EFFECT OF LAND DEGRADATION ON LAND COVER ATTRIBUTES OF EAST SUEZ CANAL USING REMOTE SENSING TECHNIQUES

By

NAGWAN MAHMOUD MAHMOUD AFIFY
B. Arts and Education. (Geographic), Ain Sham University, 2000
M.Sc. Agric. Sc. (Agriculture in desert and salt affected areas),
Ain Shams University, 2013

A Thesis Submitted in Partial Fulfillment

Of

The Requirements for the Degree of

DOCTOR OF PHILOSOPHY
in
Agricultural Sciences
(Agriculture in desert and salt affected areas)

Arid land Agricultural graduate studies
And Research Institute
Faculty of Agriculture
Ain Shams University

2017

Approval sheet

EFFECT OF LAND DEGRADATION ON LAND COVER ATTRIBUTES OF EAST SUEZ CANAL USING REMOTE SENSING TECHNIQUES

By

NAGWAN MAHMOUD MAHMOUD AFIFY

B. Arts and Education. (Geographic), Ain Sham University, 2000
M.Sc. Agric. Sc. (Agriculture in desert and salt affected areas),
Ain Shams University, 2013

This thesis for Ph.D. degree has been approved by:

Dr. Ahmad Mohamed yousef ……..……
Researcher Prof. of Geophysics, Desert Research Center.

Dr. Ayman Farid Abou Hadid ……..……
Prof. Emeritus of Vegetable Crops, Faculty of Agriculture, Ain Shams University.

Dr. Abdel Aziz Saad Nasr Sheta ……..……
Prof. Emeritus of Soils Science, Faculty of Agriculture, Ain Shams University.

Dr. Adel El-Sayed El-Beltagy ……..……
Prof. Emeritus of Vegetable Crops, Faculty of Agriculture, Ain Shams University.

Date of Examination: 14 / 8 / 2017

EFFECT OF LAND DEGRADATION ON LAND COVER ATTRIBUTES OF EAST SUEZ CANAL USING REMOTE SENSING TECHNIQUES

By

NAGWAN MAHMOUD MAHMOUD AFIFY

B. Arts and Education. (Geographic), Ain Sham University, 2000
M.Sc. Agric. Sc. (Agriculture in desert and salt affected areas),
Ain Shams University, 2013

Under the supervision of:

Dr. Adel El-Sayed El-Beltagy
Prof. Emeritus of Vegetable Crops, Department of Horticulture, Faculty of Agriculture, Ain Shams University (Principal Supervisor).

Dr. Abdel Aziz Saad Nasr Sheta
Prof. Emeritus of Soils Science, Department of Soil Sciences, Faculty of Agriculture, Ain Shams University.

Dr. Sayed Medany Arafat
Researcher Prof. Emeritus of Soils, Department of Agricultural Applications, National Authority for Remote Sensing and Space Sciences.

ABSTRACT

Nagwan Mahmoud Mahmoud Afify: Effect of Land Degradation on Land Cover Attributes of East Suez Canal Using Remote Sensing Techniques, Unpublished Ph.D. thesis, Arid Land Agricultural Graduate Studies and Research Institute, Faculty of Agriculture, Ain Shams University, 2017.

The use of remote sensing techniques has become increasingly important in describing a variety of satellite derived data sets and their application to understand changes in the landscape. The aim of this investigation is to employ remote sensing data, GIS and extensive field observations to monitor land cover in the study area and to assess the land degradation status. Also, to predict the deterioration magnitude in the study area under the existed informal agriculture management practices. The selected area for this study represented by about 163527 hectares located in Ismailia Governorate east of Suez Canal, Egypt. In this work, both Hyperion and Landsat 8 data were employed to achieve the study objectives. The study area was classified into four physiographic units including; Alluvial terraces of flat surfaces, Aeolian plain of shifting sands, Sabkhas and Submerged areas. Soil drainage conditions are classified into three categories that described as excessively drained soils located in the Aeolian plain, well drained soils occurred in alluvial terraces and very poorly drained soils that were developed within the waterlogged areas or under the submerged ones. Pearson's correlation coefficients indicated that NDVI for Hyperion data is highly correlated to NDWI, NDMI and NDSI as the correlation coefficient magnitudes are 0.95, 0.75 and 0.82 respectively. They are all above the value of 0.7 (highly correlated variables). Accordingly, NDVI index can be considered as a master index that can be used for well identification of the multiple land cover features and their distributions. Change detection using NDVI data of Landsat 5, 7 and 8 satellite images for the years 1988, 2001 and

2016, respectively were used to map the change in land cover. The cultivated land increased from 1635 to 22616 hectares during the period between 1988 and 2016, meanwhile, the stony soils decreased from 49693 to 23633 hectares. During the same period the shifting sands decreased by 1463 hectares and the urban area increased by 316 hectares. Waterlogged area increased from 1176 to 5204 hectares, while the submerged areas increased by 1181 hectares. It could be concluded that the study area is going to be negatively affected on the long run under the current surface irrigation system on these sandy soils of elevations range from 10 to 50 meters (asl). Also, considering the 30 meters contour line as the line of break slope. The detectable extension of land degradation will most probably occur westwards from that contour line. The seepage of drained water will spread over 35303 hectares to be deteriorated wherever they are cultivated areas or bare ones.

Keywords: Land degradation, Land cover, Change detection, Physiographic soil, NDVI, NDWI, NDMI, NDSI, Landsat8, EO-1data, remote sensing and GIS.

ACKNOWLEDGEMENT

Special and sincere gratitude for **Prof. Dr. Adel El Sayed El Beltagy, Prof.** Emeritus of vegetables, Horticulture Department, Faculty of Agriculture, Ain Shams University for his scientific support and suggestions during this work.

I would like to thank **Prof. Dr. Abdel Aziz Saad Nasr Sheta,** Prof. Emeritus of soil science, in Soil Science Department, Faculty of Agriculture, Ain Shams University who has been a dedicated advisor, throughout my ph.D studies. He has been guidance for my academic work. giving valuable advices in all items of this work.

My sincere thanks extend to **Prof. Dr. Sayed Medany Arafat,** Prof. and Head of Agricultural Applications Department, National Authority for Remote Sensing and Space Sciences (NARSS) for supervising this work, providing suggestions, encouragement valuable data, facilities, and revision of all items of the work.

My greatest debt is to **Dr**. **Mohamed Seifeldeen Abd El-Wahed,** Lecturer of Soil Science, Soil Science Department, Faculty of Agriculture, Ain Shams University, for his continuous support, guidance, fruitful help in the field, in writing the thesis, and suggestions to improve and finalize this work.

The authoress wishes to express her deep gratitude to **Prof. Dr. Afify Abbas Afify,** Head of Research. Emeritus of soils, Soil, Water and Environment Research Institute, Agricultural Research Center, throughout my Ph.D. studies. He provided constant guidance to my academic work. I would like to express my deep gratitude for his valuable advices and revising all items of the work.

Thanks are due to **Prof. Dr. Usama Ahmed El-Behairy** and all other members in Arid Land Agriculture Services and Research Center for their valuable supports

My great appreciation to my **Dear Father, My brothers, my sisters, my Husband, mother of my husband and my Children** for their patience and continuous encouragement during this time.

The authoress would like to express her gratitude to the National Authority for Remote Sensing and Space Sciences **(NARSS)** for providing all required facilities and remote sensing data for this work. I would like to express all deep thanks to my colleagues and friends at NARSS.

CONTENTS

		Page
LIST OF TABLES		**IV**
LIST OF FIGURES		**VI**
LIST OF ABBRIVATION		**VII**
INTRODUCTION		**1**
REVIEW OF LITERATURE		**3**
2.1	The environmental attributes of the study area	3
2.1.1	Climatic elements	3
2.1.2	Natural vegetation	3
2.1.3	Geological units of the study area.	6
2.1.4	Geomorphological features of the study area and its outskirts.	9
2.1.5	Physiographic soil attributes.	13
2.1.6	Drainage condition and soil fertility levels	14
2.1.7	Land cover	15
2.2	Crop delineation from hyper spectral imagery	20
2.3	Land degradation	22
2.3.1	Definition of land degradation	22
2.3.2	Causes of land degradation	23
2.3.3	Types of land degradation	25
2.4	Remote sensing (R.S.)	28
2.4.1	Digital image pre-processing	28
2.4.2	Digital image processing	29
2.4.2.1	Using remote sensing data for assessing LST	32
2.4.2.2	Change detection methods	33
2.4.2.3	Classification accuracy assessment	34
2.5	Remote Sensing (RS) and Geographic Information System (GIS) applications for agricultural purposes	34
MATERIALS AND METHODS		**36**
3.1	Study Area Description	36
3.2	Remote sensing data and ancillary data	38
3.2.1	Hyperion data	38
3.2.2	Multispectral data	38
3.3	Data pre-processing	40
3.3.1	Linear interpolation of sensor	40

3.3.2	Data resizing	43
3.3.3	Atmospheric corrections	43
3.3.4	Geometric corrections	44
3.3.5	Image sub-setting	44
3.3.6	Image enhancement (band combination)	45
3.4	Visual interpretations	47
3.5	Land cover classification	47
3.6	Field work	47
3.6.1	Soil Profiles Description, Sampling and Soil Preparation	47
3.6.2	Laboratory analyses	51
3.7	Data processing	51
3.7.1	Applied spectral indices	51
3.7.2	Identification of land cover classes from NDVI index.	53
3.7.3	Land surface temperature	53
3.7.4	Image post classification	56
3.7.5	Accuracy assessment	56
3.8	The sequence of methodological approach	57
RESULTS AND DISCUSSIONS		**58**
4.1	The current status of land unit features.	58
4.1.1	Topographic features and slope directions.	58
4.1.2	Physiographic unit’s delineation using physiographic approach.	59
4.1.3	Drainage condition as a clue for the deteriorated areas	63
4.1.3.1	Excessively drained soils	63
4.1.3.2	Well drained soils	63
4.1.3.3	Very poorly drained soils.	64
4.1.4	Soil Properties and Soil classification	64
4.1.4.1	Realizing Soil temperature regime based on land surface temperature (LST) and weather station data	65
4.1.4.2	Processing soil taxa for categorizing taxonomic units.	66
4.2	Validity assessment of NDVI for defining land cover	92
4.2.1	NDVI versus other indices of Hyperion data in a pilot area	92
4.2.2	Land cover in the pilot area based on NDVI of Hyperion data	97
4.2.3	Correlation between NDVI values calculated from TM 8 and	98

	Hyperion data.	
4.3	Follow up land degradation using change detection of land cover distributions in the study area	101
4.3.1	Post Classification Change Detection	105
4.3.1.1	LC changes between 1988 and 2001	105
4.3.1.2	LC changes between 2001 and 2016	107
4.3.1.3	LC changes between 1988 and 2016	108
4.4	predictable extension of land deterioration in the study area	111
4.5	Accuracy assessment of land covers classes	112
SUMMARY AND CONCLUSION		**116**
REFERENCES		**120**
APPENDIX		**136**
ARABIC SUMMARY		

LIST OF TABLES

Table		Page
1	Climatic elements of the study area issued by WMO (2016).	4
2	Classification key According to LCCS which was used in the land cover classes.	21
3	Hyperion Sensor (EO-1) Characteristics.	39
4	The Spectral specification of the Landsat 5 Data.	41
5	The Spectral specification of the Landsat 7 Data.	41
6	The Spectral specification of the Landsat 8 Data.	41
7	Parameters used in FLAASH Atmospheric Correction.	44
8	No. of ground truth points for each LC classes for TM data	48
9	No. of ground truth points for each LC classes for Hyperion data	48
10	Physiographic areas of land features in the 2016	60
11	Soil drainage conditions and the associated physiographic units	64
12	Sabkha Particle size distribution, texture class, CaCO3% and gypsum contents (Gypsic Aquisalids, sandy, hyperthermic)	72
13	Sabkha Chemical composition of the soil saturation extract (Gypsic Aquisalids, sandy, hyperthermic)	72
14	Sabkha Particle size distribution, texture class, CaCO¬3% and gypsum contents (Calcic Aquisalids, coarse loamy, mixed, hyperthermic)	76
15	Sabkha Chemical composition of the soil saturation extract (Calcic Aquisalids, coarse loamy, mixed, hyperthermic)	76
16	Alluvial terraces Particle size distribution, texture class, CaCO3, and gypsum contents (Typic Haplocalcids, sandy, mixed, hyperthermic)	81
17	Alluvial terraces Chemical composition of the soil saturation extract (Typic Haplocalcids, sandy, mixed, hyperthermic)	81
18	Alluvial terraces Particle size distribution, texture class, CaCO3, and gypsum contents (Typic Haplocalcids, coarse loamy, mixed, hyperthermic)	84
19	Alluvial terraces Chemical composition of the soil saturation extract (Typic Haplocalcids, coarse loamy, mixed, hyperthermic).	84
20	Aeolian plain Particle size distribution, texture class, CaCO3 and gypsum contents (Typic Torripsamments, mixed, hyperthermic)	90
21	Aeolian plain Chemical composition of the soil saturation extract (Typic Torripsamments, mixed, hyperthermic)	91

22	Physiographic and soil taxa	91
23	The values of indices from Hyperion data	93
24	Pearson's Correlation Matrix between NDVI and other indices for Hyperion image	94
25	Land cover classes based on Hyperion data (EO-1) in the selected projection	97
26	NDVI values of Hyperion and TM8 data versus land cover classes	99
27	Land cover classes in the study area based on TM8 data.	100
28	Summary of Landsat classification area statistics for 1988, 2001 and 2016.	103
29	Cross tabulation for the period between 1988 and 2001 showing gain and losses	106
30	Cross tabulation for the period between 2001 and 2016 showing gain and losses	107
31	Cross tabulation for the period between 1988 and 2016 showing gain and losses	109
32	Confusion matrix for Hyperion land cover classification	113
33	Accuracy totals for the classified images	114
34	Confusion matrix for TM8 land cover classification	114
35	Accuracy totals for the classified images	115

LIST OF FIGURES

Table		Page
1	Climatic data graphed after WMO (2016).	4
2	Geologic Map sourced from UNSECO Cairo Office, (2005).	7
3	Simplified geological map of study area and its vicinity.	9
4	Sinai physiogrphic geomorphic provinces.	12
5	Physiographic soil map of the study area and its outskirts by Masoud (2003).	14
6	Nutrients levels for annual (AC) and perennial crops (PC) versus physiographic units of different drainage conditions in North Sinai.	16
7	Land covers classification system (LCCS).	19
8	Types and processes of soil degradation.	26
9	Location map of the study area.	37
10	Sub scene of Landsat 8 image and the selected frame of Hyperion data.	39
11	Spectral signature of EO-1 Hyperion.	40
12	Spectral signature of Landsat.	42
13	Sub-scenes of Landsat data covering the study area.	42
14	Spectral Curve of Vegetation (a) before FLAASH and (b) after FLAASH.	46
15	Sites of ground observations including soil profiles overlying the TM data projection for the studied area (163527 ha)	49
16	Sites of ground observations overlying the Hyperion data projection for the selected pilot area (14355 ha)	50
17	Illustrated steps of classification method.	54
18	Graphical Model For determine the threshold of the class LC.	55
19	Flow chart of methodology applied in the current study.	57
20	Gross flow directions of drainable water (A) within landscape configuration (B)	59
21	physiographic units of the study area	61
22	Distribution of drainage condition classes within the physiographic units	65
23	Assessing of LST in 2016 (A) in July and (B) in January. Based on the formula of Valor and Caselles, (1996) using TM8 specified bands	67
24	Custom tone mapping of NDMI (A), NDVI (B), NDSI(C) and NDWI (D) values derived from EO-1 data	95
25	Validity assessment of NDVI based on NDWI (A), NDMI (B) and NDSI (C)	96

26	Land covers distributions in a selected projection based on NDVI of Hyperion data	98
27	Land covers spatial distributions in the study area based on NDVI of TM 8.	101
28	custom tones mapping of NDVI values derived from TM5, 7 and 8 data for the years 1988, 2001 and 2016	102
29	The spatial distribution of land cover pattern in the ultimate date 2016	104
30	Net change for LC classes between 1988 and 2001	106
31	Net change for LC classes between 2001 and 2016.	108
32	Net change for LC classes between 1988 and 2016.	109
33	Contributors to net change in cultivated area (1988 – 2016).	110
34	Contributors to net change in water logged area (1988 – 2016).	110
35	Contributors to net change in submerged area (1988 – 2016).	111
36	Predictable extension of land deterioration in the study area.	112