NILE DELTA FLOODING DUE TO SEA LEVEL RISE

By

Mohammed Safaa EL-Din Moustafa AbdelHamed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirement for Degree of
MASTER OF SCIENCE
In
Irrigation and Hydraulics Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis: Nile Delta Flooding Due to Sea Level Rise

Key Words: **Nile Delta, Flooding, Sea Level Rise, Digital Elevation Model, Vulnerability maps**

Summary:

The present thesis studies the negative impacts of the concurrent changes in the climatic system in term of flooding due to sea level rise (SLR) on the northern part of the Egyptian Nile Delta. Flooding due to SLR was estimated using a digital elevation model (DEM) created from digitized topographic maps coupled with SRTM data and GPS observations. SLR scenarios of 0.5, 1.0, 1.5, 2.0, 2.5 m were applied. A modified bathtub inundation model was used to produce the flooded areas for each SLR scenario. After identifying the mechanism of flooding, vulnerable areas and the locations of the adaptation measures were detected.

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Mohamed Safaa El-Din Moustafa

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Nomenclature

AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
ASLR	Accelerated Sea Level Rise
ASTER	Advanced Spaceborne Thermal Emission and Reflection
BTELSS	Barataria-Terrebonne Ecosystem Landscape Spatial Simulation
CC	Climate Change
CMIP5	Coupled Model Intercomparison Project Phase 5
CoRI	Coastal Research Institute
DEM	Digital Elevation Model
DIVA	Dynamic Interactive Vulnerability Assessment
DTM	Digital Terrain Model
EEAA	Egyptian Environmental Affairs Agency
EGM	Earth Gravitational Model
ENTRO	Eastern Nile Technical Regional Office
ETM	Egyptian Transverse Mercator
FUND	Framework for Uncertainty, Negotiation and Distribution
GDEM	Global Digital Elevation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIS	Geographic Information System
GPS	Global Positing System
GSFC	Goddard Space Flight Center of NASA
ICH	International Coastal Highway
INS	Inertial Navigation System
InSAR	Synthetic Aperture Radar Interferometry
IPCC	Intergovernmental Panel on Climate Change
JPL	Jet Propulsion Laboratory of NASA
LIDAR	Light Detection and Ranging
METI	Ministry of Economy, Trade, and Industry of Japan
MSL	Mean Sea Level
NASA	National Aeronautics and Space Administration
NGA	National Geospatial-Intelligence Agency
NIMA	National Imagery and Mapping Agency of NASA
NOAA	National Oceanic and Atmospheric Administration
SLAMM	Sea-level Affecting Marshes Model
SLR	Sea Level Rise
SRTM	Shuttle Radar Topography Mission
TIN	Triangular Irregular Network
WGS	World Geodetic System

Abstract

As rates of sea-level rise (SLR) continue to increase due to climate change, land planners require an acceptable spatial analysis on the extent and timing of coastal flooding and associated hazards. The Nile delta of Egypt is one of the most vulnerable deltas to flooding due to SLR. Thus, it is essential to understand the direct impacts and identify the reaches that require some long-term mitigation measures. Such measures will be important to protect the existing coastal systems, infrastructures and properties of the Nile Delta. Based on recent studies of SLR predictions to the end of 21st century, which vary from 0.3 to 2.4 m, an inundation model is developed using Geographic Information System (GIS) accounting for connectivity with the sea or lakes. The developed inundation model depends mainly on Digital Elevation Models (DEMs), generated from digitized topographic maps of scale 1:25,000 and surveyed key features that are not included in the original maps using GPS observations. The Shuttle Radar Topography Mission (SRTM) data is used to fill the gaps between digitized. The impact of SLR is assessed by producing maps for the inundated areas in the Nile Delta due to a 0.5, 1.0, 1.5, 2.0 and 2.5 m SLR. The study shows that initially the water will mainly enter the low-laying areas from the coastal lakes (Manzala, Burullus and Idku). For example, over 3150 km^2 will be inundated for a 1.0 m SLR scenario including about 2675 km^2 of affected cropland. Finally, vulnerability maps and critical reaches that require mitigation measures are provided based on several SLR scenarios and the activities in these areas.

Chapter One: Introduction

1.1. Overview

Modern societies are becoming more sophisticated and are changing faster than ever. Additionally, it is increasingly vague what the future world will look like under the current changes in the climatic conditions. Indeed, there is massive scientific consensus that Climate Change (CC) is occurring globally, as identified in the five assessment reports published by the International Panel on Climate Change (IPCC) in 1990, 1995, 2001, 2007 and 2013, respectively.

In the Fourth Assessment Report (AR4, 2007) and the Fifth Assessment Report (AR5, 2013), it was stated that the warming in the climatic system is unequivocal globally. A study by Naomi Oreskes (2004) clarified that the scientific consensus on global warming was commanding. Oreskes' research reviewed 928 studies published in refereed scientific journals between 1993 and 2003, where the authors of all papers were in agreement with the IPCC conclusion.

Owing to the rapid expansion in the industrial sectors in the past decades, the rates of the Greenhouse Gases (GHG) emissions increased in an uncontrolled manner starting from the preindustrial era creating a case of disequilibrium in our environment, one of those impacts is the rising of the sea level.

Sea-Level Rise (SLR) as an impact of human-induced climate change has significant implications to low-lying coastal areas and beyond it, some coastal zones that contains valuable ecosystems and prosperities has higher population densities than inland areas. In addition, it generates considerable amounts of economic activity contributing to national gross domestic product (GDP) (AR5, 2013).

In physical terms, the foremost direct impacts of SLR includes inundation of low-lying areas, shoreline erosion, coastal wetland loss, saltwater intrusion, higher water tables and higher extreme water levels leading to coastal flooding. Human-induced pressures on the coastal zone (such as growing population, water abstraction, and alteration of the hydrological regime including the damming of sediments) will exacerbate the effects of SLR.

The impacts of SLR have been studied less intensely in developing countries as compared to developed countries. Yet developing countries – in dense population areas, may be severely affected by SLR as they have a lower ability to prepare, adapt and respond. The continent of Africa represents such a vulnerable region and many coastal African countries are vulnerable to SLR, particularly where large growing cities with high population density are located in a vulnerable coastal zone. With most African coastal countries undergoing rapid population growth, urbanization, coastward migration and associated socioeconomic growth, countries are experiencing dramatic coastal change. This includes a rapid increase in exposure of people and assets to sea-level variability and long-term rise.

However, due to uncertainties in future projections and the lack of systematic data, these factors cannot be fully considered in this study. Henceforward, the main issue addressed in this research is assessing SLR impacts on the coastal areas.