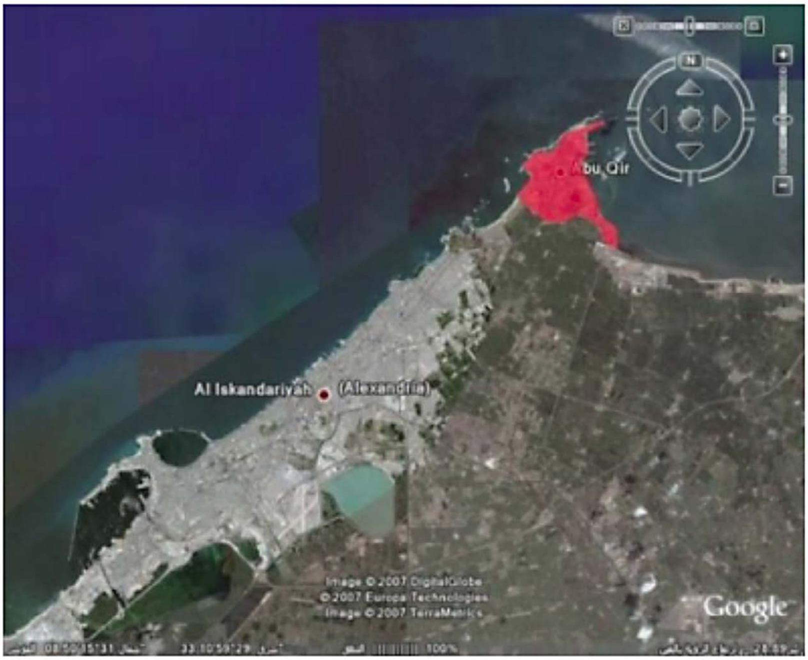

Figure 2: Location of Abu Qir (Source: Google Maps, accessed June 2011).

5.2 CATALYSTS FOR REPLANNING

1. It holds a strategic location as the eastern gate to Alexandria.
2. It contains many catalysts for development: waterfront, brownfields, unplanned open spaces, historical sites and sunken treasures (Goddio, 2007; Encyclopaedia of the Orient, May 2011)
3. The presence of three important historical fortresses – El Sabaa, Tawfeekeya and El Raml fortresses – could form an important historical tour in Alexandria as they represent an important era in the history of Egypt, but they are strongly in need of rehabilitation.
4. Abu Qir Bay (Dead Sea area) is considered a fertile marine habitat when compared to other Egyptian Mediterranean coastal waters (ASRT, 1984; Hamouda & Abdelsalam, 2010).
5. Abu Qir Bay can be used for a variety of purposes: commercial and recreational fishing, shipping, recreational boating, yachting, swimming and diving to explore sunken monuments.
6. Abu Qir's well-known warm temperature and warm seawater facilitate the development of many recreational beaches and touristic facilities on the waterfront, which would contribute to the economic development of the area.

5.3 SITE ANALYSIS

It is observed from reviewing the master plan and the land use, accessibility and building conditions analysis that martial sites occupy a large area of the waterfront, which act as a barrier between central Abu Qir and the waterfront. This leaves scattered groups of buildings in the center of the region. Another barrier is the train line separating west Abu Qir from east Abu Qir.

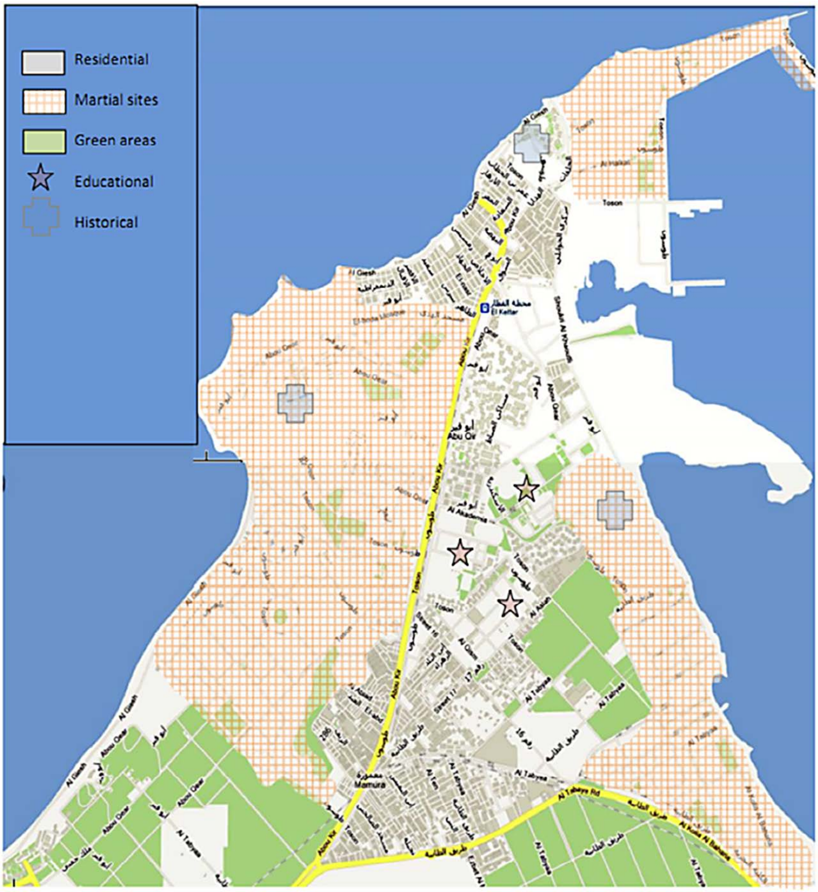

Figure 3: Map showing the Master plan, street layout in Abu Qir (Source: the author).

5.4 SITE PROBLEMS

Analysis of the context of Abu Qir; its natural, historical, economic and touristic features; and its land use, accessibility and building conditions identified the following problem themes.

Problems Related to Community Layout & Integration with the Waterfront

1. Abu Qir is not well integrated to its waterfront due to:
   a) the absence of pedestrian access routes leading to the waterfront (the current routes are limited to either very narrow streets between slums in the residential areas on the waterfront or inaccessible streets within military sites on the waterfront);
   b) inefficient street access with only one main street serving as the entrance to Abu Qir and Toson beyond the Mamoura neighborhood (Gabr, 2009);
   c) the absence of connected open spaces on the waterfront;
   d) the absence of well-developed attractive beaches or recreational facilities on the waterfront;
   e) the absence of usable (open) marinas, which prevents access to the area by water transport; and
   f) the presence of several military sites in restricted zones on the waterfront, which cut the route between downtown Abu Qir and the waterfront.
2. Abu Qir consists of large areas with solely residential or industrial use or restricted military sites with no mixed land use. (see Figure 4)
3. There are unplanned areas and many scattered slums.
4. There are a lot of agricultural or empty lands separating the Abu Qir urban zone from the rest of Alexandria.
5. The calculations of population density in Abu Qir community made by Alexandria governorate have proven that there is a continuous growth in population density in Abu Qir without a balance in working opportunities, facilities, housing and infrastructure (Alexandria comprehensive plan for 2017, 1997).

Figure 4: Large areas within Abu Qir with single or restricted use. *(a) Presence of a lot of high illegal buildings on the waterfront. (b) Presence of martial sites in separated zones.*

Problems Related to Transportation

1. Growth in population with insufficient public transportation leads to increased dependence on private cars and buses.
2. Traffic congestion caused by high dependence on cars.
3. Traffic problems due to unplanned intersections with different directions.
4. Inadequate train transportation serving the site as the Abu Qir train station is the only means of transportation for most workers employed in Abu Qir commuting from afar. The station is not maintained and the trains and train lines are too old, dirty and do not operate with full power (Gabr, 2009).
5. Train lines occupy a large percentage of the street width, exacerbating traffic congestion. They also form a physical barrier between west and east Abu Qir as they are closed with a high wall barrier.

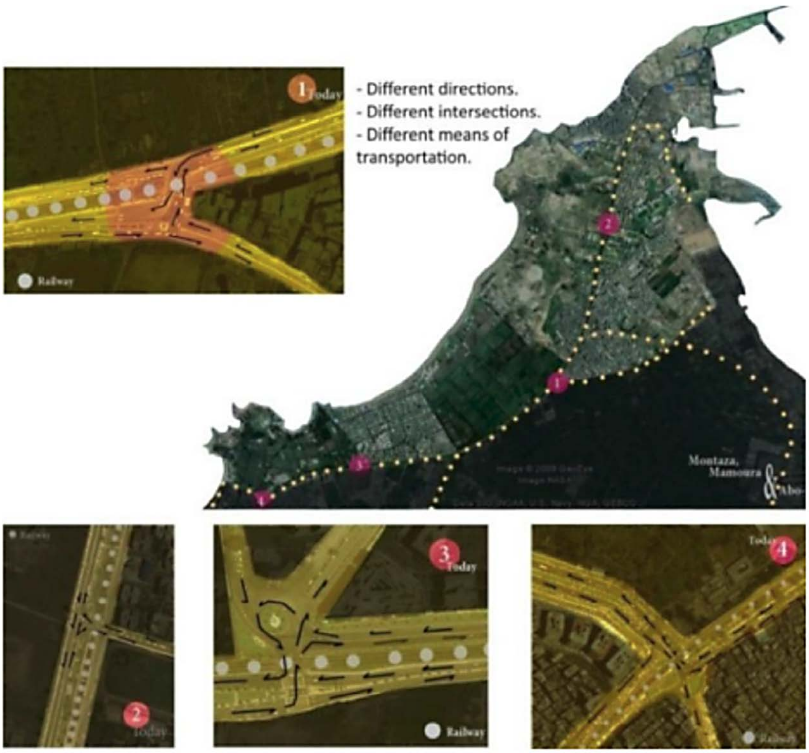

Figure 5: Traffic Problems in Abu Qir (Source: the author).

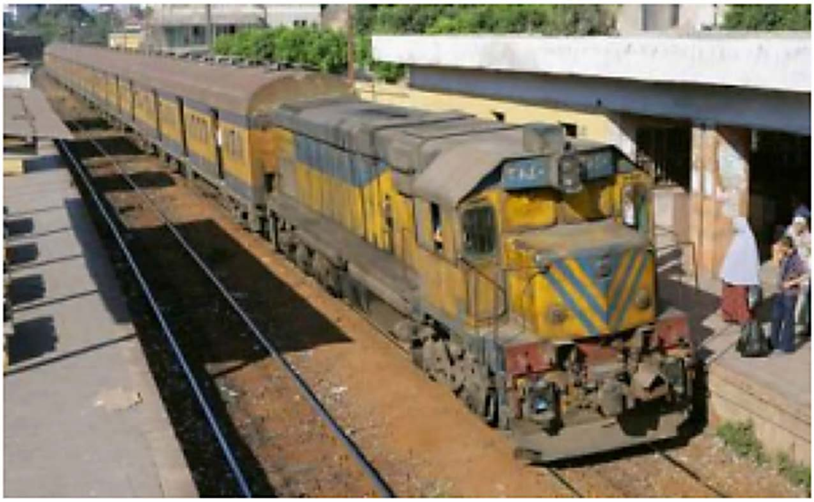

Figure 6: The problems of transport in Abu Qir (Source: the author).

Problems Related to Buildings

1. There are illegal high-rise buildings on the waterfront of Abu Qir (Alexandria governorate, 1997).
2. The presence of slums in scattered areas, deteriorated buildings and very narrow streets prevent the establishment of efficient infrastructure (waste, water supply, electricity).
3. Illegal and rushed construction in many areas, including the sea shore, leads to the sloping and collapse of buildings. They also lead to the creation of unplanned streets and narrow corridors.
4. The illegal buildings do not consider the architectural character of the area.

Figure 7: The problems of buildings in Abu Qir
(Source: http://www.flickr.com/photos/david_vilder).

Problems Related to Waste

1. There are many areas with no access to drainage pipes leading to draining in wells.
2. These wells cannot be reached by maintenance cars because of the very narrow streets so blockage of these wells result.
3. Abu Qir Bay is polluted by discharge of untreated sewage and industrial wastes from different sources. For example, El-Tabia pumping station discharges polluted industrial waste from food processing and canning, paper industry, fertilizers industry and textiles manufacturing sources; the outlet of Idku Lake contains agricultural drainage water containing pesticides; and the Rosetta mouth of the Nile River has discharged water carrying agricultural waste from cultivated lands (Nasr *et al.*, 2003).
4. There is no waste collection service, which leads to accumulation of waste in front of buildings.

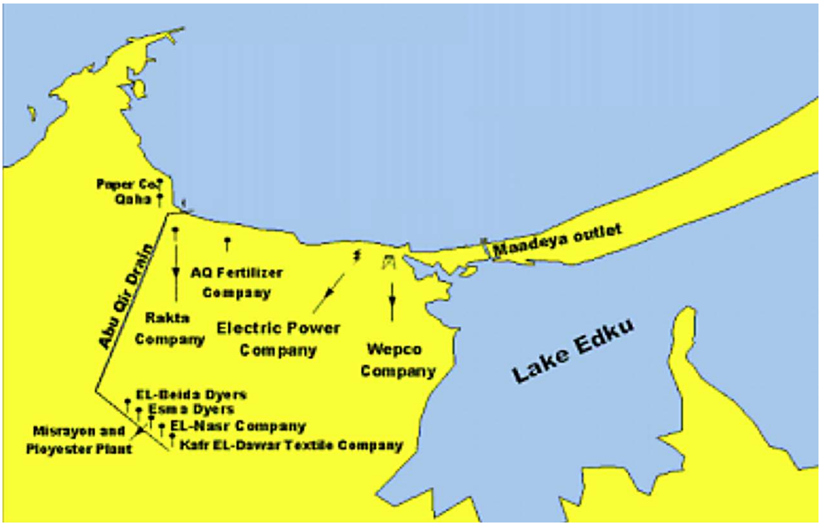

Figure 8: The study area where the arrows indicate the sources of pollution along Abu Qir Bay (Source: the author).

Figure 9: The problems of waste in Abu Qir (Source: http://www.flickr.com/photos/david_vilder).

Problems Related to Water

1. Inefficient water supply infrastructure leads to the blockage of streets during rainy days (Alexandria governorate comprehensive plan for 2017)
2. The lack of water supply in many areas (slums) leads to illegal connections carried out by many citizens.

Problems Related to Environment

1. There is air pollution from several industrial factories in Abu Qir (Kamel, 2002).
2. There is water pollution in the eastern Abu Qir Bay (Dead sea) from ships and marine wastes (Gabr, 2009).
3. The issue of climate change is being taken seriously by the Egyptian authorities. Low lying land in the Nile delta region is considered especially at risk from the effects of any sea level rise resulting from global warming. In particular, the cities of Alexandria, Rosetta and Port Said, which are major industrial and economic centres, are expected to experience serious environmental impacts if no action is taken (El-Raey, 2009). Therefore, Abu Qir represents a large area of the coast of Alexandria that is considered to be at high risk of submerging.

Problems Related to Energy

1. The absence of any means of energy saving in buildings or in the community as a whole due to all the previous problems.
2. Although Abu Qir (and Alexandria as a whole) is one of the sunniest places in the world, there has been no effort to benefit from the sun as a renewable source of energy.

5.5 DEFINING PRIORITIES

It is concluded from the site analysis, a document review of the future comprehensive planning for development strategy of Abu Qir (Consultant Body For the follow up of Alexandria comprehensive planning, Futuristic planning of Abu Qir, 2003; Alexandria Governorate, 2017), site visits and interviews, and consultations with experts in urban planning, coastal planning & environmental design that most of the problems present in Abu Qir are related to community planning and integration with the waterfront. The remainder of the problems of transportation, buildings and environment are all due to the unplanned nature of Abu Qir and can be solved if community planning and integration with the waterfront are put in place. Therefore, community layout and integration with the waterfront should have the highest priority (as shown in Figure 10) when considering the development. Transportation is the secondary issue which should be solved as Abu Qir is full of workplaces and important facilities that require easy access. The next issue of importance is buildings; the field study showed that building conditions, heights and building utilities are the main concerns. Last is the environment category; the goal is to accomplish higher levels of sustainability.

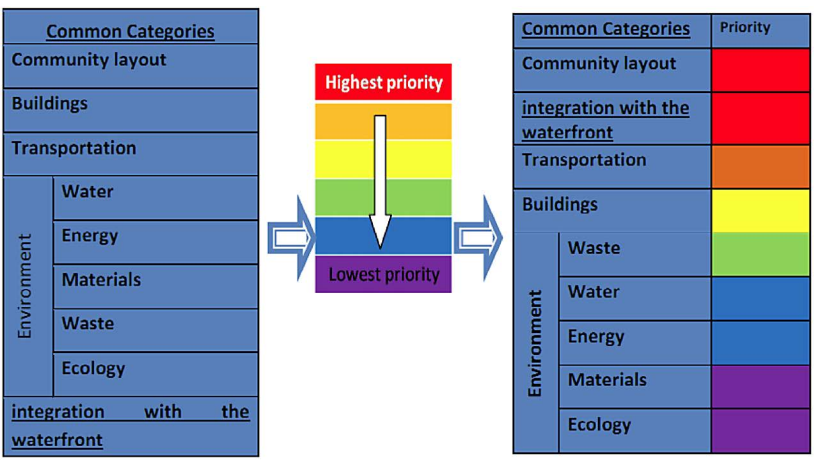

Figure 10: Defining priorities from problems of the case analysis

5.6 IMPLEMENTATIONS OF SUSTAINABILITY GUIDELINES IN THE DEVELOPMENT OF ABU QIR

Sustainable urban planning of the Abu Qir community needs to consider all of the previous categories due to the problems discussed above in order of priority. The solutions should be sustainable in environmental, social and economic terms. The three rating systems analysed in section 3 each contain indicators that assess sustainability. Table 7 lists indicators relevant to the issues concerning Abu Qir, as well as indicators specific to waterfront development (from Figure 1). This forms a checklist of criteria as recommendations for the replanning of Abu Qir.

Table 7: The Checklist of criteria produced for sustainable replanning of Abu Qir.

Category		Indicator	
Community layout		Open community	
		Compact development	
		Diversity of uses	
		Street network	
		Access to public spaces	
		Universal accessibility	
		Community outreach & involvement	
Integration with the waterfront		Degree of Integration with the water body	
		Degree of benefiting from the water source	
		Open spaces on the waterfront	
		Land use adjacent to or on the waterfront	
		Recreational facilities on the waterfront	
		Linked facilities and open spaces on the waterfront	
Transport		Public transport	
		Reduced automobile dependence	
		Bicycle network	
		Transportation demand management	
		Transit facilities	
		Street network	
		Walkable streets	
		Reduced parking footprint	
		Traffic management	
Buildings		Energy efficient buildings	
		Construction pollution prevention	
		Reuse of historic buildings	
		Building reuse & adaptive reuse	
		Housing & jobs proximity	
		Diversity of housing types	
		Affordable housing	
Environment	Waste	Waste management	
		Proximity to waste water infrastructure	
		Construction waste management	
	Water	Water resources management	
		Water consumption management	
		Community water strategy	
		Wet land & water body conservation	
		Building water guidelines	
		Water monitoring & leak detection	
		Community water use reduction	Landscaping
			Heat rejection
			Water features
		Storm water management	
		Water efficient buildings	
		Proximity to water infrastructure	
	Energy	Energy consumption management	
		Community energy strategy	
		Building energy guidelines	
		Energy monitoring & reporting	
		Community strategies for passive cooling	
		Urban heat reduction	
		Renewable energy	Onsite
			Offsite
		Energy efficient buildings	
		Infrastructure energy efficiency	
	Materials	Local materials	
		Recycled materials	
	Ecology	Biodiversity	
		Conservation management of habitat & wetland	
		Natural systems protection	
		Reuse of land	
		Remediation of contaminated land	
		Habitat creation & restoration	
		Local food production	
		Minimize site disturbance through site design	
		Minimize site disturbance during construction	
		Heat island reduction	
		Solar orientation	
		Reduce air pollution	

Therefore, the rating system developed specifically to evaluate and upgrade Abu Qir as a waterfront community aims to:

- look to address priorities first (biggest problems are the first to be solved);
- try always to create connections between waterfront and inner city districts;
- benefit from the water source either physically or environmentally;
- leverage water as means of transportation to reduce city traffic & improve the quality of the urban environment;
- develop land use and expands public access to the waterfront by linking open spaces and recreational facilities to increase social and economic income;
- enliven the waterfront with attractive uses, high-quality public spaces, and publicly oriented water-dependent uses that are integrated with adjacent communities; and
- maintain and improves the environmental quality of water bodies, land and air.

6. Conclusions

Waterfront sustainable development is now an obligation for all waterfront cities. Since waterfront planning differ from one place to another based on each region's needs and problems, a unique rating system must have its own weighted set of sustainability indicators. Sustainable strategies worldwide all call for the same principles but are subject to different obligations, rules and regulations depending on its locale. The Egyptian region, the waterfront in particular, needs its own rating system to pursue strategies to improve the sustainability of its waterfront and increase its resilience to climate change and projected sea -level rise.

Economic interests must be balanced with environmental and social concerns. However, waterfront work is not just about economic development, environment issues, or a design exercise. Rather it is a fusion of these and related disciplines like Balance-People-Recreation-Public access-Open space-Safety-Suitable and diverse living-Mix of uses- Environment- Transport, which are all principles of sustainability.

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PAPER 25

Drivers and Barriers facing adoption of Green Supply Chain Management in the Egyptian Food and Beverage Industry

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Abstract: Green Supply Chain Management (GSCM) has become an initial key factor for corporate sustainability. Many researchers have investigated its practices, adoption drivers and barriers globally. Cost reduction, brand image development and gaining a competitive advantage were the main drivers which encouraged corporations to adopt GSCM practices. On the other hand, lack of resources, suppliers' resistance to change and lack of awareness were found to be the main concerns behind adopting GSCM practices. Unfortunately, in spite of the importance of GSCM, there is a paucity of research which investigated the drivers and barriers facing GSCM practices adoption in Egyptian industrial sectors. This paper intends to identify such drivers and barriers for the Egyptian Food and Beverage Industry (EFBI). Undertaking a qualitative approach, 16 EFBI companies represented by 31 participants were studied via a questionnaire and a focus group. This paper relies on descriptive analysis to conclude its results. Analysis of the questionnaire was based on company size and local versus international orientation. The results indicate that organization values are the main driver for adopting GSCM practices in EFBI, while the lack of resources and governmental support are the main barriers. This research sets primary road signs for corporations seeking to adopt and researchers looking to investigate GSCM practices in the Egyptian Food and Beverage Industry.

Keywords: Drivers and barriers, sustainability, Green Supply Chain Management, Food and Beverage Industry, Egypt

1. Introduction

The concept of production optimization by obtaining the greatest value for the best possible reduced cost has been a common business framework over the last two decades. Yet, the future is focusing on Sustainable Supply Chain Management (SSCM) (Linton *et al.*, 2007). Interactions between sustainability and supply chain management is the framework of the future. Optimization of environmental factors has become important for each step of the supply chain: production, consumption, customer service and post-disposal disposition of the product (Linton *et al.*, 2007).

The concept of sustainability first appeared in the 1970s, but actually flourished in 1987 when The World Commission on Environment and Development (WCED) released the Brundtland Report titled 'Our Common Future' in Oxford, United Kingdom. It defines sustainable development as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs".

This paper undertakes the viewpoint of sustainability as it was introduced by Elkington (1998), who perceived the three main dimensions of sustainability as the three bottom lines of the 21st century. Elkington (1998) defined sustainability as the intersection among these three dimensions - social, environmental and economic performance.

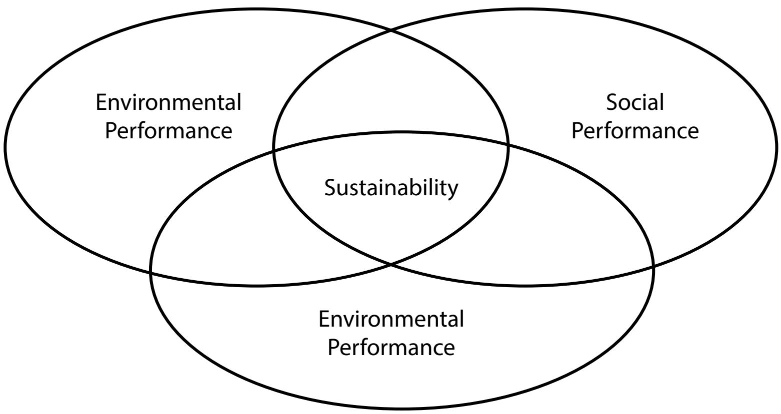

Figure 1: "Sustainability" (Source: Carter et al., 2008).

From Figure 1, it could be noticed that creating Sustainable Supply Chain Management (SSCM) calls for the integration of all three spheres.

This research is mainly related to the "Environmental Performance" sphere of SSCM, taking into consideration the other essential dimensions of SSCM. Environmental Supply Chain Management (ESCM), or referred to previously in many research papers as Green Supply Chain Management (GSCM) (Olugu *et al.*, 2011), is defined as "the set of supply chain management policies held, actions taken, and relationships formed in response to concerns related to the natural environment with regard to the environment the design, acquisition, production, distribution, use, reuse and disposal of the firm's goods and services" (Zsidisin & Siferd, 2001). On the other hand, managers need to know the economic payback of adopting such policies, aside from the environmental aspects.

In a developing country such as Egypt, the attention is mainly focused on cost reduction. Seldom, if any, is consideration given to the environmental impacts of business operations, including GSCM practices. This lack of awareness explains the gap in the literature concerning the application of

GSCM in Egypt. Our main contribution is to identify the major drivers and barriers facing GSCM practices adoption in The Egyptian Food and Beverage Industry (EFBI) and disclose their effect on such adoption.

Research was conducted using two main sources of data. First, primary sources consisted of a focus group and a survey, to build the core part of the research in order to enhance the practical vision of the study. Second, secondary sources will consist of findings and conclusions collected from the literature review. The importance of such data is to build the complementary part of the study for the focus group results and findings. The methodology mainly will be based on qualitative data.

Survey responses were collected from representatives of the public and private EFBI sectors. ISO 14001 certified companies, companies which apply SCM concept, as well as franchised global companies in Egypt were our target samples as it was necessary to study the application of GSCM in Egypt from different perspectives. The survey results and findings will be categorized into three parts for analysis from different standpoints within the scope of EFBI and the chosen focus group. These categories will include: general perspective of the research; company size perspectives, which considers the number of employees as a proxy for company size; and the perspective of local versus international companies.

2. Literature Review

Due to the relative novelty of GSCM, this area of research has only recently been penetrated by researchers. Thus, literature regarding drivers and barriers facing the adaption of GSCM practices in developing countries is extremely limited. In this literature review, the global perspective on GSCM drivers and barriers will be recognized through previous research papers, books and governmental reports from China, Germany, United States of America, Turkey, Italy, South Korea, Kenya, Japan, New Zealand and Sweden.

2.1 GSCM DRIVERS

Zhu *et al.* (2004) found that there are some main drivers behind applying GSCM in Chinese manufacturing industry, such as straightforward cost reduction to facilitate the development of co-operative relationships with suppliers and encouraging life-cycle. On the other hand, despite increasing environmental awareness, the implementation of GSCM across enterprises is slow and it is confirmed through the study that converting the awareness and pressures into practices and performance will take some time in the Chinese manufacturing industry.

Zhu and Sarkis (2006) investigated the occurrence of thirteen pressures and drivers for the automobile industry and other industries in China. The results indicated that pressures and drivers for the automobile industry in China are the greatest among the industries studied. Regulatory compliance was indicated as one of the main pressures on the Chinese automobile industry due to China's entry to the WTO (World Trade Organization). The results also demonstrated that the automobile industry in China has a good opportunity to gain a competitive advantage and be an environmentally aware industry, which is in itself a driver to green its automobile supply chain.

Testa and Irlado (2010) proved that there is a positive relationship between GSCM practices adoption and the desire to enhance an organization's reputation and brand image. A sample of 4188 facility managers was investigated in seven OECD (Organization for Economic Co-operation and Development) countries. Of the four drivers tested – reputation, efficiency (i.e. cost reduction), innovation, and "follower" strategy (i.e. adoption only after another firm has tested and reaped benefit from applying GSCM practices) – the study confirmed all except the efficiency-led approach as drivers of adopting green practices.

Using Interpretive Structure Modeling (ISM) in an Indian case study, Diabat and Govindan (2011) investigated eleven drivers GSCM practices implementation. Top drivers mentioned in the research were green design, integrated quality environmental management into the planning and operation process, energy consumption reduction, and the reuse and recycle of materials and packaging.

Large and Thomsen (2011) suggested that the degree of green supplier assessment and the level of green collaboration exert direct influence on environmental performance. Whereas the firm' commitment influences green assessment directly, the impact of commitment on green collaboration is mediated by the capabilities of the purchasing department. These results were based on 725 questionnaires sent to German managers in the field of purchasing and supply and analyzed using SEM (Structural Equation Modeling).

Unlike previous research, Andic *et al.* (2012) mentioned new drivers for GSCM practices adoption in Turkey. The research considered social responsibilities and commercial prestige as two of the main GSCM drivers in the country in addition to economic advantages such as economy of production, increased competitiveness and increased profit. Andic *et al.* (2012) added that, in general, environmental activities support organization by developing innovative technology and increasing negotiation power with potential customers.

2.2 GSCM BARRIERS

In 2011, Luthra *et al.* aimed to develop a structural model of the barriers to GSCM implementation in the Indian automobile industry. With the help of MICMAC analysis, the drivers were categorised based on their dependence and driving power. Market competition and uncertainty, lack of green practice implementation, cost implications and customers' unawareness of the benefits of green products have been identified as top level barriers. The lack of government support systems was identified as the most important bottom level barrier.

Sarkis (2012) provided a very unique identification of GSCM by considering its boundaries and flows. Sarkis identified GSCM boundaries from nine different perspectives which added unique value to the research. The nine boundaries are: organizational, proximal, informational, political, temporal, legal, cultural, economic and technological. These boundaries were analyzed at different levels ranging from individual (sub-micro) to global cross-industry supply chain (supra-macro) boundaries.

Recently, Abbasi and Nilsson (2012) identified challenges facing sustainable supply chain in Sweden and they included costs, complexity, operational, mindset and culture changes and uncertainties as the main barriers. The lack of governmental regulation is one of major barriers facing GSCM practices in many industries (Walker *et al.*, 2008; Lee, 2008).

2.3 GSCM DRIVERS AND BARRIERS

In order to explore what will drive Hong Kong SMEs (small and medium-sized enterprises) to adopt GSCM environmental practices, Studer *et al.* (2006) initiated research to investigate incentives and barriers to adopting voluntary green practices by local SMEs. More than 392 SMEs in Hong Kong were investigated through a survey. Studer *et al.* found that legislation and stakeholders' demands are the two main drivers for SMEs to adopt environmental practices in Hong Kong. If not for these drivers, SMEs in Hong Kong would rarely adopt green practices. On the flip side, the general lack of interest in environmental issues and how green processes could add value was the most significant barrier. Without any obligations set by stakeholders, customers, regulators, or legislators, SMEs are not willing to consider environmental initiatives. The underlying reason may the lack of an organizational role to lead such initiatives and undertake them as best practices.

Rao and Holt (2005) indicated that GSCM practices adoption might lead to gaining competitive advantages. The research paper gained excessive popularity due to its originality and value in being the first to empirically test the link between GSCM practices adoption, increased competitiveness and improved performance. Despite the small sample size taken from South-East Asian countries, the research was considered valid due to the core value of its empirical evaluation. Using SEM, results indicated that GSCM practices adoption lead to increasing competitiveness and boosting economic performance. Rao and Holt (2005) also identified barriers facing GSCM practices adoption such as green purchasing application. These barriers include but are not limited to the high cost of environmental programs; for example, uneconomical reusing and recycling. There are additional elements that should be considered, such as the lack of management commitment and lack of suppliers' awareness.

Through interviews with seven public and private organizations in the United Kingdom, Walker *et al.* (2008) identified drivers encouraging the adoption of environmental practices and categorized them into six categories. They included, cost reduction, organizational values, pressure from customers and regulatory compliance. Walker *et al.* (2008) also investigated internal and external barriers to GSCM adoption. Internal barriers included costs, lack of resources, and the lack of legitimacy of environmental supply issues. Exposing poor environmental performance, lack of information, poor competition, procurement legislation and supplier's reluctance to change were considered as external barriers.

Other than a reference to the work done by Rao and Holt (2005) in linking economic performance to GSCM, Hoskin (2011) also mentioned in his research that adopting green practices leads to satisfying customer demands. His paper highlighted pressure by large enterprises on the supply chain, since they are customers to many upstream SMEs, as a major driver. Pressure from the end-consumer on large enterprises cannot be addressed without the engagement of upstream SMEs in green practices. Hoskin (2011) also identified government legislation as a significant external driver for New Zealand organizations. On the flip side, a major barrier which might hinder institutions from applying GSCM practices is cost. Hoskin (2011) also added that lack of resources is a major barrier to environmental improvement for New Zealand SMEs. They require some sort of governmental support. Governmental support and incentives do not have to be financial in nature; they may take other forms such as technical advice, information and training programs.

3. Research Methodology

As mentioned above, the paper's main goal is to identify drivers and barriers facing GSCM practices adoption in EFBI. The research is designed to furnish an opportunity for future researchers to gain market familiarity with the drivers and barriers of adopting GSCM practices in EFBI based on realistic results and findings that are supported by a sound technique. The group of factors (drivers and barriers) under study have been previously investigated and proven to be directly related to the application of GSCM practices globally in different industrial and service sectors (Walker *et al.*, 2008).

3.1 QUALITATIVE APPROACH

Previous research regarding drivers and barriers to GSCM practices adoption uses different approaches based on their differences in research questions. This paper undertakes a qualitative methodology using a survey to achieve its goals. The nature of the research topic and the relatively small sample size make a qualitative approach the most suitable for this study. The flexibility and applicability in exploratory research granted by such an approach were the main reasons for its choice.

Two qualitative techniques that can effectively gather responses to the research questions were chosen: focus group and survey. The rationale behind choosing the focus group method was to give the group an opportunity for in-depth discussions to make sure that the global variables (i.e. drivers and barriers facing countries other than Egypt) are valid in the EFBI. The focus group consisted of five active participants from top managerial levels in supply chains from different companies in the EFBI sector. The main role of the group was to discuss the applicability of GSCM drivers and barriers identified in previous literature to EFBI. On the other hand, choosing the survey method was based on different reasons; a survey is more flexible due to its ease of data gathering using convenient electronic tools such as e-mails and effective due to its data being measurable to gain meaningful results. The other major reasons for choosing a survey were its cost-effectiveness and lack of bias. Both techniques allowed questions to be directly posed to the respondents and the answers to be effectively gathered.

3.2 FOCUS GROUP

There were discrepancies among the participants' views about GSCM drivers and barriers. This can be explained by the difference in the nature of their organizations' cultures and policies. Despite the differences in opinions, the overall conclusion indicated that 60% of GSCM drivers and barriers investigated in the literature apply to EFBI and can be further examined to see which are of high significance.

Participants expressed their pessimism regarding the application of GSCM practices in Egypt in its current climate. They agreed that Egypt suffers from major issues such as infrastructure problems, lack of information dissemination, absence of environmental culture and awareness, economic and political instability, and the inability of the Egyptian Government in managing successful environmental policies. These problems, according to participants, impose serious barriers against investigating the application of GSCM in Egypt at the present time. However, they agreed that the GSCM drivers and barriers mentioned in the research review included and investigated the majority of variables from different perspectives: the supplier's, focal company's and customer's perspectives.

3.3 SURVEY

The survey was divided into three parts: the first part consisted of basic personal questions, with 4 introductory questions to test for the green orientation of the participant; the second part was related to drivers of GSCM practices adoption; and the third part was related to the barriers of GSCM practices adoption. The last two parts consisted of 17 questions each and are directly related to the main goal of the research – trying to identify the most significant drivers and barriers affecting participating in GSCM initiatives or projects within the EFBI sector. The types of questions used ranged from multiple choice and open-ended to multiple choice and rating scale (Likert-scale) questions. An advanced web-based survey application called Survey Monkey® was used to setup and start the survey process. In addition to using the web, a field visit was initiated to a meeting related to the Supply Chain Council (SCC) at the American University in Cairo (AUC).

Since experienced Industrial Supply Chain Management experts in Egypt are very few, as are ISO 14001 certified companies, the sample for the survey is determined by the "opportunity sampling" technique. A filtering process was implemented to avoid including any inexperienced participants in the supply chain management field within the EFBI sector. Using different electronic databases and social communication websites, the number of Egyptians working or with experience in the supply chain management in this sector was found to be almost 200. Given this population size, 51 participants are required to achieve significant results supporting a 90% confidence level. The survey was sent to a number of participants above than the needed sample size. It was taken into account that there would be a number of invalid e-mails, uncompleted surveys, and uninterested participants.

Unfortunately, due to the problem of information dissemination in Egypt, the survey did not succeed in gathering the needed sample size. At the SCC meeting, only 18 out of 30 surveys were received from participants. After refinement, only 10 surveys were successfully completed. Of the 52 surveys sent through Survey Monkey®, only 8 were successfully completed. Overall, a total of 82 surveys were distributed to suitable participants and only 26 of the completed surveys were examined in this research (see Table 3.1).

Table 3.1: Survey responses in numbers/percentage of the needed sample size.

Mode of information gathering	E-mails	SCC Meeting	Total in numbers/Percentage of the needed sample size		Filtered Surveys after refinement in numbers/percentage of the needed sample size	
	52	30	82	160%	26	51%

The research uses the Likert-scale to analyze responses for scaled questions of the survey. The Likert-scale involves five types of weights. For this research, they are: Very Strong=5, Strong=4, Moderate=3, Weak=2, and Very Weak=1. Every question has a response average; a higher response average indicates a higher support rate from participants. The survey passed many levels of validity and reliability testing before being distributed to the participants.

As mentioned by Joppe (2000), validity might be categorized into many types. A survey should undertake the content validity type that best meets the research objectives. Content validity is defined as the degree to which the instrument fully assesses or measures the construct of interest. This was applied to this survey by reviewing the survey questions to ensure they comprehensively capture the needed information to help answer the main research question. More importantly, the survey's questions were also reviewed to ensure they are appropriate for the target audience by reviewing their form and language to be congruent with the participants' way of thinking.

The survey was also assessed for its reliability. Joppe (2000) defined reliability as "the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable". There are four general classes of reliability estimates used to assess the consistency of results across items within a test. This research analysis will be based on internal consistency reliability. It is an effective and supportive methodology to analyze the survey's questions and responses. Internal consistency reliability is mainly divided into different sub-types; the most important type is the "Cronbach Alpha (α)" which measures the degree of reliability.

*"Alpha was developed by Lee Cronbach in 1951 to provide a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. Internal consistency describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test. Internal consistency should be determined before a test can be employed for research or examination purposes to ensure validity." (*Tavakol and Dennick, 2011)

$$\alpha = \left[1 - \frac{\sum(\%pos)_i(\%neg)_i}{var}\right]\left[\frac{K}{K-1}\right] \quad (1)$$

Where,

- *%pos* = Total response average of a question divided by %100 of Response Average
- *%neg* = 1- *%pos*
- *K* = Number of questions tested

Response Average is calculated as the total number of Response Rates of a question divided by the total number of participants – 26. For example, the survey full Response Average score equals the Very Strong average rate times the total number of participants = 5*26 = 130. The survey's Cronbach Alpha was calculated to be 0.97 out of 1. As mentioned before, Cronbach Alpha (α) is expressed between 0 and 1. As α approaches 1, results become more reliable. Thus, with an α value of 0.97, the survey results can be deemed reliable.

4. Research Analysis

Investigation of this research takes place through two main parts: GSCM drivers and GSCM barriers. Each part includes three categories: general perspective, company size and local versus international orientation. In an effort to validate the survey results, a part with questions regarding the participants' green orientation was also included.

4.1 PART 1 – GREEN ORIENTATION

In this part there are four questions indicating the extent of the participants' green thinking or their tendency to "go green". The first question investigated the participants' habits surrounding electricity usage. 65% of respondents switch off electricity before leaving their places. The second question measured the participants' ability to perform an environmental action toward recycling. 85% of respondents are able to sort their garbage to make it easier to be recycled. The third question measured participants' ability to pay more money to reduce consumption of water. 96% of respondents are able to replace their traditional faucets with automated ones to save water. The fourth and final question investigated the participants' habits surrounding fuel usage. 50% of participants never turn-off their engines at traffic jams.

Results for this part of the survey confirmed a high validity to the research. It has indicated that a high percentage of participants are tending to "go green" in their daily personal actions toward the environment.

4.2 PART 2 – GSCM DRIVERS

4.2.1 First Category – General Perspective Analysis

General perspective analysis for the GSCM drivers indicates that the most undertaken driver for GSCM practices adoption is organization values. With the highest response average (4.4), this reflects the importance of organization values as a driver for GSCM practices adoption for the vast majority of participants. Organization values have a positive relationship with GSCM practices adoption (Walker *et al.*, 2008). Results also indicate positive relationship between the values of the company's founder and GSCM practices adoption. Participants indicated that the most influential values which might increase the ability of the organization to adopt GSCM practices are 'discipline' and 'freedom for initiative employees'. This reflect the importance of encouraging employees to be more creative to enhance efficiency of the company in additional to monitoring and control actions undertaken by upper managerial levels.

Improving performance, improving quality and brand image got the second highest response average (4.1). 'Desire to reduce cost' comes third and the other five GSCM Drivers are less significant in the participants' point of views.

4.2.2 Second Category – Company Size Perspective Analysis

Participants working in companies with fewer than or equal to 500 employees have supported five GSCM drivers with the same top importance (4.0): desire to reduce cost, competitive advantage, regulatory compliance, organization values and brand image. Results demonstrate that companies of small size are extremely interested in decreasing their costs while gaining a competitive advantage and following governmental regulations, and those will be the reasons behind adopting GSCM practices from their perspectives.

Participants working in companies with fewer than or equal to 1000 employees have identified organization values as the top GSCM driver (4.5). They listed improving performance as the second most important driver. Brand image, improving quality and pressure by customers to adopt green practices are third in importance.

Participants working in companies with greater than or equal to 1000 employees selected organization values as the primary GSCM Driver. Next, participants identified improving performance and quality. Finally, participants showed less interest in brand image, desire to reduce cost, environmental risk minimization and ISO 14001. Results indicate that participants from large companies are driven by very different factors than small companies; they give competitive advantage and pressure by customers low importance as GSCM Drivers.

4.2.3 Third Category – Local versus International Companies

Results showed that local companies are interested mostly in organization values as a top GSCM driver. Brand image scored second. Scoring third were competitive advantage, improving performance, improving quality and pressure by customers in the attention cycle. As expected, local companies did not mention that ISO 14001, environmental risk minimization and regulatory compliance as prominent GSCM drivers in EFBI.

International companies also considered organizational values as the top GSCM driver in EFBI. On the other hand, they have chosen improving performance as the second main driver. Desire to reduce cost, improving quality and brand image scored low in importance as the most important GSCM drivers in EFBI.

4.3 PART THREE – GSCM BARRIERS

4.3.1 First Category – General Perspective Analysis

Participants chose two main barriers to reflect their vision about barriers of GSCM in EFBI. Participants' responses exceeded the "Strong" rating at the lack of resources and lack of governmental support. The next most important barrier is 'lack of understanding how to implement GSCM practices'. On the level of importance below that include buyer pressure for lower prices, supplier resistance to change and lack of awareness.

4.3.2 Second Category – Company Size Perspective Analysis

Participants working in companies with fewer than or equal to 500 employees considered three top GSCM barriers: lack of governmental support, lack of information technology and lack of resources. Participants believe that green practices expense and lack of understanding on how to implement GSCM practices are second in importance. Lack of awareness, buyer pressure for lower prices and supplier resistance to change are third in importance.

Participants working in companies with fewer than or equal to 100 employees chose lack of resources as the main GSCM barrier. Next, participants chose lack of understanding on how to implement GSCM practices and buyer pressure to lower prices to be secondary level barriers. The lack of governmental support and lack of awareness are third in importance.

Participants working in companies in greater than or equal to 1000 employees gave lack of government support the highest score (4.5). Lack of understanding on how to implement GSCM Practices and lack of resources were scored in second in importance. Lack of awareness and buyer pressure for lower prices were third in importance. Supplier resistance to change was also considered.

4.3.3 Third Category – Local versus International Companies

International companies identified lack of resources as the main GSCM barrier in EFBI. International companies considered the lack of governmental support and supplier resistance to change as second in importance. International companies scored buyer pressure for lower prices third. Participants also selected lack of awareness and lack of understanding on how to implement GSCM practices within the sphere of important GSCM Barriers but they did not score as high.

Understandably, the lack of resources was identified by local companies as the primary barrier. It is not possible initiate any green practices without adequate resources. On the secondary level of importance are a lack of governmental support and a lack of understanding on how to implement GSCM practices. This is unsurprising due to the lack of supply chain experience, training and governmental economic status in Egypt.

5. Conclusions

The purpose of this research is to identify the drivers and barriers facing the adoption of GSCM practices in EFBI. Its main question was focused to investigate the research purpose. The research objective was settled after reviewing the literature carefully to identify the gap of knowledge within the field of the study.

The literature review indicated that research focused on GSCM in Egypt is limited. Clean production and recycling were the most investigated sustainability topics during the last decade in Egypt. In spite of this, sustainability research did suffer from governmental negligence until now.

This research focuses on literature identifying drivers and barriers facing GSCM practices adoption globally. It included literature undertaken by developed and developing countries: China, Germany, United States of America, Turkey, Italy, South Korea, Kenya, Japan, New Zealand and Sweden. The literature included different industries such as automobile manufacturing but it did not include the food and beverage industry.

Using a qualitative approach, the research has gained detailed information about drivers and barriers facing GSCM practices adoption in EFBI. To provide an in-depth examination, questionnaire responses have been analyzed from company size and internationalization perspectives. Due to the experience of participants involved in the questionnaire and the concentration on certified ISO14001 companies, the research will be reliable and significant for future research within the field of the study.

Companies viewed GSCM drivers from different perspectives due to their sizes and their internationalization degree. For instance, small companies mentioned that there are five drivers to GSCM practices adoption while large companies indicated that there are three. Despite this, the overall survey results indicated that the main GSCM driver supported by participants was organization values. Research found that the reason behind participants' choice of organization values as the main driver is its vital role in drawing attention to the importance of GSCM initiatives. Organization values is the basis for the nature of a company's vision and mission, whatever its size or internationalization degree.

On the other hand, research analysis indicated that the main GSCM barriers are lack of resources and lack of governmental support. Companies also viewed GSCM barriers from different perspectives due to their size and internationalization degree. Although the different perspectives produced different outcomes, the overall results indicated that the main barriers to GSCM practices adoption is limited governmental support for environmental initiatives and the lack of financial resources and the lack of understanding on GSCM practices adoption techniques and tools.

One of the findings of the research is the supportive attitude of participants for the need of governmental support due to the lack of resources. Governmental support does not necessarily have to be financial support; it might include other incentives for companies seeking GSCM practices adoption. It was obvious in the survey results that the lack of resources was considered a major barrier for the vast majority of companies. Regardless of a company's size or internationalization degree, it does not have adequate resources to initiate GSCM practice adoption.

The research made three major contributions to the existing literature. First, the research indicated the major drivers for GSCM practices adoption in EFBI. Second, the research identified the major barriers facing GSCM practices adoption in EFBI, explaining companies' hesitation in GSCM practices adoption. Third, detailed and specific information about drivers and barriers of GSCM practices adoption in EFBI could be used in further researches as guidelines for practical adoption of GSCM practices. These contributions are new to the research field as none of the reviewed literature included information specific to GSCM practices adoption in the EFBI. This paper sets the groundwork by positioning the resistance to GSCM practices adoption for future research to build upon. This paper also acts as the start of a growing amount of research dedicated to increasing knowledge in the importance of GSCM in Egypt and the necessity for identifying ways and tools for the development and enhancement of GSCM.

There are limitations to this research that should be considered when interpreting the study results. Lack of information was the main limitation to this research due to the scarcity of information regarding previous environmental initiatives and their implications on corporate image and competitive advantage. Consideration of sharing information between governmental institutions led to very limited information about corporations with environmental organization values. Lack of experience in supply chain management and the small number of certified ISO14001 companies restricted the number of professionals that could be targeted for the questionnaire.

It is recommended for future research to include different industrial sectors to be examined. Different industrial sectors will result different drivers and barriers facing GSCM practices adoption in Egypt and it will support a larger sample size. If any future research relate to GSCM practice adoption for the EFBI, it is recommended that this paper's findings be used to find a relation between drivers and barriers with overall corporate performance in Egypt. Such research will support the literature with more information about the importance of GSCM practices adoption.

Value of future research could be obtained through investigating the social sphere of sustainability in Egypt. The effect of considering social responsibility in companies' objectives on their overall supply chain performance could lead to a clear framework of sustainability in Egypt. Does sustainable supply chain management benefit Egyptian economically, socially and environmentally?

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PAPER 26

Influence of Cement Factories on the South Cairo District Regarding SO2, NO2 and PM10 Emissions

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Abstract: The cement industry plays a very important role in the growth of the national economy and the social development of any country. Pollutants released from the cement industry are sulphur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2) and particulate matter (PM). Therefore, severe restrictions and controls must be placed on the cement industry to assess the environmental impacts of its projects, not only before implementation, but also during and after the operation of these projects. This research builds a model using the AERMOD air dispersion modeling package to perform an environmental impact assessment of cement factories by predicting maximum hourly and daily emissions of SO_2, NO_2 and PM_{10} at different receptor points.This model was applied to two currently operating cement plants, the Helwan plant and the Tourah plant, in Cairo, Egypt to study the presence of environment pollutants emitted by both plants collectively on an area of 14 km by 14 km, located at a distance of 2.5 km from the Helwan plant, and about 15 km from the Tourah plant. The study showed that the emission concentrations of sulphur dioxide (SO_2) based on the maximum daily rate (MD), and the emission concentrations of nitrogen dioxide (NO_2) and particulate matter (PM_{10}) based on maximum hourly (MH) and maximum daily (MD) rates are in the permissible range. However, the emission concentration of sulphur dioxide (SO_2) based on the maximum hourly (MH) rate is higher than the allowable limits set by the Egyptian Environmental Law (EE) and Air Quality Standards for the UK (AQSUK). The research results are irrespective of background emissions reading caused by other industries and human activities.

Keywords: Cement factories, EIA, air pollution, environmental legislation, AERMOD package

1. Introduction

Scientists are working to reduce the cement industry's negative impacts on the environment. Industry should continually aim to reduce maximum concentrations at sensitive locations by reducing emission rates and optimizing exit stack conditions. Air dispersion modeling helps to relate the emission rates and stack configurations to the corresponding pollutant concentrations in areas surrounding the source. It allows industry to determine the maximum released emissions allowed to remain compliant with ambient air quality standards. This helps industry to control air quality and evaluate the effectiveness of improvements in technology (e.g. increasing exit velocity, external baffles, etc.) on the dispersion and maximum concentration of the contaminants.

The main environmental impacts of the manufacture of cement are related to the following categories:

1. dust from stack emissions and fugitive sources;
2. gaseous atmospheric emissions of NOx, SO_2, CO_2, VOC, and others;
3. other impacts like noise and vibrations, odour, process water, production waste, etc; and
4. consumption of energy and raw materials.

Sulphur dioxide emissions are influenced by several factors, including the sulphur content of the fuel, the sulphur and mineralogical content of the stone feed, the quality of lime being produced and the type of kiln. The dominant source of sulphur emissions is kiln fuel, particularly coal and petroleum derived coke, where the levels of sulphur may be as high as 5% by weight. The amount of sulphur varies widely according to the nature of the deposits used. Upon combustion of the fuel, the sulphur compounds in the fuel are oxidised and form sulphur dioxide, which pass through the burning zone of the kiln with the exhaust gases. When sulphur-containing fuels are burnt, for practical purposes, sulphur in the kiln exhaust may be assumed to be emitted as sulphur dioxide, although there is usually some sulphur trioxide formed. In the case of lime manufacture in shaft kilns, much of the sulphur re-combines with the burnt lime and the emissions of sulphur dioxide are subsequently reduced. In the case of rotary and rotating hearth kilns, combinations of process design and combustion conditions can be selected to ensure that most of the sulphur is expelled as sulphur dioxide.

Nitrogen oxides are produced when the oxygen in the air oxidizes the nitrogen compounds contained in the fuel. There is a significant increase in the amount of nitrogen, mainly as nitric oxide, at process temperatures above 1400°C. The formation of nitric oxide is also a function of excess air. When operating near the stoichiometric conditions in the kiln, there is localised generation of carbon monoxide (EEAA, 2005; SINTEF, 2006).

2. Identification of Air Dispersion Model Parameters

There are several competing requirements in the design of an air dispersion model. A model must capture the essential physics of the dispersion process and provide reasonable and repeatable estimates of downwind concentrations. This generally requires detailed knowledge of meteorological conditions, land use/terrain considerations and source/emission parameters.

2.1 METEOROLOGICAL DATA

Meteorological data is used by the model to help simulate plume transport and dispersion. Data quantifying the wind direction and speed, ambient temperature, pressure, precipitation, clouds and humidity are used as an input to the model.

2.2 TERRAIN DATA

Land use information and terrain elevations are also important input parameters in the dispersion modeling analysis. The rate at which a plume disperses and eventually reaches ground level is affected by the degree of urbanization of the surrounding area. Generally, greater plume dispersion is found in urban environments due to enhanced mechanical and thermal turbulence. Land use within the vicinity of the facility is used to determine whether the area should be viewed as urban or rural. This data is used to establish the base elevation of onsite structures including buildings and the stack. It is also used to establish the elevation of receptors where pollutant concentrations are to be predicted.

2.3 SOURCE/EMISSION PARAMETERS

To define how the emissions are released into the atmosphere, input parameters required for the model include stack configurations (e.g. number of stacks, their distribution in the site layout, height and diameter of each stack) and pollutant configurations (e.g. types of pollutant, emission rates of each pollutant, temperature and velocity of the pollutants exiting the stack).

3. Modeling System

3.1 THE AERMOD MODEL

The complete modeling system consists of two preprocessors – AERMET and AMERMAP – and the AERMOD dispersion model itself. The meteorological pre-processor, AERMET, is a stand-alone program which provides AERMOD with the information it needs to characterize the state of the surface and mixed air layers, and the vertical structure of the Planetary Boundary Layer (PBL). The mapping program, AERMAP, is a stand-alone terrain pre-processor, which is used to both characterize terrain and generate receptor grids for AERMOD. Figure 1 describes the complete modelling process. The term “preprocessor” is used because the raw data from the National Weather Service (NWS) requires a certain amount of processing and merging before such compilation is useful to AERMOD (EPA, 2004c).

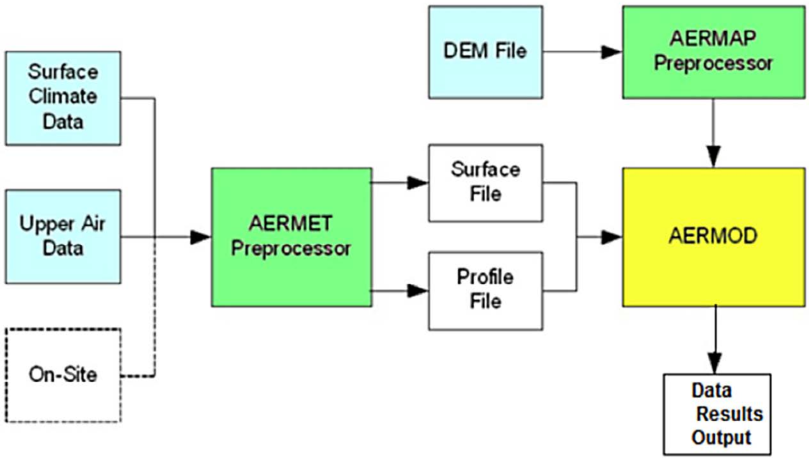

Figure 1: AERMOD structure.

AERMET Preprocessor

AERMET is designed to be run as three-stages and operate on three types of data: National Weather Service (NWS) hourly surface observations, NWS twice-daily upper air soundings and data from a site-specific meteorological measurement program. Site data can be collected by equipment such as a radiosonde, which is attached to a weather balloon filled with hydrogen gas. When released, the radiosonde measures upper air conditions such as geopotential height, atmospheric pressure, dry bulb temperature, dew point temperature, humidity, wind direction and wind speed. Data can be collected using an on-site measurement program from an instrumented tower. The first stage of AERMET extracts (retrieves) data and assesses data quality. The second stage combines (merges) the available data for 24-hour periods and writes these data to an intermediate file. The third and final stage of processing is to read the merged file and, in conjunction with site-specific parameters that characterize the underlying surface, produce two input files for AERMOD (EPA, 2004a).

AERMAP Preprocessor

The terrain pre-processor, AERMAP, is designed to simplify and standardize the input of terrain data for AERMOD. The terrain data may be in the form of Digital Elevation Model (DEM). For each receptor, the output includes a location and height scale, which is an elevation used for the computation of air flow around hills. The file consists of a regular array of elevations referenced horizontally on the latitude/longitude coordinate system of the World Geodetic System (EPA, 2004b).

3.2 MODEL VERIFICATION

In order to confirm the validity and accuracy of the AERMOD model proposed by this paper, a comparison of the results from two air dispersion models – AERMOD and the ISCST3 model built by Al-almery *et al.* – was undertaken.

ISCST3

The Shubra al-Kheima power plant Station consists of four steam turbines using natural gas as the operating fuel. The capacity of each is 315 megawatts, with total capacity of 1260 megawatts. The general description and specifications for the station is shown in Table 1 (Al-almery *et al.*, 2005).

Table 1: General description and specifications for Shubra al-Kheima power station.

Unit capacity MW	Number of stacks	Stack height (m)	Stack Diameter (m)	Type of fuel	GPS		Area m2	Number operating days/year	Temperature of stack gases (oC)
					N	E			
315	1	122.9	4.6	NG	30.1224	31.23585	136194	349.962	121
315	1	122.9	4.6	NG	30.1220	31.23606		349.962	121
315	1	122.9	4.6	NG	30.1216	31.23629		349.962	121

Model ISCST3 built by Al-almery *et al.* is applied to study the effects of pollution caused by emissions from power plants stacks. The required data for ISCST Model is shown in Table 2. The concentration of each gas for the first three months of 2008 is inputted.

Table 2: The input data values entered into Model ISCST3 for Shubra al-Kheima station.

X m	Y m	SH m	ST K	SD m	VE m/s	NO2 t/y	PM10 t/y
48	323	123	394	4.60	19.8	1925.3	52.0
29	345	123	394	4.60	25.2	2459.7	66.4
0	356	123	394	4.60	19.8	1925.3	53.4

AERMOD

When using AERMOD, there are data requirements above and beyond the local data listed in Table 2: meteorological data from a regional meteorological model for the time period under study (used to create an input file for AERMET) and terrain data extracted from DEM (with a receptor grid covering an area of 21 km by 21 km with 200 m resolution).

Comparison and Verification of the two Models

The outputs from the ISCST3 and AERMOD models are shown in Table 3. It is clear that the results of the AERMOD air dispersion model were slightly under-predicted. The conclusion was that the proposed AERMOD model can be used efficiently.

Table 3: Comparison between the results of two different air dispersion models.

Emissions	Maximum value (µg/m3)	ISCST3 results	AERMOD results	Deviation
NO2	MH	185	177.15	-4.3 %
PM10	MH	5	4.85	-3 %

3.3 MODEL APPLICATION

The model was built using AERMOD to study the collective effects of the Helwan and Tourah cement plants on the surrounding area using the dispersion and concentration of air emissions at various receptor locations during the first three months of 2009.

Meteorological Data

AERMOD requires steady and horizontally homogeneous hourly surface and upper air meteorological observations for simulating the dispersion. In the absence of meteorological observations at an hourly interval, the use of regional model derived meteorological parameters is well suited. However, meteorological observations with such frequency are not available for Helwan city. To overcome this difficulty, the required meteorological parameters are derived from high resolution simulations using a regional Mesoscale Model (MM5) for creating weather forecasts and climate projections model outputs and create the AERMOD meteorological input file by-passing the need for AERMET and thus any observational data requirement.

MM5 model is integrated for the period from January 1 to March 31, 2009 using time step of seconds. Angular distribution of wind directions and Wind Class Frequency Distribution for the entire period simulated by MM5 as shown in Figure 2.

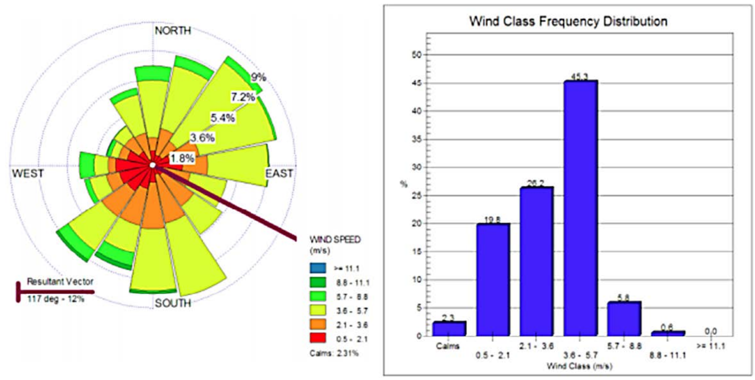

Figure 2: MM5 model simulations for the period January 1 to March 31, 2009
(a) Angular distribution of wind directions (b) Wind Class Frequency Distribution

Terrain Data

The terrain data is in the form of Digital Elevation Model (DEM). The receptor grid has specified covering an area of 14 km x 14 km with 200 m resolution with center coordinates of latitude 29.798460^{O} and longitude 31.301965^{O}. The Helwan plant is located at a distance of 2.5 km from the center and Tourah plant is 15 km from the same center.

Source/Emission Parameters

In order to study the effect of cement factories on the environment, AERMOD model was used to predict the dispersion of total suspended sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter (PM10) emissions released from the Helwan and Tourah cement plants at selected receptor points. The predicted concentrations of the air pollutants (without background concentrations) are compared with different international environmental laws.

5. Cement Plants of Helwan and Tourah

5.1 INPUT DATA

The objective of this research is to evaluate the aggregate air impacts of the Helwan and Tourah cement plants. The Helwan plant is located 30 km south of Cairo in an area of 1,000,000 m^2 with 10 production lines (8 in operation). There are two dry lines and six wet lines for grey cement in addition to two wet lines for white cement. The dry lines I and II were inaugurated in 1985 and 1987 respectively to yield a maximum of ton of cement per day for each.

Cement Plant Tourah is located 5 km south of Cairo in an area of 10,000,000m^2 with 9 production lines (4 in operation).

The stacks emission data and its coordinates for both factories relative to the supposed point (X=336565m, Y=3300806m; Universal Transverse Mercator) are shown in Table 4.

Table 4: Stacks emission data and its coordinates for both factories

	N	X m	Y m	Stack Height (m)	Stack Diameter (m)	Exit Temp. K	Exit Velocity (m/s)	SO_2 g/s	NO_2 g/s	PM_{10} g/s
Cement plant (Helwan)	1	-100	140	95	3.5	395	13.5	49.42	21.30	21
	2	-100	105	95	3.5	388	13.5	51.12	27.26	20
	3	-100	70	95	3.5	408	13.5	49.42	24.20	20
	4	-100	35	95	3.5	395	13.5	49.42	21.30	21
	5	0	165	95	3.5	423	27	52.82	24.71	8
	6	0	235	95	3.5	443	27	49.42	21.30	7
	7	400	35	90	3.5	414	13.3	6.00	26.24	20
	8	400	70	90	3.5	414	13.3	6.00	26.24	20
	9	-100	0	95	3.5	395	13.5	49.42	21.30	21
	10	-100	175	95	3.5	388	13.5	51.12	27.26	20
Cement plant (Tourah)	1	-1790	10765	95	3.5	395	13.5	49.42	21.30	21
	2	-1790	10755	95	3.5	388	13.5	51.12	27.26	20
	3	-1735	10712	95	3.5	408	13.5	49.42	24.20	20
	4	-1735	10702	95	3.5	395	13.5	49.42	21.30	21
	5	-1690	10585	95	3.5	423	27	52.82	24.71	21
	6	-1702	10578	95	3.5	443	27	49.42	21.30	20
	7	-1661	10537	95	3.5	414	13.3	49.16	26.24	20
	8	-308	10925	95	3.5	414	13.3	49.16	26.24	20
	9	-353	10920	95	3.5	395	13.5	49.42	21.30	21

5.2 RESULTS

Figure 3 shows SO_2, NO_2 and PM_{10} concentrations in the air during January 1st to March 31st 2009 for the emissions from stacks for two cement plants.

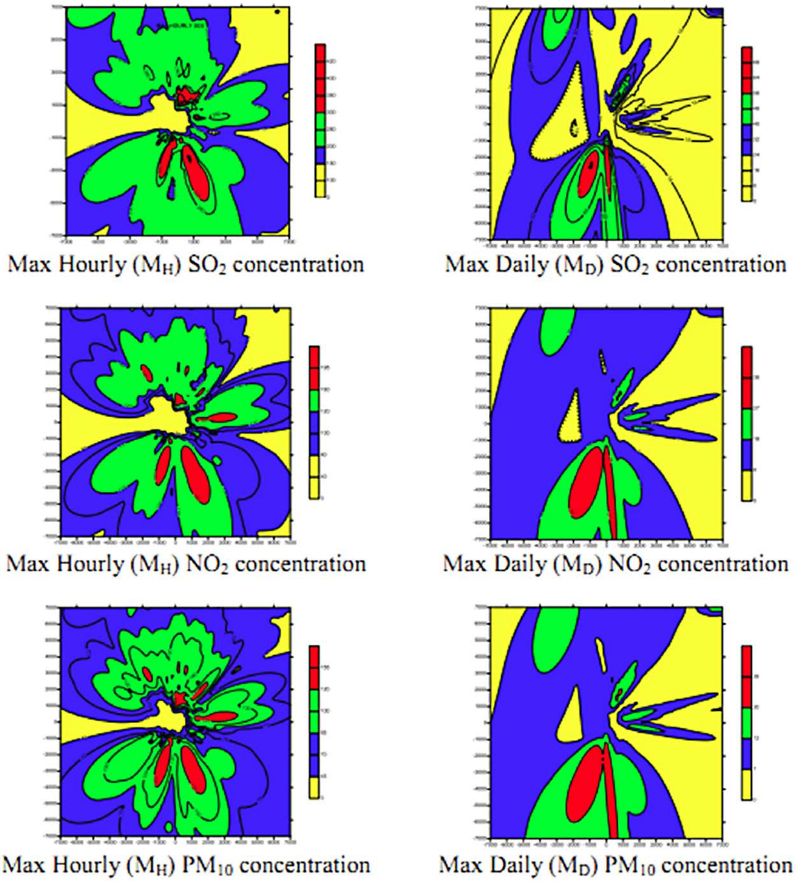

Figure 3: Max concentrations of SO_2, NO_2 and PM_{10}

Table 5: The values of Maximum Emissions Concentrations for all runs and the allowable values for different codes

Emissions	Egyptian Environmental Law		World Bank Environmental Law		Environmental Standards in U.S.A		Air Quality Standards for (U.K)		Helwan and Tourah cement plants	
	M_H	M_D	M_H	M_D	M_H	M_D	M_H	M_D	M_H	M_D
SO_2 ($\mu g/m^3$)	350	150	--	150	435	365	350	125	413.38	65.88
NO_2 ($\mu g/m^3$)	400	150	--	150	200	--	200	--	195.02	35.87
PM_{10} ($\mu g/m^3$)	--	70	--	150	--	150	--	50	157.29	27.37

6. Discussion

The results of emissions concentrations from both cement plants are computed regardless of the background pollutant concentrations resulting from other industries and human activities of both communities are shown in Figure 4 and Table 5.

1. The reference comparison limits for the pollutant concentrations are chosen from Egyptian Environmental Law (EE), World Bank Environmental Law (WB), Environmental Standards in USA (ESUS) and Air Quality Standards for the UK (AQSUK).
2. The maximum hourly and maximum daily emission concentrations of NO_2 (M_H= 195.02µg/m^3; M_D= 35.87µg/m^3) were found to be less than the maximum values recommended by all reference limits.
3. The maximum daily emission concentrations of PM10 (M_D= 27.37µg/m^3) were found to be less than the maximum values recommended by all reference limits. There is no recommended maximum hourly (M_H) limits for PM concentrations in any of the references (M_H= 157.29µg/m^3).
4. The emission concentration of SO_2 based on maximum daily concentration (M_D= 65.88µg/m^3) was found to be less than the maximum values recommended by all reference limits. However, the maximum hourly concentration (M_H= 413.38µg/m^3) was found to be less than the limit recommended by ESUS, but exceeded the limits recommended by EE and AQSUK.

Figures 4 to 8 show the comparison between maximum concentrations (hourly and daily) of SO_2, NO_2 and PM_{10} with international environmental law in the air during (January 1st to March 31st 2009).

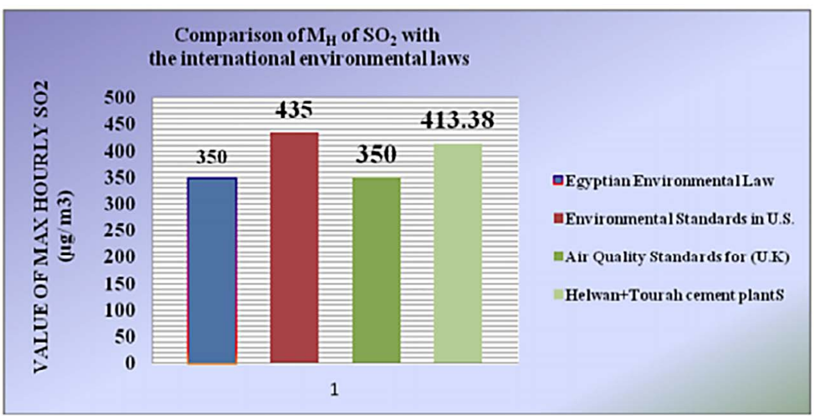

Figure 4: Comparison between the Maximum values based on Maximum Hourly for results of SO_2 concentrations and Environmental laws.

- The emission concentration of sulphur dioxide (SO_2) based on M_H is 413.38µg/m³, which is higher than the limits set by EE (350µg/m³) and AQSUK (350µg/m³) by about 18%. To reduce emission concentration, it is recommended to lower the operation levels at both cement plants and reduce homogeneous sulphur contents in inputs fuel and raw material.

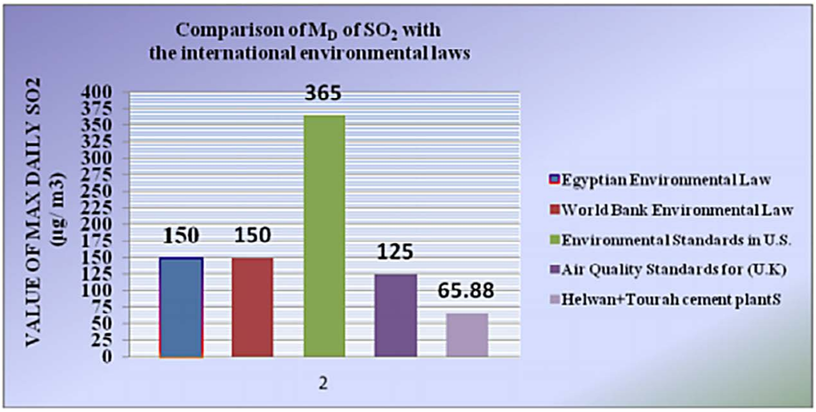

Figure 5: Comparison between the Maximum values based on Maximum Daily for results of SO concentrations and Environmental laws.

- The emission concentration of sulphur dioxide (SO_2) based on M_D is 65.88µg/m³, which is lower than the limits set by EE (150µg/m³), WB (150µg/m³), ESUS (365µg/m³) and AQSUK (125µg/m³).

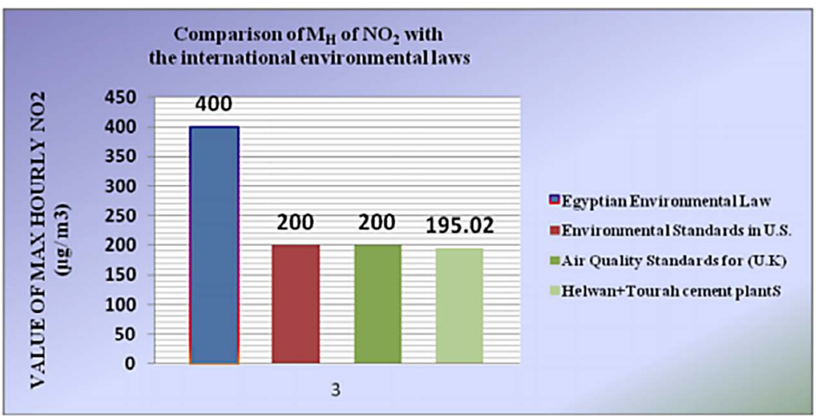

Figure 6: Comparison between the Maximum values based on Maximum Hourly for results of NO concentrations and Environmental laws.

- The emission concentration of nitrogen dioxide (NO_2) based on M_H is 195.02µg/m^3, which is lower than the limits set by EE (400µg/m^3), but very close to the limits set by the ESUS and AQSUK (200µg/m^3). No maximum limit for the emission concentration of nitrogen dioxide (NO_2) based on M_H has been set by WB.

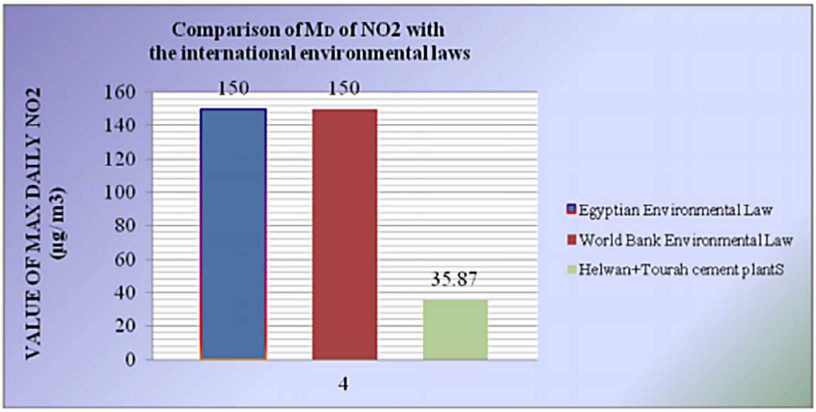

Figure 7: Comparison between the Maximum values based on Maximum Daily for results of NO concentrations and Environmental laws.

- The emission concentration of nitrogen dioxide (NO_2) based on M_D is 35.87µg/m^3, which is lower than the limits set by EE (150µg/m^3) and WB (150µg/m^3). No maximum limit for the emission concentration of nitrogen dioxide (NO_2) based on M_D has been set by ESUS or AQSUK.

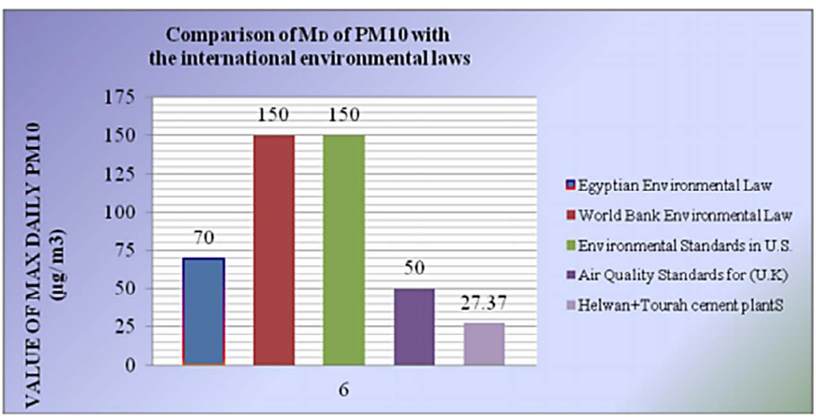

Figure 8: Comparison between the Maximum values based on Maximum Daily for results of PM_{10} concentrations and Environmental laws.

- The emission concentration of particulate matter (PM10) based on M_D is 27.37μg/m^3, which is lower than the limits set by EE (70μg/m^3), WB (150μg/m^3), ESUS (150μg/m^3) and AQSUK (150μg/m^3).
- No maximum limit for the emission concentration of particulate matter (PM10) based on M_H has been set by EE, WB, ESUS, or AQSUK.

7. Conclusions

The emission concentration of sulphur dioxide (SO_2) based on the maximum hourly rate (M_H) is 413.38 μg/m^3 and violates the limits set by EE and AQSUK.

All the other emission concentrations of sulphur dioxide (SO_2) based on the maximum daily rate (M_D), and nitrogen dioxide (NO_2) and particulate matter (PM_{10}) based on the maximum hourly (M_H) and maximum daily (M_D) rates were found to be less than the limits recommended by EE, WB, ESUS and AQSUK, irrespective of background readings caused by other activities in the studied area.

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PAPER 27

Application of Green Materials for Noise Control in Buildings with Simulation of MATLAB

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Abstract: This paper investigates the acoustical properties of local green acoustics materials, working with different kinds of residual harvesting plants: rice straw, karina of palm tree, palm fronds, palm leaf, grain zea mays (a.k.a. maize or corn) and sugarcane reed with different particulate sizes and compression loads, leading to different densities. By applying different methods of producing samples, a wide range of absorption coefficients was achieved.

Keywords: residual harvesting, green materials, noise control, acoustics, MATLAB.

1. Introduction

There is considerable interest in the use of biomass and sustainable materials for the manufacture of sound absorbent materials (Oldham *et al.*, 2011). There have been studies carried out to investigate the use of biomass (Glé *et al.*, 2011), industrial tea-leaf fibres waste materials (Sezgin and Küçük, 2009), and rice straw-wood particle composite boards (Yang *et al.*, 2003) for their sound absorption properties. There has also been work done to develop models to predict sound absorption coefficients to evaluate the effectiveness of new absorbent materials. Wassilieff (1996) tested the effectiveness of earlier models on their accuracy on wood-based materials, which were developed at a time when glass- or mineral-fibres were the prevalent materials in sound absorbers.

2. Methodology

2.1 MATERIALS

Several green materials, such as residuals from palm trees (e.g. karina, loaf, and fronds), rice straws, grain zea mays (a.k.a. maize or corn), and sugarcane reed were tested. Samples from these materials were made with varying characteristics: water content, thickness, fibre diameter, matrix density, bulk density, etc. Table 1 contains a summary of the sample materials examined. The samples were created in the new materials laboratory of the Production Department at Ain Shams University.

Variations in the samples' densities are due to different proportions of the components within each sample. For example, the lower values for rice straw and palm tree samples result from a greater proportion of lignin compared to the other fibres. The loose fibre samples were manufactured by die in the tube sample holders to give different thicknesses. The bulk density of the large tube samples were measured and replicated by the small tube samples.

Table 1: materials tested properties.

substance	Thick mm	Fiber diam. mm	Matrix Density Kg/m3	Bulk Density Kg/m3	Pre. pressed bar(kg/cm2)	Water content %wt
Rice straw dry	20	0.19	1000	132	45	4.5
Rice str. dry 1	20	0.19	850	100	34	4.5
Rice straw 2	20	0.19	950	120	40	5
Rice straw 3	20	0.19	1000	100	30	5
Rice straw	30	0.85	700	120	25	6.5
Rice straw	60	0.85	700	100	25	6.5
Karina palm	30	0.35	650	90	25	4
Karina palm	60	0.35	650	100	25	4
Palm fronds d	20	0.17	1000	90	45	3.5
Palm leaf	30	0.63	650	75	25	3.5
Palm leaf	60	0.63	700	75	25	3.5
zea mays dry	20	0.19	1000	90	45	4.5
zea mays wet	20	0.19	1000	95	45	4.5
Sugarcane dry	20	0.19	1000	90	45	5
Sugarcane wet	20	0.19	1000	95	45	5

2.2 TESTING

Moisture content and specific gravity were examined using the ASTM D1037-99 method (ASTM, 1999) in Ain Shams University's laboratories of materials testing. Specific gravity was measured using quality control testing and the final values shown in Table 1 are averages from five trials completed for each sample.

The absorption coefficients of several acoustic samples were measured using the Brüel & Kjaer (B&K) Standing Wave Apparatus Type 4206, along with the B&K Real-time Frequency Analyzer Type 2133, the B&K Frequency Analyzer Type 2107 and B&K Impedance Tube Type 4206. Using both the large and small sample holders, the absorption coefficient could be measured over the frequency range from 50 Hz to 1.6 kHz. The impedance tube measurements and are based on the two-microphone transfer-function method according to ISO 10534-2 (ISO, 1998).

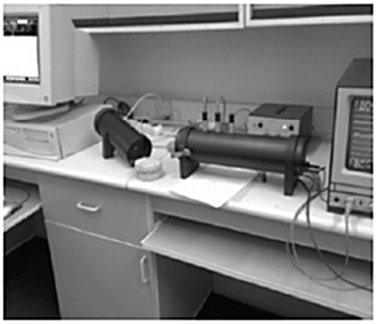

Figure 1: Schematic diagram of apparatus for measuring sound absorption coefficient.

3. Results

3.1 INSULATION BOARD

Measurements taken by the impedance tube show that wet grain zea mays gives the highest absorption coefficient out of the six samples used as insulation board (Figure 2). None of the samples achieved an absorption coefficient above 0.55. The wet grain zea mays was submerged in water for 12 hours, which makes the material more porous, resulting in higher absorption coefficients at lower frequencies. Wet sugarcane reed also increased its porosity when submerged in water, by diluting the bonding material and natural internal cellulose.

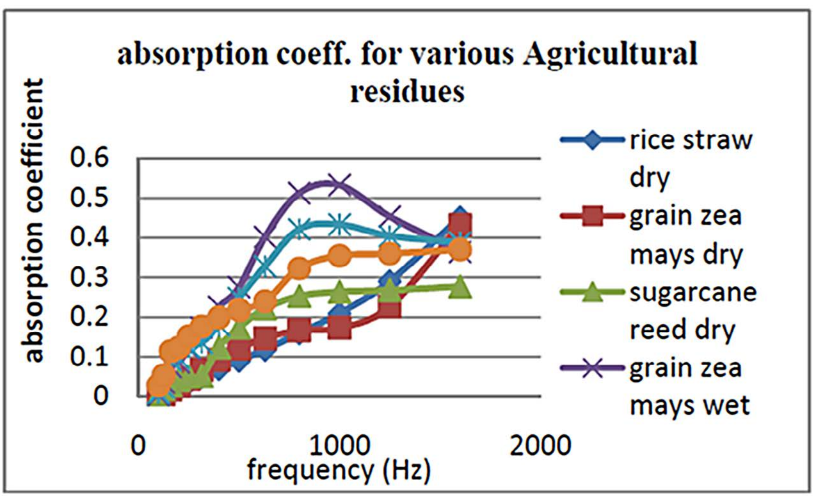

Figure 2: Different samples with MDF standards and low porosity.

3.2 RICE STRAW

Samples 1, 2, and 3 from Table 1 were manufactured according to MDF standard as insulation boards. Two uncrushed rice straw samples were used to manufacture absorption boards with high porosity and lower matrix density (compared to MDF standard) at thicknesses of 30.00 and 60.00 mm. The absorption coefficients of these five materials were measured (Figure 3). Higher absorption coefficients of approximately 1 are achieved by the uncrushed natural fibre samples. The 30 mm thick sample did so at approximately 500 Hz and the 60 mm thick sample did so at approximately 1000 Hz. The different pressure loads for the crushed samples (25 kg/cm^2 for sample 3, 34 kg/cm^2 for sample 1 and 40 kg/cm^2 for sample 2) indicate that lower pressure loads at constant thickness and bulk density result in higher absorption coefficients and flow resistivity (Rayls/m).

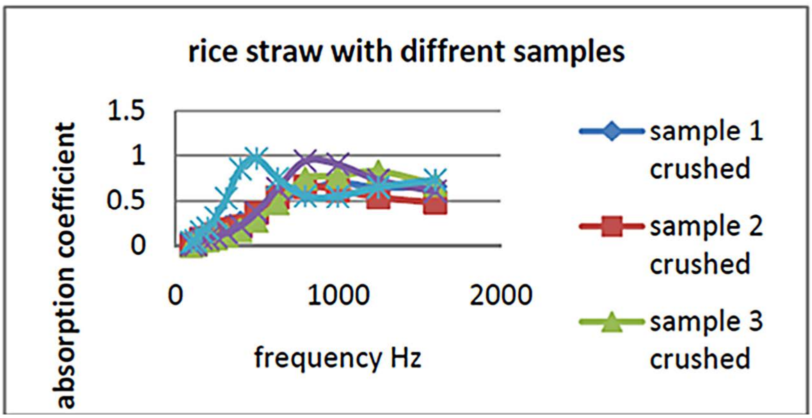

Figure 3: Different porosity samples of rice straw.

3.3 PALM RESIDUALS

As demonstrated in Figure 4, palm karina provides better absorption at greater thicknesses. It also shows that a sample of palm karina with 60.0 mm thickness gives good absorption at low frequencies up to 600 Hz but poorer absorption at high frequencies. A 30.0 mm thick sample of the same materials has low absorption coefficient at low frequency and increasing absorption coefficient at increasing frequency.

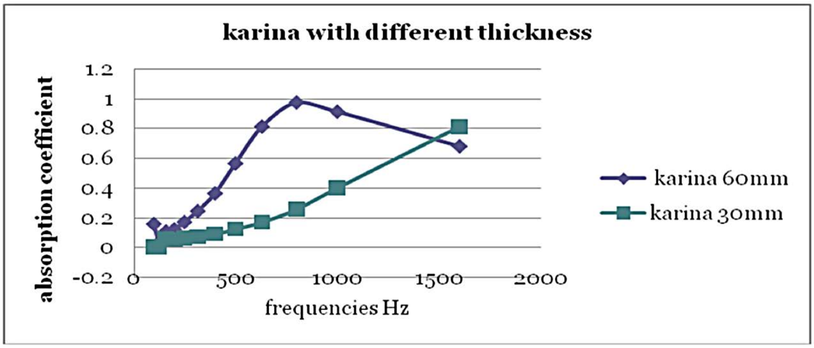

Figure 4: Absorption coefficient for palm karina (average of face and rea of the sample) with 30 mm and 60 mm thickness.

Figure 5 gives the relationship between the frequencies and the absorption coefficient for the palm loaf with different thicknesses. The behaviour of the palm loaf at 30 mm and 60mm thicknesses were nearly identical to that of the palm karina. For the 60 mm sample, the absorption coefficients increased at low frequencies until 800 Hz then started decreasing at higher frequencies. In reality, the absorption coefficient for the floor doesn't usually exceed 0.02 – 0.4 in normal incidence.

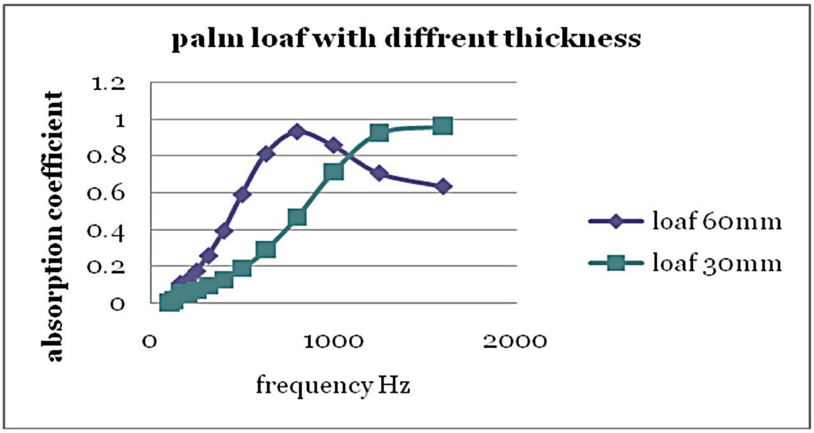

Figure 5: Absorption coefficient for palm loaf (average of face and rea of the sample) with 30 and 60 mm thickness.

3.4 A MATLAB SIMULATION OF ROOM ACOUSTICS

The surface absorption sheet below (Figure 6) presents a table for entering the absorption coefficients. The values can be entered individually or copied and pasted from the supplied list of surface types on the sheet. The calculator for speed of sound as a function of temperature (and temperature to achieve a desired speed of sound) is duplicated on this sheet, for use with a calculator for estimating reverberation time RT60. This can be done interactively through the menu prompt system by submitting a Microsoft Excel spreadsheet form (Figure 6) or by selecting a MATLAB *.mat file which saved a configuration from a previous run.

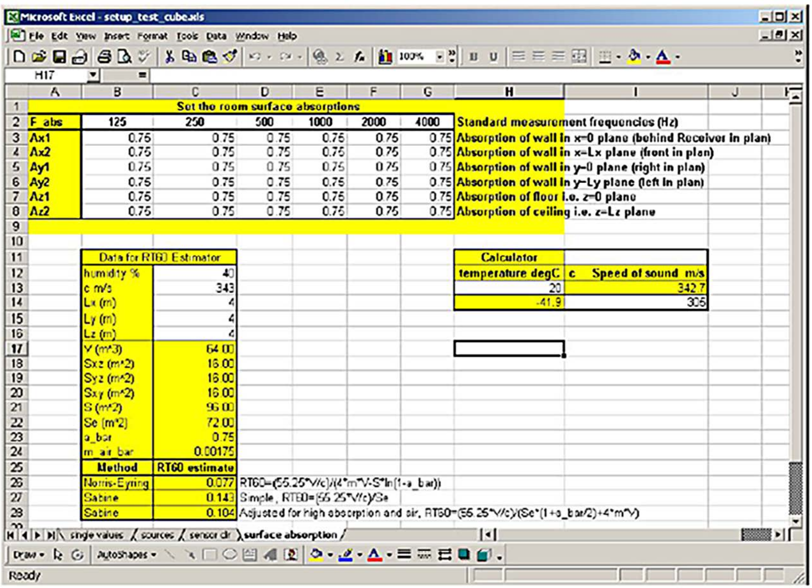

Figure 6: Data sheet of calculate the reverberation time.

The excel datasheet export to m-code by six sheets with the following assumptions:

1. apply different acoustics panels for all six surfaces;
2. apply same acoustics panels for all six surfaces;
3. apply the highest absorption coefficient material on one surface only;
4. apply the highest absorption coefficient material on two opposite walls;
5. apply the two highest different absorption materials on two opposite walls;
6. apply the highest absorption coefficient material on two adjusted walls; and
7. apply the two highest different absorption materials on two adjusted walls.

4. Conclusions

- Rice straw wood particle composite boards were manufactured as insulation boards using MDF standards. The raw materials, rice straw and palm residuals, were chosen because of their availability. Although better agreement between theory and measurement might be possible with the introduction of pore-shape factors, the new materials offers many options including integrity of fibres (e.g. crushed or natural fibres) and exposure to water (e.g. wet or dry). Exposure of the material to water may subject it to fungal attacks. In a dry building, this will present no problem but the risk of fungal attacks may preclude the application of these materials in some environments. Another practical consideration is the need to develop suitable binders to hold the fibers together without adversely affecting the absorption characteristics.
- The natural fibres without crushing with low pressure (less than 15.00 kg/ cm^2) gives the best results in low frequencies.
- The best absorption coefficients from the rice straw were obtained at low frequencies with natural fibre samples (i.e. not crushed); coefficients of approximate 1 was achieved at 500Hz for 30 mm thickness and at 1000Hz for 60 mm thickness.
- Karina of palm trees with 60 mm thickness provides good absorption at low frequencies up to 600 Hz. Then, it decrease with increasing frequency. At 30 mm thickness, karina of palm trees does not provide acceptable absorption coefficients at low frequencies. Similar results were obtained from the palm loaf samples.
- When applying absorption materials to six sides of a room, very low reverberation time was achieved but this was not realistic. So, it was taken into consideration the application of the absorption material on floor range (0.02-0.4 absorption coefficients).
- Further investigations are required to study the effect of other acoustics parameters such as porosity, airflow resistance, tortuosity and viscous characteristic length on absorption coefficient at different frequencies.

Acknowledgments

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