

AGRO-ECOLOGICAL EVALUATION OF SUSTAINABLE AREA FOR CITRUS
CROP PRODUCTION IN RAMSAR DISTRICT, IRAN

HASAN ZABIHI

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Geoinformatics)

Faculty of Geoinformation and Real Estate
Universiti Teknologi Malaysia

JULY 2017

“Dedicated to my wife and my newborn baby”

and

My father and mother

Allah bless them

ACKNOWLEDGEMENTS

I would like to thank my supervisor Assoc. Prof. Dr. Anuar Ahmad for his tremendous support, care, patience, guidance and many hours of valuable discussions. I will always be a proud student of my supervisor whom I admire for his talent as an incredible writer, critical thinker and educator, who has taught me many lessons and has prepared me for academic life in research.

It is my privilege to thank my co-supervisor Assoc. Prof. Mohamad Nor Said, and also, Dr. Eskandar Zand, Dr. Morteza Golmohammadi, Dr. Javad Fattahi Moghaddam, Dr. Sirous Aghajanzadeh, Dr. Seyed Mahdi Banihashemian, Dr. Hormoz Ebadi and Dr. Behrouz Golein for their enormous support and help during the time of preparing this thesis. They give me the encouragement I needed to carry out the research and write the report of the proposal.

My thanks and gratitude to the Faculty of Geoinformation and Real Estate at Universiti Teknologi Malaysia and Citrus and Subtropical Fruits Research Center, Ramsar for providing the academics supports giving me the opportunity to learn many things. Many thanks also to dean and all lectures in the faculty, especially the Department of Geoinformation who have encouraged and helped me to get through the most difficult times and with whom I have enjoyed many great social events.

My sincere thanks to my family especially my wife Mrs. Ladan Rouhani for her endless support and my newborn baby Nikan, positive attitude and encouragement, without which, this thesis would never have been possible. Finally, my gratitude to my mother and father (Allah bless them).

ABSTRACT

Citrus growing is regarded as an important cash crop in Ramsar, Iran. Ramsar District has a temperate climate zone, while citrus is a sub-tropical fruit. Few studies on citrus crop in terms of negative environmental factors have been carried out by researchers around the world. This study aims to integrate Geographical Information System (GIS) and Analytical Network Process (ANP) model for determination of citrus suitability zones. This study evaluates the agro-ecological suitability, determine potentials and constraints of the region based on effective criteria using ANP model. ANP model was used to determine suitable, moderate and unsuitable areas based on (i) socio-economic, morphometry and hydro-climate factors using 15 layers based on experts' opinion; (ii) Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite image of the year 2003 with 98.45% overall accuracy, and (iii) developed Multiple Linear Regression (MLR) model for citrus prediction. Thereby, weighted overlay of 15 factors was obtained using GIS. In this study, the citrus orchards map of 2003 and the new map of the citrus areas of 2014 namely Citrus State Development Program (CSDP) of the study area were compared. The results of this study demonstrated: (i) suitable areas (free risk areas) based on negative environmental factors and areas which are susceptible to citrus plantation; (ii) high-risk areas which are unsuitable for citrus plantation, and (iii) the high weights derived by ANP model were assigned to altitude, frost and minimum temperature. The MLR model was successfully developed to predict citrus yield in Ramsar District by 10% error. The MLR model would propose optimum citrus crop production areas. As conclusion, the main outcome of this study could help growers and decision makers to enhance the current citrus management activities for current and future citrus planning.

ABSTRAK

Penanaman sitrus boleh dianggap sebagai tanaman tunai penting di Ramsar, Iran. Daerah Ramsar yang mempunyai zon iklim sederhana, manakala sitrus adalah buah sub-tropika. Beberapa kajian tentang penanaman sitrus dari segi faktor-faktor alam sekitar yang negatif telah dilaksanakan oleh penyelidik di seluruh dunia. Kajian ini bertujuan untuk menilai mengintegrasikan sistem maklumat geografi (GIS) dan model proses analitik jaringan (ANP) untuk penentuan zon-zon sitrus yang sesuai. Kajian ini menilai kesesuaian ekologi pertanian, menentukan potensi dan kekangan kawasan berdasarkan kriteria berkesan dengan menggunakan model ANP. Model ANP telah digunakan untuk menentukan kawasan-kawasan yang sesuai, sederhana dan tidak sesuai berdasarkan (i) sosio-ekonomi, morfometri dan faktor-faktor hidro-iklim menggunakan 15 lapisan berdasarkan pendapat pakar, (ii) imej satelit Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) bagi tahun 2003 dengan 98.45% ketepatan menyeluruh, dan (iii) membangunkan model regresi linear berbilang (MLR) untuk ramalan sitrus. Dengan itu pemberat lapisan bagi 15 faktor diperolehi dalam GIS. Dalam kajian ini, peta dusun-dusun sitrus 2003 dan peta baru 2014 bagi kawasan-kawasan sitrus yang dinamakan program pembangunan sitrus negeri (CSDP) bagi kawasan kajian telah dibandingkan. Hasil kajian ini menunjukkan: (i) kawasan-kawasan yang sesuai (kawasan bebas risiko) berdasarkan faktor-faktor alam sekitar utama yang negatif dan kawasan-kawasan yang berkemungkinan ada penanaman sitrus, (ii) kawasan-kawasan berisiko tinggi yang tidak sesuai untuk penanaman sitrus, dan (iii) pemberat tinggi yang diperolehi dari model ANP untuk altitud, fros dan suhu minimum. Model MLR dibangunkan dengan jayanya untuk meramal hasil sitrus di Daerah Ramsar dengan selisih 10%. Model MLR mencadangkan kawasan-kawasan pengeluaran tanaman sitrus optimum. Kesimpulannya, hasil utama kajian ini dapat membantu penanam dan pembuat keputusan untuk menambah baik aktiviti-aktiviti pengurusan sitrus untuk perancangan semasa dan yang akan datang.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xii
	LIST OF FIGURES	xvii
	LIST OF ABBREVIATIONS	xxii
	LIST OF APPENDICES	xxv
1	INTRODUCTION	1
	1.1 Background	1
	1.2 Problem Statement	7
	1.3 Aim of Study	9
	1.4 Objectives of Study	10
	1.5 Scope of Study	10
	1.6 Significance of Study	11
	1.7 Thesis Outline	12
2	LITERATURE REVIEW	14
	2.1 Introduction	14
	2.5 Sustainability Concept in Crop Production	15
	2.4 The Concept of Agro-ecological Evaluation	18

2.3	Citrus Distribution, production and Phenology	19
2.5	Environmental Factors	22
2.5.1.	Hydro-climatic Factors	23
2.5.2	Morphometry Factors	26
2.5.3	Socio-economic Factors	27
2.6	Ecological Suitability Approach	27
2.7	Ecological Suitability Approach in Iran	35
2.8	Agro-ecological Approach Using GIS, Remote Sensing and Limitation Factors	38
2.9	ANP Approach as Multi-Criteria Evaluation Techniques, Definition and Application	51
2.10	Site Selection Procedure Using ANP in Comparison with AHP	56
2.11	Multiple Linear Regression (MLR) Model Description	59
2.11.1	Dependent Variable and Independents variables	62
2.11.2	Parametric Data and Non-Parametric Data	62
2.11.3	Parametric Regression Methods	
2.12	Summary	63
3	METHODOLOGY	65
3.1	Introduction	65
3.2	Study Area	65
3.3	Framework of the Research Study for Citrus Suitability Zones	67
3.4	Data Collection	69
3.5	Data Acquisition and Processing	70
3.6	Elevation of the Study Area	72
3.7	Hydro-Climate Factors of Ramsar County	75
3.7.1	Temperature	75
3.8	Hydro-Climate Data Procedure	78

3.8.1	Temperature Isolines	84
3.8.2	Rainfall as Isohyets Map	84
3.8.3	Calculating HeatUnits or Growing Degree Days	87
3.9	Relative Importance Index (RII)	91
3.10	Questionnaire Using ANP Model	91
3.10.1	Weighted Overlay Method	101
3.11	Multiple Linear Regression (MLR) Model as Statistical Analysis	104
3.11.1	T-test Analysis	107
3.11.2	Durbin-watson Test and Kolmogorov– Smirnov test	107
3.11.3	Correlation Coefficients	108
3.11.4	Fisher Test Analysis	108
3.11.5	P-value	109
3.12	Satellite Data Processing	109
3.13	General Methodology	110
3.13.1	Image Preprocessing	110
3.13.1.1	Radiometric and Atmospheric Correction	110
3.13.1.2	Geometric Correction	112
3.13.1.3	Accuracy Assessment	112
3.14	Summary	114
4	RESULTS AND DISCUSSION	115
4.1	Introduction	115
4.2	Map Classification	116
4.3	Results of the Questionnaire	116
4.4	Evaluation of Current and Suitable Regions for Citrus Production	124
4.4	Temperature and Rainfall Ranges as Climate Variables	127
4.5	The Aspect of the Study Area	137

4.6	Relative Humidity	138
4.8	Growing Degree Days (GDD)	140
4.9	Sunshine Hours	142
4.10	Water Available (spring, water wells and river)	143
4.10.1	Springs	144
4.10.2	Distance to Water Wells Criterion	146
4.10.3	Distance to River Criterion	149
4.11	Population Areas	152
4.12	Proximity to Roads Network	154
4.13	Rainfall Ranges in Ramsar	157
4.14	Topography	159
4.15	Slope of the Study Area	161
4.16	Land-use/Cover Classification of the Study Area	162
4.17	Optimum Land Suitability Analysis for Citrus Crop Production	170
4.18	Statistical Analysis	175
4.18.1	Statistical Analysis of Altitude	177
4.18.2	Statistical Analysis of Frost	179
4.18.3	Statistical Analysis of Minimum Temperature	181
4.18.4	Statistical Analysis of Distance to River	183
4.18.5	Statistical Analysis of Distance to Water Well	185
4.18.6	Statistical Analysis of Distance to Springs	187
4.18.7	Statistical Analysis of Rainfall	191
4.18.8	Statistical Analysis of Aspect	193
4.18.9	Statistical Analysis of Slope	
4.18.10	Statistical Analysis of population Areas	195
		197

4.18.11	Statistical Analysis of Maximum Temperature	199
4.18.12	Statistical Analysis of Relative Humidity	201
4.18.13	Statistical Analysis of Distance to Roads	203
4.18.14	Statistical Analysis of Sunshine Hours	205 208
4.18.15	Statistical Analysis of Growing Degree days	220
4.19	Results of Developed MLR Model	
4.20	Summary	
5	CONCLUSIONS AND RECOMMENDATIONS	221
5.1	Introduction	221
5.2	Summary of Main Finding and Discussion	221
5.3	Conclusions	224
5.4	Recommendations	225
5.5	Limitation of Thesis	227
	REFERENCES	228
	Appendices A-I	264-296

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1.1	Top ten total citrus fruit producers in 2007 (tones) (FAO, 2007)	4
2.1	The timing of seasonal vegetative and reproductive phenological events for citrus for regions in the temperate Northern Hemisphere (Connellan <i>et al.</i> , 2010)	21
2.2	Evaluation indexes of ecological suitability of tobacco crops (Chen <i>et al.</i> , 2010a)	28
2.3	Land suitability classification (Chen <i>et al.</i> , 2010b)	32
2.4	Input parameters for the land capability and land allocation model (Tenerlli and Carver, 2012)	49
2.5	Models for crop production in Iran and other countries	50
2.6	Advantages and disadvantages of analytical network process (ANP) and Analytical hierarchy process (AHP) as multi-criteria decision making (MCDM) methods	57
3.1	List of datasets used in the study	70
3.2	Meteorological stations in and around the study area (Climatic Atlas of Iran, I.R. of Iran Meteorological Organization, 2010)	76
3.3	The mean temperature and the mean minimum temperature (30 years period) of the study area (Ramsar Synoptic Station Statistics, 2007)	76

3.4	Absolute minimum air temperature (the lowest recorded temperature) (50 years period) of the study area. (Ramsar Synoptic Station Statistics, 2010)	77
3.5	Number of days with freezing temperature in the study area from the year 1955-2005 (Ramsar Synoptic Station Statistics, 2007)	78
3.6	Meteorological stations in and around study area (Climatic Atlas of Iran, I.R. of Iran Meteorological Organization, 2010)	86
3.7	The average temperatures (25 years period) from 1985 to 2010 derived from five meteorological stations	89
3.8	GDDs for five stations from 1985 to 2010 in the study area	90
3.9	The fundamental scale of absolute numbers in questionnaire (Saaty, 1997)	95
4.1	The final rank of the most critical criteria (importance of criteria) for citrus crop production in Ramsar district	124
4.2	The mean rainfall (30 years period) of the study area (Ramsar Synoptic Station Statistics, 2010)	159
4.3	The seasonal rainfall amount (mm) and percentage of the case study (Synoptic Station of Ramsar, 30 years period, 2010)	159
4.4	RMSE of eight ground control point in the study area	163
4.5	The land use and land cover classification accuracy in Ramsar district	165
4.6	The percentage of land-use/cover in 2003 of the study area	167
4.7	The average citrus crop yield (tones/hectares) in three sites in Ramsar district (reference: Ramsar agricultural and natural resources organization)	174
4.8	The descriptive statistics and Kolmogorov-Smirnov test factors	176

4.9	Pearson correlation coefficients and coefficients of determination between altitude and citrus production	177
4.10	ANOVA testing between altitude and citrus production	178
4.11	Analysis of regression coefficient between altitude and citrus production	178
4.12	Pearson correlation coefficients and coefficients of determination of frost and citrus production	179
4.13	ANOVA testing between frost and citrus production	180
4.14	Analysis of regression coefficient between frost and citrus production	180
4.15	Pearson correlation coefficients and coefficients of determination of minimum temperature and citrus production	181
4.16	ANOVA testing between minimum temperature and citrus production	182
4.17	Analysis of regression coefficient between minimum temperature and citrus production	182
4.18	Pearson correlation coefficients, coefficients of determination of distance to river and citrus production	183
4.19	ANOVA testing between distance to river and citrus production	184
4.20	Analysis of regression coefficient between distance to river and citrus production	184
4.21	Pearson correlation coefficients and coefficients of determination of distance to water well and citrus production	185
4.22	ANOVA testing between distances to water well and citrus production	186
4.23	Analysis of regression coefficient between distance to water well and citrus production	186
4.24	Pearson correlation coefficients and coefficients of determination of distance to springs and citrus production	187

4.25	ANOVA testing between distance to springs and citrus production	188
4.26	Analysis of regression coefficient between distance to springs and citrus production	188
4.27	Pearson correlation coefficients and coefficients of determination of rainfall and citrus production	189
4.28	ANOVA testing between rainfall and citrus production	190
4.29	Analysis of regression coefficient between rainfall and citrus production	190
4.30	Pearson correlation coefficients and coefficients of determination of aspect and citrus production	191
4.31	ANOVA testing between aspect and citrus production	192
4.32	Analysis of regression coefficient between aspect and citrus production	192
4.33	Pearson correlation coefficients and coefficients of determination of slope and citrus production	193
4.34	ANOVA testing between slope and citrus production	194
4.35	Analysis of regression coefficient between slope and citrus production	194
4.36	Pearson correlation coefficients and coefficients of determination of population areas and citrus production	195
4.37	ANOVA testing between population areas and citrus production	196
4.38	Analysis of regression coefficient between population areas and citrus production	196
4.39	Pearson correlation coefficients and coefficients of determination of maximum temperature and citrus production	197
4.40	ANOVA testing between maximum temperature and citrus production	198
4.41	Analysis of regression coefficient between maximum temperature and citrus production	198

4.42	Pearson correlation coefficients and coefficients of determination of relative humidity and citrus production	199
4.43	ANOVA testing between relative humidity and citrus production	200
4.44	Analysis of regression coefficient between relative humidity and citrus production	200
4.45	Pearson correlation coefficients and coefficients of determination of distance to roads and citrus production	201
4.46	ANOVA testing between distance to roads and citrus production	202
4.47	Analysis of regression coefficient between distance to roads and citrus production	202
4.48	Pearson correlation coefficients and coefficients of determination of sunshine hours and citrus production	203
4.49	ANOVA testing between sunshine hours and citrus production	204
4.50	Analysis of regression coefficient between sunshine hours and citrus production	204
4.51	Pearson correlation coefficients and coefficients of determination of growing degree days and citrus production	205
4.52	ANOVA testing between growing degree days and citrus production	206
4.53	Analysis of regression coefficient between growing degree days and citrus production	206
4.54	Summarizes the overall model statistics of the regression conducted in this study using SPSS software version 16.0.	207
4.55	Numerical values of 15 factors in suitable area in Ramsar district	209
4.56	Numerical values of 15 factors in moderate area in Ramsar district	209

4.57	Numerical values of 15 factors in unsuitable area in Ramsar district	210
4.58	The regression coefficients and constant of 15 factors and the true data (17 citrus yields) in Ramsar district	216
4.59	The actual dataset and predicted of citrus yield, absolute percentage error and mean percentage error of MLR model in Ramsar district in three sites	217

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Example of two different species of citrus trees (left panel shows sweet orange and the right panel shows mandarin). (Source: Tree pictures online.com)	2
1.2	Major producers of citrus fruits (FAO, 2007)	3
2.1	Agricultural sustainability as described by the intersection of three disciplines: ecology, economics and sociology (Bongiovanni and Lowenberg-Deboer, 2004)	16
2.2	Major citrus growing areas in Iran	21
2.3	Main steps used to build a land suitability map (Joerin <i>et al.</i> , 2001)	33
2.4	Land evaluation procedure performed in GIS (Martin and Saha, 2009)	39
2.5	Proposed agricultural sustainability assessment indicators in Bangladesh (Roy and Chan, 2012)	44
3.1	Location map of the study area in Mazandaran province, Iran (Ramsar agricultural and natural resources organization, 2014)	66
3.2	The flowchart of citrus suitability analysis and determination of the limitation zones	68
3.3	DEM of the Study Area	73
3.4	3D DEM of the Study Area	74
3.5	The lethal freezing temperature in the study area in January 2008 (Zabihi, 2008)	77

3.6	Regression trend between annual mean temperature and elevation using Curve Expert software	79
3.7	Flowchart of Processing of hydro-climatic data input into Curve Expert software	82
3.8	Input meteorological stations in and around study in excel 2007	82
3.9	A schematic process of 15 factors using raster calculator into ArcGIS 10.2	83
3.10	Regression trend between cumulative rainfall and elevation using Curve Expert software	85
3.11	Flowchart illustrating the multi-criteria model used for the assessment of citrus suitability	92
3.12	Decision making with ANP modeling	93
3.13	Selected critical criteria in Ramsar, Iran using ANP framework in Super Decision software window	95
3.14	The sample questionnaire of pairwise node comparison	96
3.15	General structure of the supermatrix (Neaupane and Piantanakulchai, 2006)	98
3.16	Adding all 15 data layers in ArcMap	100
3.17	Weighting analysis using raster calculator in ArcGIS	101
3.18	Suitability analyses using weighting overlay in ArcGIS	104
4.1	Comparison of other criteria with respect to altitude and its inconsistency index	117
4.2	Comparison of other criteria with respect to aspect and its inconsistency index	118
4.3	Comparison of other criteria with respect to slope and its inconsistency index	118
4.4	Comparison of other criteria with respect to frost and its inconsistency index	119
4.5	Comparison of other criteria with respect to the minimum temperature and its inconsistency index	119
4.6	Comparison of other criteria with respect to maximum temperature and its inconsistency index	120

4.7	Comparison of other criteria with respect to rainfall and its inconsistency index	120
4.8	Comparison of other criteria with respect to growing degree days and its inconsistency index	121
4.9	Comparison of other criteria with respect to population area and its inconsistency index	121
4.10	The sample questionnaire of pairwise node comparison	122
4.11	Matrix final weights after normalization	123
4.12	Citrus suitability map based on mean minimum temperature	125
4.13	Citrus suitability map based on mean maximum temperature	126
4.14	Annual mean temperature map (scale: 1:50,000)	128
4.15	The mean minimum temperature map (scale: 1:50,000)	129
4.16	Cut-off citrus trees due to a severe freeze in the study area in February 2014	130
4.17	Two major frost damages in January 2008 and February 2014 in the study area	131
4.18	The effect of high temperature as a limiting factor that cause injury in the study area	132
4.19	Citrus suitability map based on rainfall ranges	134
4.20	Citrus suitability map based on altitude ranges	136
4.21	Geographical aspects of the study area	138
4.22	The mean relative humidity in the study area	140
4.23	Growing degree days of the study area	141
4.24	The annual sunshine hours of the study area	143
4.25	The spatial distribution of springs in the study area (source: Ramsar agricultural and natural resources organization, 2014)	145
4.26	Classification of springs buffer in the study area	146
4.27	The geographical distribution of wells within the study area	147
4.28	Wells buffer in the study area	148

4.29	The rivers flow in the study area	150
4.30	The river buffer zone in the study area	151
4.31	Change of orchards land-use to build-up areas in urban space of the study area	153
4.32	The buffer zone of urban population areas	154
4.33	The roads network in the study area	155
4.34	Three classified roads network buffer map	156
4.35	Climatograph of the study area (30 years period) from 1980 to 2010	157
4.36	The seasonal rainfall distribution in the study area (Synoptic Station of Ramsar, 30 years period, 2010)	158
4.37	Topography map of the study area (1:50,000 scale)	160
4.38	The slope of the study area	162
4.39	The ground control point (GCP) which were used for the classification accuracy assessment in the study area (ASTER imagery, Date of acquisition: 6th October 2003)	164
4.40	Seven classifications of land-use/cover types based on ASTER image	166
4.41	The citrus orchards distribution in the study area in 2003	169
4.42	The final map of citrus production areas derived from ANP along with citrus distribution in the study area derived from ASTER imagery	171
4.43	The percentage of citrus suitability value in Ramsar district in 2003	172
4.44	The overlay of current citrus orchards distribution in the study area in 2014 (Source: Ramsar agricultural and natural resources organization)	173
4.45	The percentage of current citrus suitability value in Ramsar district in 2014	175
4.46	The actual citrus yield (17 orchards) in three sites at an average of 10 years	211

4.47	The scatter plots based on the dependent variable (citrus yield) and 15 independent variables	213
4.48	Correlation between the actual and the multiple linear regression model predicted in citrus yield (ton/hect) for training data	219
4.49	Correlation between the actual and the multiple linear regression model predicted in citrus yield (ton/hect) for validation data	219

LIST OF ABBREVIATIONS

AEZ	-	Agro-Ecological Zones
AHP	-	Analytic Hierarchy Process
ALES	-	Automated Land Evaluation System
ANOVA	-	Analysis of Variance
ANP	-	Analytic Network Process
ASTER	-	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATCOR	-	Atmospheric Correction
B.C.	-	Before Christ
C	-	Carbon
°C	-	Degree Centigrade
CL ⁻	-	Chloride
DEM	-	Digital Elevation Model
Df	-	Degree of Freedom
DSS	-	Decision Support System
DTM	-	Digital Terrain Model
Elev	-	Elevation
ES	-	Ecological Suitability
ESRI	-	Environmental Systems Research Institute
ETM ⁺	-	Enhanced Thematic Mapper Plus
EVI	-	Ecological Vulnerability Index
FAO	-	Food and Agriculture Organization
FLOWA	-	Fuzzy Linguistic Ordered Weighted Averaging
GDD	-	Growing Degree Days
GIS	-	Geographical Information System

GPS	-	Global Positioning System
IFI	-	Integrated Ecology Suitability Index
ILWIS	-	Integrated Land and Water Information System
K	-	Potassium
L.	-	Linnaean
Lat.	-	Latitude
LCA	-	Land Capability for Agriculture
LCC	-	Land Capability Classification
LEIGIS	-	Land Evaluation uses Intelligent GIS
Lon.	-	Longitude
LSIs	-	Land Suitability Indices
MCA	-	Multi Criteria Analysis
MCE	-	Multi Criteria Evaluation
MCDA	-	Multi Criteria Decision Analysis
MCDM	-	Multi Criteria Decision Making
MLR	-	Multiple Linear Regression
mm	-	Millimeter
MOLA	-	Multi Objective Land Allocation
MSL	-	Mean above Sea Level
N	-	Nitrogen
NASA	-	The National Aeronautics and Space Administration
NDVI	-	Normalized Difference Vegetation Index
NDWI	-	Normalized Difference Water Stress Index
NSP	-	Natural and Social Pressure
OWA	-	Ordered Weighting Averaging
P	-	Phosphorus
PH	-	Potential (Power) of Hydrogen
RC	-	Recovery Capacity
RMSE	-	The Root Mean Square of Error
ROI	-	Region of Interest
RS	-	Remote Sensing
SBI	-	Soil Brightness Index

SMCE	-	Spatial Multi Criteria Evaluation
SP.	-	Species
SPP.	-	Species
SPSS	-	Statistical Package for the Social Sciences
SQL	-	Structure Query Language
TEMP	-	Temperature
TM	-	Thematic Mapper
UK	-	United Kingdom
USD	-	United States Dollar
UTM	-	Universal Transverse Mercator
WLC	-	Weighted Linear Combination
WHO	-	World Health Organization

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Questionnaire	264
B	Results of comparison between weighted and unweighted matrix score	269
C	Top selection meteorological stations in and around study area	273
D	List of Publications	274
E	The personal information of experts group	275
F	The Results of Statistical Analysis Using MLR model	279
G	Morgan Table	290
H	Expert Questionnaire Form for Relative Importance Index	291
I	The Numerical Data related to the 15 environmental Factors and Citrus Yield at Three Sites in Ramsar	296

CHAPTER 1

INTRODUCTION

1.1 Background

Citrus is a genus of flowering perennial plants of the family Rutaceae and sub-family of Aurantioideae. Citrus is one of the world's most important fruit cash crops. It is widely grown in the tropical, subtropical and borderline subtropical areas of the world (CDCGC, 2004). Citrus species grow as large shrubs or small trees about 2-8 meters high, bearing alternate, evergreen leaves, typically aromatic flowers, and large, conspicuously colored (usually orange, orange-red, yellow or green), edible and aromatic fruits. Orange fruits are reddish-green to yellowish-green, rounded, 4-12 cm and the onset of flowering and begin to bear fruit after 3-5 years. Trees' flower and fruits mature differently in different regions around the world. Citrus flowering occurs in April and May in Ramsar district, Iran and some fruits mature from the end of October to February. Figure 1.1 shows an example of two different species of citrus trees.

Citrus is primarily valued for the fruit, which is either eaten alone (sweet orange, tangerine, grapefruit, etc.) as fresh fruit, processed into juice, or added to dishes and beverages (lemon, lime, etc.). All species have traditional medicinal value. Citrus has many other uses including animal fodder and craft and fuel wood.



Figure 1.1 Example of two different species of citrus trees (left panel shows sweet orange and the right panel shows mandarin). (Source: Tree pictures online.com)

Citrus fruits are rich in vitamin C. In brief, vitamin C properties are mentioned below:

- i. Degradation of cholesterol, which helps protecting against heart disease;
- ii. Reduction of the severity and duration of cold symptoms;
- iii. Anticancer properties;
- iv. Reduction of the risk of iron deficiency, which causes anemia;
- v. Relieve tension, generally strengthen of the body, anti-toxin, anti-seizure medication, etc. (source: www.FAO/WHO.org, 2002).

The importance of citrus horticulture in the world context is shown by its worldwide distribution and its large-scale production. Citrus production (including oranges, grapefruit, tangerines and mandarins, lemons and limes) has experienced continuous growth in the last decades of the twentieth century, reaching a total annual production of more than 120 million tons (FAOSTAT, 2010). Figure 1.2 shows the main production areas in the world.

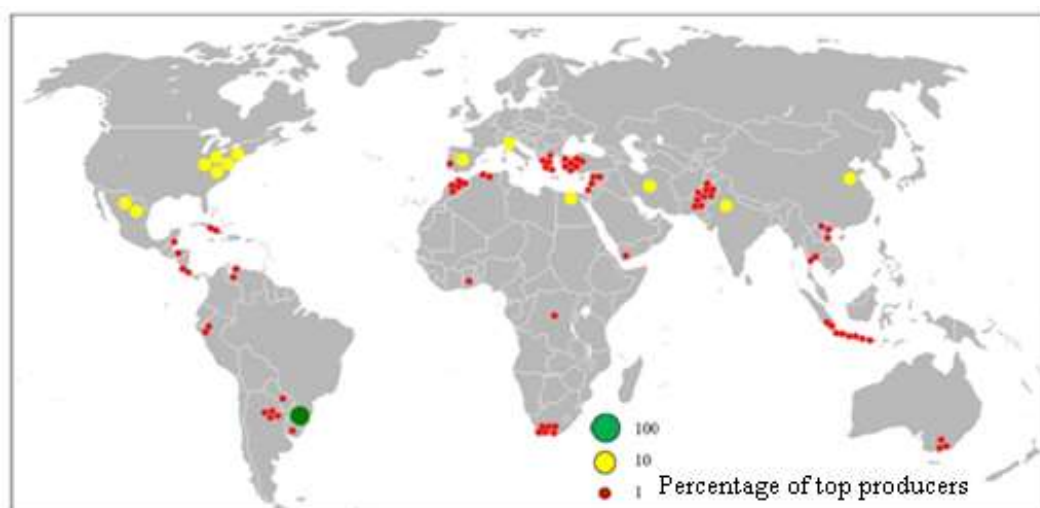












Figure 1.2 Major producers of citrus fruits (FAO, 2007)

Table 1.1 shows top ten major citrus fruit producers. Citrus is grown commercially in more than 140 countries around the world in tropical and sub-tropical climates (approximately 40°N and 40°S of the equator). Due to the citrus adaptation to the tropical and subtropical conditions, these species are easily dispersed around the world.

Table 1.1: Top ten total citrus fruit producers in 2007 (tonnes) (FAO, 2007)

Country	Grapefruit	Lemon and Limes	Oranges	Tangerine, etc.	Other	Total (fruit production)
 Brazil	72,000	1,060,000	18,279,309	1,271,000	-	20,682,309
 China	547,000	745,100	2,865,000	14,152,000	1,308,000	19,617,100
 U.S.A	1,580,000	722,000	7,357,000	328,000	30,000	10,017,000
 Mexico	390,000	1,880,000	4,160,000	355,000	66,000	6,851,000
 India	178,000	2,060,000	3,900,000	-	148,000	6,286,000
 Spain	35,000	880,000	2,691,400	2,080,700	16,500	5,703,600
 Iran	54,000	615,000	2,300,000	702,000	68,000	3,739,000
 Italy	7,000	546,584	2,293,466	702,732	30,000	3,579,782
 Nigeria	-	-	-	-	3,325,000	3,325,000
 Turkey	181,923	706,652	1,472,454	738,786	2,599	3,102,414
World	5,061,023	13,032,388	63,906,064	26,513,986	7,137,084	115,650,545

Iran has always been a major component of citrus production in the world. According to FAO 2007, Iran is ranked seventh in the production of grapefruit, lemon and sweet orange and fifth in the mandarin production in the world. Citrus growing in Iran has a very old history, which goes back as far as 330 BC (Ebrahimi, 2000). Citrus is the most important fruit crop in the world and citrus cultivation in the entire world is 7,600,000 hectares and 290,000 hectares in Iran (FAO, 2007). This study has addressed Ramsar district that is located in Mazandaran province as the biggest producer of citrus with forty-seven percent of the produced citrus crop in Iran. Ramsar district is chosen as the target sample of the study as it is ranked fifth in the Mazandaran province. (Ramsar Agricultural Organization, census bureau, 2010).

There are two major citrus areas in Iran, the Caspian Sea belt and the coast of the Persian Gulf and the Gulf of Oman (southern coastal belt). In the frosty and snowy winter seasons (end of December to February), the damage of citrus fruits by frost is inevitable. In this region, the harvesting time is coincident with late autumn and early winter seasons (end of November to February). In other words, in some years due to frost period and snowy days, all crop yields are destroyed. In reality, the effective environmental parameters and lack of recognition of ecological region's potential were ignored in the area. Citrus production is the main occupation for the growers of this region. Hence, this research attempts to identify negative factors and their effect on citrus production.

The population of the planet is growing dramatically. The farming community is responsible for meeting the increasing demand for food. To ensure a sustainable development and use of resources, planners must know completely and exactly the limitations and capacities of a given area. Knowing the environment extent and its events, conditions and changes are interest. The economic development of each country is largely dependent on its ecological capability derived from its the agricultural production capacity. Land use planning and ecological land capability evaluation are considered the most important tools and factors of sustainable development. There are two concepts that are basic to the system. The first concerns the potential of the land for use in specified ways and the second concern specified management practices (Davidson, 1992).

Land use planning is the process for optimum utilization of human and natural resource potential in the achievement of objectives, growth and balanced society and region. Hence, land suitability analysis is the process of determining the fitness (potentials and constraints) of a given tract of land for a defined use (Steiner *et al.*, 2000). In other words, land suitability is the fitness of a certain area of land for a specific use and to determine the suitability level or/and any decision on sustainable land use, which is influenced by these potentials and constraints (Dent and Young, 1981).

The use of Geographical Information System (GIS) on land use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability/habitat for animal and plant species (Store and Kangas, 2001), suitability of land for agricultural activity (Kalogirou, 2002) and regional planning (Janssen and Reitseveld, 1990). GIS technology certainly plays a significant part in a precise agriculture scheme (Washington-Ottombre *et al.*, 2010 ; Palaniswami *et al.*, 2011; Walke *et al.*, 2012). GIS is used in the field to the scientific analysis of production data at the farm manager's office, and plays an increasing role in the agricultural production throughout the world by helping farmers to increase production, reduce costs, and manage their land more efficiently (ESRI, 2009; 2011). Analytic Network Process (ANP) (Saaty, 2004) and computer based planning tools like GIS can assist in the analysis, integration and interpretation of information (Bojorquez *et al.*, 2001; Ayad, 2005).

GIS acts as a powerful tool to analyze both spatial and attribute data and proved its potential to interpret data more accurately (Burrough, 1986; Cowen, 1988; Star and Estes, 1990; Clarke and Lowell 2002; Malczewski, 2004; Longley *et al.*, 1999; 2005). It has been widely used in agricultural production, planning and management including citrus growing (Wu *et al.*, 2011). It has successfully indicated areas with the most potential based on the multi-criteria characteristics and also recommended ecological potential and suitable crops to grow all year round. GIS technique is a computer-based technology that describes, stores, manipulates and analyses spatial information. It also presents outputs in the map and tabular for decision making in the planning aspects of agricultural development.

Dent and Young (1981) defined land evaluation as the process of estimating the potential of land for alternative kinds of land use. Conventionally, land capability systems have been used for the following reasons:

- i. to contribute to the national inventory of land resources;
- ii. to provide a standardized method for assessing land quality as a key component of strategic land use, environment and amenity planning;
- iii. as a basis for planning and management, particularly at farm level;

- iv. as a component of land evaluation, including the attribution of ecologic and economic value.

Since the late 1980s, multi- criteria analysis (MCA) has been coupled with GIS to enhance multi-criteria evaluation (MCE) methods. Several researcher's have studied multi-criteria decision making (MCDM) in field of agriculture, land use planning, site selection decision and remote sensing (Joerin *et al.*, 2001; Gomes and Lins, 2002; Feick and Hall, 2004; Agrell *et al.*, 2004; Khoram *et al.*, 2005; Perveen *et al.*, 2007; Preda *et al.*, 2007; Tang *et al.*, 2007; Tao *et al.*, 2007; Radiarta *et al.*, 2008; Ismail, 2009; Abdi *et al.*, 2009; Ligmann-Zielinska and Jankowski, 2010; Chen *et al.*, 2010a; Etazarini, 2011; Pourebrahim *et al.*, 2011; Sahnoun *et al.*, 2012).

GIS is playing an active role in spatial modeling (Yaakup *et al.*, 2004) spatial problems, such as global and regional changes (Jelineski, 1994) involve a large number spatial decision problems (Malczewski, 2006) and providing alternative scenarios (Yaakup *et al.*, 2005). GIS provides facilities to use geographic information to help with decision making and problem solving. GIS, however, is not an automated decision making system, but a tool to query analysis and produce a map in support of the decision making process (Burrough, 1986).

1.2 Problem Statement

Preserving the ecological potential would be realized, whenever land is used according to its capacity and potential. If natural and environmental boundaries were considered in optimum production, the investment would not be wasted.

The geographical environment is dynamic and for having this trait, its changes should be understood and evaluated correctly. In this study, Ramsar district is selected which is located in the west of the Mazandaran province in Iran. The altitude of Ramsar begins at a height of -20 meters near the Caspian Sea to 3600 meters above sea level in the Alborz Mountains. The lowest mean minimum temperature of Ramsar over a-

30 year period is 1.9 °C, while the lowest recorded temperature was -10 °C in January (Ramsar Synoptic Station Statistics, 2010).

In addition, there were two frosts in January 2008 and February 2014 as severe as -3 °C and continued for several days, which was very critical and damaging to citrus (fruits and trees). In fact, the snow destroyed some citrus fruits in this area. The cost of the damage was estimated at around USD 400,000,000 (Sadeghi and Ghanbari, 2008). In reality, citrus trees are semi-tropical plant in origin and cannot tolerate severe frosts and realistically temperatures not falling below -2 °C for successful cultivation (Ghazvini and Moghaddam, 2007). However, the north of Iran (the Caspian Sea belt, particularly), and in some regions of Ramsar county have high potential for production and cultivation of citrus due to favorable ecological potential and climate indicators which make them suitable for citrus planting.

In the literature, few studies were carried out in the field of citrus crop in terms of negative environmental factors. This study is concerned with critical criteria and its impact on citrus as a crucial factor. Many previous researches have been carried out in terms of ecological capability of a given area and used all criteria i.e. climate, soil characteristics and topography criteria, but it was not enough (Khoram *et al.*, 2005; Sahnoun *et al.* 2012). Indeed, in the context of environmental assessment based on negative criteria are not considered as the main effective factors on citrus crop production and fruit quality. Few papers deal with integration of GIS-ANP model to evaluate the agro-ecological suitability and spatial distribution of citrus crops. Furthermore, previous researchers ignored the critical factors, and this had the drastic impact leading to the destruction of citrus (fruits and trees) crops in Iran.

Furthermore, a Multiple Linear Regression (MLR) model was developed to validate the results of ANP model regarding citrus production. It should be sataed that, there is no established model done to associate the production of citrus with all those parameters. There is the main gap between suitable regions and citrus planning procedure in Ramsar district, Iran.

In previous studies in overseas (e.g., Ceballos-Silva and López-Blanco, 2003a, b; Kalibatas and Turskis, 2008; Chen *et al.*, 2010a; Wu *et al.* 2011; Li *et al.*, 2012;

Chung and Kim, 2014; Caubel *et al.*, 2015) criteria were considered as climate criteria while the integration of three main factors including socio-economic, hydro-climate and morphometry are neglected. Indeed, this study will try to create limitation layers such as isohyets diagram, minimum and maximum temperature isolines map, relative humidity, population areas, proximity to the river, and road networks could help the user to analyze the suitable regions using analytical network process (ANP) method.

This study focuses on the critical factors that evaluate the agro-ecological suitability and spatial distribution of citrus using GIS and ANP model. This study also attempts to identify problems that significantly influence the production of citrus fruits (crop production). Ultimately, the final map for suitable regions or/and unsuitable regions (high risk for planting) will be created based on the limitation factors for citrus trees and fruits.

The results of this study could surely enhance future citrus crop production planning process of the study area. Accordingly, there is a need to design integrated approaches for agro-ecological suitability, applying techniques such as GIS-ANP to help in bridging the gap between negative factors and citrus crop production planning process. Finally, it needs to design integrated approaches for two main reasons. Firstly, this improves assessment of citrus suitability areas using GIS-based ANP and applying prediction analysis using the developed Multiple Linear Regression (MLR) model.

1.3 Aim of Study

The aim of this research is to identify suitable areas for citrus production using the integration of GIS-based ANP model and developed MLR model. The results of this study demonstrate suitable area for citrus production based on environmental factors in Ramsar district, Iran.

1.4 Objectives of Study

The objectives of the study are as follows:

- i. To identify the hydro-climate, socio-economic and morphometry factors that influence on the citrus production.
- ii. To integrate GIS-based Analytical Network Process (ANP) to generate citrus suitability map
- iii. To develop a Multiple Linear Regression (MLR) model to predict citrus yield.

1.5 Scope of Study

This research focuses on identifying limitation factors in the study area including minimum temperature, maximum temperature, relative humidity, GDD (growing degree-days), sunshine hours, frost, water available (accessibility to spring, water well and river) as hydro-climate factors. Morphometry factors including slope, aspect and altitude. Socio-economic factors including population areas and proximity to roads network (road accessibility). These factors are used in this study to determine the suitable regions in terms of citrus crop production.

Due to the fast growing rate of citrus production in Ramsar district, the government of Iran has identified Ramsar district as a citrus development zone, and accordingly has provided support for the mass production of citrus in the area (Citrus State Development Program (CSDP, 2014). However, it needs an urgent sustainable plan for future citrus production. The main approaches in this study are using Analytic Network Process (ANP) as the multi-criteria evaluation method and using the analytical capabilities of the GIS for citrus production procedure. MLR model was developed to find the coefficients among the fifteen factors regarding citrus yield prediction using SPSS programme.

The ArcGIS 10.2, Super Decision Software version 2.2 and SPSS software version 16.0 have been used for analysis. These approaches can be regarded as a guideline procedure in area exploitation and citrus management. Rapid advances in GIS technology and multi-criteria decision making (MCDM) such as ANP method has created the best opportunity for evaluation of citrus suitability (Ghazvini and Moghaddam, 2007).

This study uses appropriate tools like GIS and the ANP in spatial planning based on hydro-climate, socio-economic, and environmental factors that formed a suitable plan for citrus crop production. There are several reasons that we have chosen ANP model in this study. ANP allows the construction of a model that can incorporate feedbacks and dependencies of factors. This is important for the obvious reason that spatial elements are often associated with each other, such as aspect and land cover for example. ANP technique gives the user the ability to define these dependencies and their direction into a network. In addition, ANP uses the same concept of pair-wise comparison to determine criteria weighting. Consequently, ANP with Super Decision software 2.2 has helped as an effective means of dealing with complex decision making the strategies to be prioritized, optimized and rationalized.

1.6 Significance of Study

Agriculture plays a vital role in the growth and stability of the region's economy. Thus, appropriate areas for plantation and cultivation are important for decision making. Citrus production is regarded as an important cash crop in Ramsar district. This study will develop the economy of Ramsar region and enriches local growers for planting and managing citrus trees and fruits. Therefore, this study could offer an ideal perspective and precision management to growers, planners and decision makers.

This study could provide insight and guidelines for the development of citrus orchards and other potentials fruit crops based on the capability of the zone. There are several benefits and application of this research. The information of crucial

environmental factors could help growers and decision makers to refine the current citrus management activities i.e., prevent citrus planting in high-risk areas in the future. There is lack of research that combines these two methods for suitability assessment. Hence, this study will attempt to solve the complex problems and identify the relationships among the criteria and indicators. In contrast, MLR model is applied to estimate citrus yield In Ramsar district, Iran. The MLR analysis is a useful method used to find the relationship between factors (correlation) and predict citrus yield. Therby, MLR was developed to predict citrus yield recommended to other regions as an applicable model. Consequently, insights and guidelines for future citrus production could be provided by using high potential areas based on the impact of environmental factors.

1.7 Thesis Outline

Chapter 1 introduces the study, and consists of the background of the study, problem statement, aim and objectives of the study, scope of study, and significance of the study.

Chapter 2 is a review of existing literature and describes the fundamental part of the research which provides appropriate knowledge including the theories and applications employed in this study. This chapter reviews the previous literature related to hydro-climate criteria, morphometry and socio-economic variables as critical factors in terms of citrus production.

Chapter 3 addresses each of the objectives outlined in Chapter 1 by adopting the appropriate research methodology. In Chapter 3, it focuses on ANP as novel method in horticultural crops to solve the problem of citrus production in Ramsar district. MLR model is developed to estimate citrus production. Two essential steps are necessary. First, the critical criteria for citrus crop have to be made known, and second, the planning process to find agro-ecological suitability must be defined. Data collections, data layer, hydro-climate, socio-economic criteria and morphometry are discussed in this chapter. Brief descriptions of methods and criteria using ANP

techniques and developed MLR model, to find the significant criteria and relationship between factors and citrus yield are included in this chapter.

Chapter 4 presents the results obtained from the implementation of the methods. The results and relevant analysis are illustrated and elaborated in various forms such as tables and diagrams. In this Chapter, the final equation of MLR is proposed with the mean absolute percentage error.

Chapter 5 delivers the conclusions of the study and makes recommendations for future research.

REFERENCES

- Abbasi, S., Zandi, P. and Mirbagheri, E. (2005). Quantitation of limonin in Iranian orange juice concentrates using high-performance liquid chromatography and spectrophotometric methods. *European Food Research and Technology*, 221, 202–207.
- Abdi, E., Majnounian, B., Darvishsefat, A., Mashayekhi, Z., and Sessions, J. (2009). A GIS-MCE based model for forest road planning. *Journal of Forest Science*, 4, 171–176.
- Al-Alawi, S.M., Abdul-Wahab, S.A., Bakheit, C.S. (2008). Combining principal component regression and artificial neural networks for more accurate predictions of ground-level ozone. *Environ. Modell. Softw.* 20, 1263–1271.
- Allen, D.J., Ort, D.R. (2001). Impacts of chilling temperatures on photosynthesis in warm-climate plants. *Trends Plant Sci.* 6, 36–42.
- Agrell, P.J., Stam, A., and Fischer, G.W. (2004). Interactive multiobjective agro-ecological land use planning: The Bungoma region in Kenya. *European Journal of Operational Research*, 158(1), 194–217.
- American Society of Agronomy, (1989). Decision reached on sustainable agriculture. *Agronomy News*. January, p. 15, Madison, Wisconsin.
- Aragonés-Beltrán, P., Chaparro-Gonzalez, F., Pastor-Ferrando, J.P., and Rodríguez-Pozo, F. (2010). An ANP-based approach for the selection of photovoltaic solar power plant investment projects. *Renewable & Sustainable Energy Reviews*, 14 (1), 249–264.
- Aragonés-Beltrán, P., Chaparro-González, F., Pastor-Ferrando, J. P., & Pla-Rubio, A. (2014). AHP (analytic hierarchy process)/ANP (analytic network process)-based multi-criteria decision approach for the selection of solar-thermal power plant investment projects. *Energy*, 66(1), 222–238.

- Aroca, R., Tognoni, F., Irigoyen, J.J., Sánchez-Díaz, M., Pardossi, A. (2001). Difference in root low temperature response of two maize genotypes differing in chilling sensitivity. *Plant Physiol. Biochem.* 39, 1067–1075.
- Asan, U., and Soyer, A. (2009). Identifying strategic management concepts: An analytic network process approach. *Computers & Industrial Engineering*, 56 (2), 600–615.
- Ashraf, S. (2010). Land Suitability Analysis for Wheat Using Multi-criteria Evaluation and GIS methods. *Research Journal of Biological Sciences*, 5(9), 601–605.
- Atmaca, E., and Basar, H.B. (2012). Evaluation of power plants in Turkey using Analytic Network Process (ANP). *Energy*, 44, 555–563.
- Ayad, Y.M. (2005). Remote sensing and GIS in modeling visual landscape change: a case of the northwestern arid coast of Egypt. *Landscape and Urban Planning*, 73(4), 307–325.
- Ayalew, L., Yamagishi, H., and Ugawa, N. (2004). Landslide susceptibility mapping using GIS-based weighted linear combination, the case Tsugawa area of agano River, Niigata prefecture, japan. *Landslides*, 1, 73–81.
- Ayag, Z., and Ozdemir, R.G. (2009). A hybrid approach to concept selection through fuzzy network process. *Computers and Industrial Engineering*, 56, 368–379.
- Badeck, F., Bondeau, A., Böttcher, K., Doktor, D., Lucht, W., Schaber, J. and Sitch, S. (2004). Responses of Spring Phenology to Climate Change. *New Phytologist*, 162, 295–209.
- Baja, S., Chapman, D.M., and Dragovich, D. (2002). Using GIS-based continuous methods for assessing agricultural land-use potential in sloping areas. *Environment and Planning B: Planning and Design*, 29, 3–20.
- Balaghi, R., Tychon, B., Eerens, H., Jlibene, M. (2008). Empirical regression models using NDVI, rainfall and temperature data for the early prediction of wheat grain yields in Morocco. *International Journal of Applied Earth Observation and Geoinformation*. 10, 438–452.
- Barry, R.G. (1992). *Mountain Weather and Climate (2nd edn)*. Methuen: London.
- Basist, A., Bell, G. D., and Meentemeyer, V. (1994). Statistical relationships between topography and precipitation patterns. *Journal of climate*, 7(9), 1305–1315.

- Beigbabayi, B. and Azadi, M. M. (2012). Using AHP Modeling and GIS to Evaluate the Suitability of site with Climatic Potential for Cultivation of Autumn Canola in Ardebil Province in Iran. *Annals of Biological Library*, 3(5), 2307–2317.
- Belton, V., Stewart, T. (2002). *Multiple Criteria Decision Analysis: An Integrated Approach*. Kluwer Academic Publishers, Boston.
- Bendig, J., Yu, K., Aasen, H., Bolten, A., Bennertz, S., Broscheit, J., ... and Bareth, G. (2015). Combining UAV-based plant height from crop surface models, visible, and near infrared vegetation indices for biomass monitoring in barley. *International Journal of Applied Earth Observation and Geoinformation*, 39, 79–87.
- Ben-Hayyim, G., and Moore, G.A. (2007). *Recent advances in breeding citrus for drought and saline stress tolerance*. In: Jenks, M.A., Hesegawa, P. M. Jain, S. M. (Eds), *Advances in molecular breeding toward drought and salt tolerant crops*. Springer, NY, pp. 627–642.
- Bishop, Y.M.M., Fienberg, S.E., and Holland, P.W. (1975). *Discrete Multivariate Analysis Theory and Practice*, MIT Press, Cambridge, Massachusetts, p. 557.
- Blanc, E. (2012). The impact of climate change on crop yields in Sub-Saharan Africa. *American Journal of Climate Change*, 1, 1–13.
- Blandford, T.R., Humes, K.S., Harshburger, B.J., Moore, B.C., Walden, V.P., and Ye, H. (2008). Seasonal and synoptic variations in near-surface air temperature lapse rates in a mountainous basin. *Journal of Applied Meteorology and Climatology*, 47, 249–261.
- Bojorquez-Tapia, L.A. Diaz Mondragon, S., and Ezcurra, E. (2001). GIS-based approach for participatory decision making and land suitability assessment. *International Journal of Geographical Information Science* 15, 129–151.
- Bongiovanni, R., and Lowenberg-Deboer, J. (2004). Precision Agriculture and Sustainability. *Precision Agriculture*, 5, 359–387.
- Braimoh, A., Valek, P.L.G., and Stein, A. (2004). Land Evaluation for Maize Based on Fuzzy set and Interpolation. *Environmental Management*, 2, 226–238.
- Bray, E.A., J., Bailey,-Serres, Bailey,-Serres, J., Weretinlly, E. (2000). *Responses to abiotic stress*. In: Buchanan, B., Gruissem, E., Jones, R. (Eds.), *Biochemistry and Molecular Biology of Plants*. The American Society of Plant Physiologists, pp. 1158–1203.

- Breheny, M.J. (1988). *Practical Methods of Retail Location Analysis: A Review*. In N. Wrigley, *Store Choice, Store Location and Market Analysis*. London: Routledge. pp. 39–86.
- Brown, K. Adger, W.N. Tompkins, E. Bacon, P. Shim, D. and Young, K. (2001). Trade-off analysis for marine protected area management. *Ecology Economy*, 37, 417–434.
- Brown, I., Poggio, L., Gimona, A., and Castellazzi, M. (2010). Climate change, drought risk and land capability for agriculture: implications for land use in Scotland. *Regional Environmental Change*, 11(3), 503–518.
- Brunsdon, C., Mc Clatchey, J., and Unwin, J.D. (2001). Spatial Variations in the average rainfall-altitude relationship in Great Britain: An approach using geographically weighted regression. *International Journal of Climatology*, 21, 455–466.
- Buckner, R.W. (1998). *Site Selection: New Advancements in Methods and Technology*. New York: Chain Store Publishing Corp.
- Burger, C.J.S.C., Dohnal, M., Kathrada, and Law, R. (2001). A practitioners guide to a time-series methods for tourism demand forecasting- a case study of Durban, South Africa. *Tourism Management*, 22, 403–409.
- Burrough, P.A. (1986). *Principles of Geographic Information System for land resources assessment*. Monograph on soil and resources survey No. 12, Oxford University Press, New York.
- Burrough, P.A., MacMillan, R.A., Van Deursen, W. (1992). Fuzzy classification methods for determining land suitability from soil profile observations and topography. *J. Soil. Sci.* 43, 193–210.
- Caffey, R.H., Kazmierczak, R.F. and Avault, J.W. (2001). *Incorporating multiple stakeholder goals into the development the use of a sustainable index: Consensus indicators of aquiculture sustainability*. Department of agroecology and agribusiness of Louisiana State University, USA. pp. 8–40.
- Camacho, B., and Saul, E. (1981). Citrus culture in high altitude American tropics. *Proc. Int. Soc. Citriculture*. Vol. 1, pp. 321–325.
- Carsjens, G.J., and Van der Knaap, W. (2002). Strategic land-use allocation: dealing with spatial relationships and fragmentation of agriculture. *Landscape and Urban Planning*, 58(2-4), 171–179.

- Caubel, J., Cortázar-Atauri, I.G., Launaya, M., Noblet-Ducoudré, N., Huard, F., Bertuzzi, P., Graux, A.I. (2015). Broadening the scope for ecoclimatic indicators to assess crop climate suitability according to ecophysiological, technical and quality criteria. *Agricultural and Forest Meteorology*, 207, 94–106.
- Caviglia, J.L., and J.R. Kahn. (2001). Diffusion of Sustainable Agriculture in the Brazilian Rain Forest: A Discrete Choice Analysis. *Economic Development and Cultural Change*, 49, 311–33.
- CDCGC. (2004). Citrus and date crop germplasm Committee. USA. *Citrus and Date Germplasm: Crop Vulnerability, Germplasm Activities, Germplasm Needs. Citrus and Date Crop Germplasm Committee, USA*, 1–30.
- Ceballos-Silva, A., and López-Blanco, J. (2003a). Evaluating biophysical variables to identify suitable areas for oat in Central Mexico: a multi-criteria and GIS approach. *Agriculture, Ecosystems & Environment*, 95(1), 371–377.
- Ceballos-Silva, A., and López-Blanco, J. (2003b). Delineation of suitable areas for crops using a Multi-Criteria Evaluation approach and land use/cover mapping: a case study in Central Mexico. *Agricultural Systems*, 77(2), 117–136.
- Chalutz, E., Waks, J., Schiffmann-Nadel, M. (1981). The different responses of several citrus fruit cultivars to low temperature. In: *Proceedings of the International Citrus Congress*, pp. 773–774.
- Chang, C. (2002). The potential impact of climate change on Taiwan's agriculture. *Agricultural Economics*, 27, 51–64.
- Chang, C.W., Wu, C.R., Chen, H.C., (2009). Analytic network process decision-making to assess slicing machine in terms of precision and control wafer quality. *Robotics and Computer-Integrated Manufacturing*, 25, 641–650.
- Chapman, C., Chapman, L., Struhsaker, T., Zanne, A., Clark, C. and Poulsen, J. (2005). A long term evaluation of fruiting phenology: importance of climate change. *Journal of Tropical Ecology*, 21, 31–45.
- Chaves, M.M., Flexas, J., Pinheiro, C. (2009). Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. *Ann. Bot.* 103, 551–560.
- Chen, Z., Li, H., Wong, C.T.C. (1998). Environmental planning: analytical network process model for environmentally conscious construction planning. *ASCE Journal of Construction Engineering and Management*, 131 (1), 92–101.

- Chen, H.S., Liu, G.S., Yang, Y.F., Ye, X.F., and Shi, Z. (2010a). Comprehensive Evaluation of Tobacco Ecological Suitability of Henan Province Based on GIS. *Agricultural Sciences in China*, 9(4), 583–592.
- Chen, Y., Khan, S., and Paydar, Z. (2010b). To retire or expand? A fuzzy GIS-based spatial multi-criteria evaluation framework for irrigated agriculture. *Irrigation and Drainage*, 59, 174–188.
- Chen, M., Jiang, Q., Yin, X.R., Lin, Q., Chen, J.Y., Allan, A.C., Xu, C.J., Chen, K.S. (2012). Effect of hot air treatment on organic acid- and sugar-metabolism in Ponkan (*Citrus reticulata*) fruit. *Sci. Hortic.* 147, 118–125.
- Cheng, E.W.L., and Li, H. (2004). Contractor selection using the analytic network process. *Construction Management and Economics*, 22, 1021–1032.
- Chinnusamy, V., Zhu, J., Zhu, J. (2007). Cold stress regulation of gene expression in plants. *Trends Plant Sci.* 12, 444–451.
- Chmielewski, F., and Rötzer, T. (2001). Response of tree phenology to climate change across Europe. *Agricultural and Forest Meteorology*, 108, 101–112.
- Chrysoulakis, N., Abrams, M., Feidas, H., Korei, A. (2009). Comparison of atmospheric correction methods using ASTER data for the area of Crete. *International Journal of Remote Sensing*, 31 (24), 6347–6385.
- Chung, S.H., Lee, A.H.L., and Pearn, W.L. (2005). Analytic network process (ANP) approach for product mix planning in semiconductor fabricator, *International Journal of Production Economics*, 96, 15–36.
- Chung, E.S., and Kim, Y. (2014). Development of fuzzy multi-criteria approach to prioritize locations of treated wastewater use considering climate change scenarios. *Journal of Environmental Management*, 146, 505–516.
- Cihlar, J. (2000). Land cover mapping of large areas from satellites: Status and research priorities. *International Journal of Remote Sensing*, 21, 1093–1114.
- Clarke, G., and Lowell, S. (2002). *Historical resources cumulative effects management through predictive modeling*. In: Kennedy, A.J. Editor. *Cumulative environmental effects management: Tools and approaches*, Alberta Society of Professional Biologist, pp. 279–295.
- Climatic Atlas of Iran, I.R. of Iran Meteorological Organization, 2010. Archives bureau.
- COAG, (2008). *Gestión de los riesgos en la explotación agraria*. Coordinadora de Organizaciones de Agricultores y Ganaderos, Madrid.

- Cody, R.P., Smith, J.K. (1997). *Applied Statistics and the SAS Programming Language*. Prentice Hall, NJ.
- Coltro, L., Mourad, A.L., Kletecke, R.M., Mendonca, T.A., and Germer, S.P.M. (2009). Assessing the environmental profile of orange production in Brazil. *The International Journal of Life Cycle Assessment*, 14 (7), 656–664.
- Pindyck, R.S., Rubinfeld, D.L. (1991). *In: Econometric Models and Economic Forecasts*. McGraw Hill Inc., New York.
- Congalton, R. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Int. J. of Remote Sensing*, 37, 35–46.
- Connellan, J., Hardy, S., Sanderson, G. and Wangdi, P. (2010). Production guide for mandarin orchards in Bhutan, *Australian Centre for International Agricultural Research: Canberra*, 1–21.
- Coops, N., Loughhead, A., Ryan, P., and Hutton, R. (2000). Development of daily spatial heat unit mapping from monthly climatic surfaces for the Australian continent. *International Journal of Geographical Information Science*, 4, 345–361.
- Cowen, D. (1988). GIS versus CAD versus DBMS: what are the differences? *Photogrammetric Engineering and Remote Sensing*, 54 (2), pp. 1551–1555.
- Dageatano, A.T., Shulman, M.D. (1987). A statistical evaluation of the relationship between cranberry yield in New Jersey and meteorological factors. *Agric. Forest Meteorol.* 40 (4), 323–342.
- Dahiya, B. (2012). Cities in Asia, 2012: demographics economics, poverty, environment and governance. *Cities*, 29, 44–61.
- DaMatta, F.M. (2004). Ecophysiological constraints on the production of shaded and unshaded coffee: a review. *Field Crops Research*, 86, 99–114.
- Das, P.T., Tajo, L., and Goswami, J. (2009). Assessment of Citrus Crop Condition in Umling Block of Ri-bhoi District Using RS and GIS Technique. *Journal of the Indian Society of Remote Sensing*, 37, 317–324.
- Dash, M.C. and Dash, S.P. (2009). *Fundamentals of Ecology*. Third edition, Tata McGraw-Hill, New Delhi, India.
- Dasman, R. (1984). *Environmental Conservation*. John Wiley&Sons, New York.
- Davidson, D.A. (1992). *The evaluation of land resources*. Longman Group UK Ltd., London.

- Devi, G.M.S. and Kumar, K.S.A. (2008). Remote Sensing and GIS Application for Land Quality Assessment for Coffee Growing Areas of Karnataka. *Indian society of Remote Sensing*, 36, 89–97.
- Davies, F.S. (1986). The navel orange. In: Janick, J. (Ed.), Horticultural Reviews. AVI Publishing Co., Westport, Connecticut, pp. 129–180.
- Davies, F.S., and Albrigo, L.G. (1994). Citrus. CAB International, United Kingdom, pp. 52–53.
- De Negri, J.D. (1997). Citros. In: CATI—Coordenadoria de Assistência Técnica Integral. Manual técnico das culturas. 2 ed. Campinas: Cati, 3, *Fruticultura*, 8, pp. 69–108.
- Dent, D., and Young, A. (1981). *Soil Survey and Land Evaluation*. London: George Allen and Unwin.
- Dobrowski, S.Z., Abatzoglou, J.T., Greenberg, J.A., and Schladow, S.G. (2009). How much influence does landscape-scale physiography have on air temperature in a mountain environment? *Agricultural and Forest Meteorology*, 149, 1751–1758.
- Doorenbos, J. and Kassam, A.H. (1979). *Yield response to water*. Irrigation and Drainage Paper 33, Food and Agricultural Organisation of the United Nations, Rome, Italy.
- Draper, N.R. and Smith, H. (1998). *Applied Regression Analysis*. John Wiley and Sons, Inc., New York, P. 706.
- Drechsel, P., Dongus, S., (2010). Dynamics and sustainability of urban agriculture: examples for sub-Saharan Africa. *Sustain. Sci.* 5, 69–78.
- Dou, Y., Zhu, Q., and Sarkis, J. (2014). Evaluating green supplier development programs with a grey-analytical network process-based methodology. *European. Journal of Operational Research*, 233, 420–431.
- Dubois, D., Prade, H. (1980). *Fuzzy Sets and Systems: Theory and Applications*. Academic Press, New York.
- Dumanski, J., and Smyth, A. (1993). The issues and challenges of sustainable land management. *International Workshop on Sustainable Land Management for the 21st. Century*, University of Lethbridge, Alberta, Canada.
- Dyer, R.F., and Forman, E.H. (1992). Group decision support with the analytic hierarchy process. *Decision Support Systems*, 8(2), 99–124.

- Eastman, J.R., Jin, W., Kyem, P.A.K. and Toledano, J. (1995). Raster Procedures for Multi-Criteria/Multi-Objective Decisions. *Photogrammetric Engineering & Remote Sensing*, 61 (5), 539–547.
- Ebel, R.C., Campbell, B., Nesbitt, M.L., Dozier, W.A., Lindsey, J., and Wilkins, B.S. (2005). A temperature index model to determine freeze risk of satsuma mandarins grown on the northern coast of the Gulf of Mexico. *J. Amer. Soc. Hort. Sci.*, 130, 500–507.
- Ebel, R.C., Nesbitt, M., Dozier, W.A., Dane, F. (2008). Freeze risk and protection measures of Satsuma mandarins grown in the southeastern United States. *HortScience*, 43, 287–289.
- Ebrahimi, Y. (2000). *Citrus Industry in Iran*. Report of Citrus Research Institute of Iran, Ramsar, Iran. p.31.
- Erdogmus, S., Aras, H., Koc, E. (2006). Evaluation of alternative fuels for residential heating in Turkey using analytic network process (ANP) with group decision-making. *Renewable and Sustainable Energy Reviews*, 10 (3), 269–279.
- Ergu, D., Kou, G., Shi, Y., and Shi, U. (2014). Analytic network process in risk assessment and decision analysis. *Computers & Operations Research*, 42, 58–74.
- Erskine, W., and El Ashkar, F. (1993). Rainfall and temperature effects on lentil (*Lens culinaris*) seed yield in Mediterranean environments. *The Journal of Agricultural Science*. 121 (3), 347–354.
- Ertugrul, I., Karakasoglu, N. (2008). Comparison of fuzzy AHP and fuzzy TOPSIS methods for facility location selection. *Int J Adv Manuf Tech*. 39,783–795.
- ESRI, ArcGIS 9.0 (2006). The complete Geographic Information System, ESRI, Press, Redlands.
- ESRI, (2009). ArcGIS 9.3. ESRI, Redlands. Available on-line at <http://www.esri.com/software/arcgis>.
- ESRI Inc, ArcGIS, (2011). Redlands, CA. USA. <http://www.esri.com/arcgis/9.3>.
- Etazarini, S. (2011). GIS-based multi-source database, a strategic tool for sustainable development planning: case of Qalaat Mgouna, Morocco. *Environmental Earth Sciences*, 62, 1437–1445.
- Fairweather, J.R., and Campbell, H.R. (2003). Environmental beliefs and farm practices of New Zealand farmers: Contrasting pathways to sustainability. *Agric. Human Values*, 20, 287–300. Gottlieb, R.S. (Ed.).

- Faisal, A. (2008). Climate change and phenology. *New Age*, Monday March 03, 2008.
- FAO, (1978). Report on the agro-ecological zones project. Vol. 1. Methodology and results for Africa. World Soil Resources Report No. 48. Rome, Italy.
- FAO, (1983). *Guidelines: Land evaluation for rain fed agriculture*. Soils Bulletin, No: 52. FAO, Rome, pp. 237.
- FAO, (1985). *Guidelines: Land Evaluation for Irrigated Agriculture*. Soil Bulletin, No: 55. FAO, Rome.
- FAO, (1996). Agro-ecological zoning guidelines. FAO soil bulletin No. 73. FAO, Rome, Italy.
- FAO, (2004). *Fertilizer Development in Support of the Comprehensive Africa Agriculture Development Programme (CAADP)*. Proceedings of the 23rd Regional Conference for Africa, Johannesburg, South Africa, 1-5 March. Rome: FAO.
- FAO, (2007). *Land Evaluation. Toward a Revised Framework*. Food and Agriculture Organization of the United Nations, Rome, Italy.
- FAO, (2008a). The State of Food Insecurity in the World: High Food Prices and Food Security: Threats and Opportunities. Food and Agriculture Organisation of the United Nations, Rome.
- FAO, (2008b). Number of Hungry People Rises to 963 Million: High Food Prices to Blame – Economic Crisis Could Compound Woes (accessed 13.04.09).
- FAO, (2011). Save and Grow: a Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production. Food and Agriculture Organization of the United Nations, Rome.
- FAO, (2013) Crop water information: citrus. Fresh Fruit Portal. Pomegranate culture lacking in Europe, says Cypriot grower. February 5, 2014.
- FAOSTAT, (2010). <http://faostat.fao.org/site/339/default.aspx>.
- Fares, A. and Alva, A.K. (1999). Estimation of citrus evapotranspiration by soil water mass balance. *Soil Science*, 164 (5), 302–310.
- Fay, M.P., and Proschan, M.A. (2010). Wilcoxon-Mann-Whitney or t-test? On assumptions for hypothesis tests and multiple interpretations of decision rules. *Statistics. Surveys*, 4, 1–39.
- Feick, R., and Hall, B. (2004). A method for examining the spatial dimension of multi-criteria weight sensitivity. *International Journal of Geographical Information Science*, 18(8), 815–840.

- Fennell, A., Markhart, A.H. (1998). Rapid acclimation of root hydraulic conductivity to low temperature. *J. Exp. Bot.* 49, 879–884.
- Fidler, F., Burgman, M.A., Cumming, G., Buttrose, R. and Thomason, N. (2006). *Conserv. Biol.* 20,1539–1544.
- Fishman, J., J.K. Creilson, P.A. Parker, E.A. Ainsworth, G.G. Vining, J. Szarka, F.L. Booker, and X. Xu. (2010). An Investigation of widespread ozone damage to the soybean crop in the upper Midwest determined from ground-based and satellite measurements. *Atmospheric Environment*, 44, 2248–2256.
- Flannery, T. (2005). *The Weather makers*, The Text Publishing Company: Melbourne, 84–113.
- Forman, E.H., Selly, M.A. (2001). *Decision by Objective - How to Convince Others That You are Right*. World Scientific Publishing Co. Pte. Ltd, Singapore.
- Fotouhi Ghazvini, R., and Fattahi Moghaddam, J. (2007). *Citrus growing in Iran*. (Persian language). Second edition. University of Guilan press, Iran, pp. 305.
- Fridley, J.D. (2009). Downscaling climate over complex terrain: High finescale (b1000m) spatial variation of near-ground temperatures in a montane forested landscape (Great Smoky Mountains). *Journal of Applied Meteorology and Climatology*, 48, 1033–1049.
- Gao, Y., Chen, Z., Ju, H., Yang, S., and Tang, Y. (2009). GIS-based fine spatial climate ecological regionalization of sweet orange in Three Gorges reservoir area. *Process of SPIE*, 7491, 102–108.
- García-Luis, A., Kanduser, M., Santamarina, P. and Guardiola, J. (1992), Low temperature influence on flowering in Citrus. The separation of inductive and bud dormancy releasing effects. *Physiologia Plantarum*, 86, 648–652.
- García-Luis, A., Fornes, F., and Guardiola, J.L. (1995). Leaf carbohydrates and flower formation in citrus. *J. Amer. Soc. Hort. Sci.*, 120, 222–227.
- García -Tejero, I., Jiménez, J.A., Reyes, M.C., Carmona, A., Pérez, R., Muriel, J.L. (2008). Aplicación de caudales limitados de agua en plantaciones de cítricos del valle del Guadalquivir. *Fruticultura Profesional*, 173, 5–16.
- García-Tejero, I., Jiménez-Bocanegra, J.A., Martínez, G., Romero, R., Durán-Zuazo, V.H., Muriel-Fernández, J.L. (2010). Positive impact of regulated deficit irrigation on yield and fruit quality in a commercial citrus orchard [Citrus sinensis (L.) Osbeck, cv. salustiano]. *Agricultural Water Management*, 97 (5), 614–622.

- Geerts, S., Raes, D. Garcia, M. Del Castillo, C. Buytaert, W. (2006). Agro-climatic suitability mapping for crop production in the Bolivian Altiplano: a case study for quinoa. *Agric. Forest Meteorol.*, 139, 399–412.
- Geertman, C.M., and Toppen, F.J. (1990), Regional planning for new housing in randstad holland. In *Geographical Information Systems for Urban and Regional Planning*, edited by H.W. Scholten and J.C.H. Stillwell (Dordrecht: Kluwer Academic Publishers), pp. 95–106.
- Gessler, P.E., Chadwick, O.A., Chamran, F., Althouse, L., and Holms, K. (2000). Modeling soil- landscape and ecosystem properties using terrain attributes. *Soil Science Society of America Journal*, 64, 2046–2056.
- Ghajar, I., and Akbar Najafi, A. (2012). Evaluation of harvesting methods for Sustainable Forest Management (SFM) using the Analytical Network Process (ANP). *Forest Policy and Economics*, 21, 81–91.
- Ginestar, C., Castel, J.R. (1996). Responses of young Clementine citrus trees to water stress during different phenological periods. *J. Hortic. Sci.* 74, 551–559.
- Girard, L.F., Cerreta, M., De Toro, P. (2008). Integrated spatial assessment: a multi-dimensional approach for sustainable planning. In: *MTISD 2008—Methods, Models and Information Technologies for Decision Support Systems*, Universit a del Salento, Lecce, p. 1820.
- Glass, G.V., and Hopkins, K.D. (1996). *Statistical methods in education and psychology* (3rd ed.). Boston: Allyn and Bacon.
- Gliessman, S. R. (2007). *Agroecology: the ecology of sustainable food systems*. CRC Press, Boca Raton, Florida, USA.
- Gold, M. (1999) *Sustainable Agriculture: definitions and terms*, SRB 99-02, USDA National Agricultural Library (NAL).
- Gomes, E.G., and Lins, M.P. (2002). Integrating Geographical Information Systems and multi-criteria Methods: A case study. *Annals of Operations Research*, 116, 243–269.
- Gomez, O.D. (1992). Evaluación de impacto ambiental. Madrid. Editor Agri'cola Española.
- Good, P.I. (2005). *Permutation Parametric and Bootstrap Tests of Hypotheses*, 3rd edition Springer, New York.
- Goovaerts, P. (2000). Geostatistical approaches for incorporating elevation into the spatial interpolation of rainfall. *Journal of Hydrology*, 228 (1-2), 113–229.

- Goovaerts, P. (1999). Using elevation to aid the geostatistical mapping of rainfall erosivity. *CATENA*, 34, 227–242.
- Gouvas, M., Sakellariou, N., and Xystrakis, F. (2009). The relationship between altitude of meteorological stations and average monthly and annual precipitation. *Studia Geophysica et Geodaetica*, 53 (4), 557–570.
- Gray, D.A. (1988). An integrated GIS applied to agricultural development in Belize. In developing space: proceeding of the postgraduate workshop on application of remote sensing, Department of Geography, University of Durham, 6.5.87. (A. Southgate and A. Stone, eds), pp. 87–93. Nottingham: Remote Sensing Society, Monograph, No. 2.
- Guan, H., Wilson, J.L., and Makhnin, O. (2005). Geostatistical mapping of mountain precipitation incorporating autosearched effects of terrain and climatic characteristics. *J. Hydromet*, 6, 1018–1031.
- Guédon, Y., and Legave, J. (2008). Analyzing the time-course variation of apple and pear tree dates of flowering stages in the global warming context. *Ecological Modelling*, 219, 189–199.
- Guehl, J.M., Aussenac, G. (1987). Photosynthesis decrease and stomatal control of gasexchange in *Abies-Alba* Mill in response to vapor-pressure difference. *Plant Physiol.* 83, 316–322.
- Gül, A., Gezer, A., and Kane, B. (2006). Multi-criteria analysis for locating new urban forests: An example from Isparta, Turkey. *Urban Forestry & Urban Greening*, 5, 57–71.
- Guo, Y.P., Zhou, H.F., Zhang, L.C. (2006). Photosynthetic characteristics and protective mechanisms against photooxidation during high temperature stress in two citrus species. *Sci. Hortic.* 108, 260–267.
- Guo, W., Maas, S.J., Bronson, K.F. (2012). Relationship between cotton yield and soil electrical conductivity, topography, and Landsat imagery. *Precision Agriculture*, 13, 678–692.
- Hailegebriel, S. (2007). Irrigation Potential Evaluation and Crop Suitability Analysis using GIS and Remote Sensing Technique in Beles sub Basin, Beneshangul Gumez region. Unpublished Masters Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Harsant, J., Pavlovic, L., Chiu, G., Sultmanis, S., Sage, T.L. (2013). High temperature stress and its effect on pollen development and morphological components of

harvest index in the C3 model grass *Brachypodium distachyon*. *J. Exp. Bot.* 64, 2971–2983.

- Hasanuzzaman, M., Hossain, M.A., da Silva, J.A.T., Fujita, M. (2012). Plant Responses and Tolerance to Abiotic Oxidative Stress: Antioxidant Defenses is a Key Factor. In: Bandi V., Shanker A.K., Shanker C., Mandapaka M., editors. *Crop Stress and Its Management: Perspectives and Strategies*. Springer; Berlin, Germany: 2012. pp. 261–316.
- Hasanuzzaman, M., Nahar, K., Fujita, M. (2013). Extreme Temperatures, Oxidative Stress and Antioxidant Defense in Plants. In: Vahdati K., Leslie C., editors. *Abiotic Stress—Plant Responses and Applications in Agriculture*. InTech; Rijeka, Croatia: 2013. pp. 169–205.
- Hayashi, H. (2001). Plant temperature stress. In: *Encyclopedia of Life Sciences*. John Wiley & Sons Ltd., Chichester, doi:10.1038/npg.els.0001320 (cited online at <http://www.els.net/>).
- He, L., Huang, G.H., Lu, H.W. (2011). Bivariate interval semi-infinite programming with an application to environmental decision-making analysis. *European Journal of Operational Research*, 211 (3), 452–465.
- Hengl, T. (2009). *A practical guide to geostatistical mapping*, 2nd ed. University of Amsterdam, Amsterdam.
- Hopkins, L. (1977). Methods for generating land suitability maps: a comparative evaluation. *Journal for American Institute of Planners*, 34 (1), 19–29.
- Hopkinson, C., Pomeroy, J., DeBeer, C., Ellis, C., Anderson, A. (2011). Relationships between snowpack depth and primary LiDAR point cloud derivatives in a mountainous environment. In *Remote Sensing and Hydrology 2010*. IAHS Publ. 3XX, Jackson Hole: Wyoming, USA.
- Hu, L.M., Xia, R.X., Xiao, Z.Y., Huang, R.H., Tan, M.L., Wang, M.Y., Wu, Q.S. (2007). Reduced leaf photosynthesis at midday in citrus leaves growing under field or screenhouse conditions. *J. Hortic. Sci. Biotech.* 82, 387–392.
- Huang, I.B., Keisler, J., and Linkov, I. (2011). Multi-criteria decision analysis in environmental sciences: Ten years of applications and trends. *Science of the Total Environment*, 409, 3578–3594.
- Huang, Y.M., Liu, D., An, S.S. (2015). Effects of slope aspect on soil nitrogen and microbial properties in the Chinese Loess region. *CATENA*, 125, 135–145.

- Hubbard, R. (2004). Blurring the Distinctions Between p's and a's in Psychological Research, *Theory Psychology*, 14(3), 295–327.
- Ihalainen, M., Salo, K., Pukkala, T. (2003). Empirical prediction models for *Vaccinium myrtillus* and *V. vitis-idaea* berry yields in North Karelia, Finland. *Silva Fenn.* 37 (1), 95–108.
- Ismail, M.H. (2009). Developing Policy for Suitable Harvest Zone using Multi Criteria Evaluation and GIS-Based Decision Support System. *International Journal of Economics and Finance*, 1(2), 105–117.
- Jahandideh, S., Jahandideh, S., Asadabadi, E., Askarian, M., Movahedi, M.M., Hosseini, S., Jahandideh, M. (2009). The use of artificial neural networks and multiple linear regression to predict rate of medical waste generation. *J. Waste Manage.* 29, 2874–2879.
- Janke, J.R. (2010). Multicriteria GIS modeling of wind and solar farms in Colorado. *Renewable Energy*, 35, 2228–2234.
- Jankowski, P. Andrienko, N. and Andrienko, G. (2001). Map-centered exploratory approach to multiple criteria spatial decision making. *International Journal of Geographical Information Science*, 15 (2), 101–127.
- Janssen, R., and Reitveld, P. (1990). *Multi criteria analysis and geographical information systems: an application to agricultural land use in the Netherlands*, In: Scholten, H.J., Stillwell, J.C.H. (Eds), *geographical information systems for urban and regional planning*, Kluwer Academic Publishers, Dordrecht, pp. 129–139.
- Jelinski, D.E. (1994). *Multiple rules for GIS in global change research agenda*. In “Environmental Management and Analysis: Ecosystem to Global Scale” (W.K. Michener et al., Eds.), London: Taylors and Francis.
- Jensen, J.R. (1996). *Introductory digital image processing: A remote sensing perspective*. Second edition.
- Jia, Y., Del Rio, H.S, Robbins A.L, and Louzada E.S. (2004). Cloning and sequence analysis of a low temperature-induced gene from trifoliolate orange with unusual pre-mRNA processing. *Plant Cell Rep*, 23, 159–166.
- Jiang, X., Tang, L., Liu, X., Cao, W., and Zhu, Y. (2013). Spatial and Temporal Characteristics of Rice Potential Productivity and Potential Yield Increment in Main Production Regions of China. *Journal of Integrative Agriculture*, 12(1), 45–56.

- Jifon, J.L., Syvertsen, J.P. (2003). Moderate shade can increase net gas exchange and reduce photoinhibition in citrus leaves. *Tree Physiol.* 23, 119–127.
- Jiménez, B., Sánchez-Ortiz, A., Lorenzo, M.L., Rivas, A. (2013). Influence of fruit ripening on agronomic parameters, quality indices, sensory attributes and phenolic compounds of Picudo olive oils. *Food Research International*, 54, 1860–1867.
- Joerin, F. (1998). Décider sur le territoire. Proposition d'une approche par utilisation de SIG et de méthodes d'analyse multicritère. Thèse de Doctorat ès Sciences Techniques, Ecole Polytechnique Fédérale de Lausanne, Département de génie rural, p. 269.
- Joerin, F., Theriault, M., and Musy, A. (2001). Using GIS and outranking multicriteria analysis for land-use suitability assessment. *International Journal of Geographical Information Science*, 15(2), 153–174.
- Johnson, N.L., Kelleher, F.M., and Chant, J.J. (1998). The Future of agriculture in the peri-urban fringe of Sydney, Proceedings of the 9th Australian Agronomy Conference, New South Wales, 1–5.
- Jokimäki, J., Huhta, E. (1996). Effects of landscape matrix and habitat structure on a bird community in northern Finland: a multi-scale approach. *Ornis Fennica*, 73, 97–113.
- Jozi, A., Zaredar, N., and Rezaeian, S. (2010). Evaluation of Ecological Capability Using Spatial Multi Criteria Evaluation Method (SMCE). *International Journal of Environmental Science and Development*. 1(3), 273–277.
- Kalibatas, D., and Turskis, Z. (2008). Multicriteria Evaluation of Inner Climate by Using MOORA Method. *INFORMATION TECHNOLOGY AND CONTROL*, 37(1), 79–83.
- Kalogirou, S. (2002). Expert systems and GIS: an application of land suitability evaluation. *Computers, Environment and Urban Systems*, 26(2-3), 89–112.
- Kandiannan, K., Chandaragiri, K.K., Sankaran, N., Balasubramanian, T.N., Kailasam, C. (2002). Crop-weather model for turmeric yield forecasting for Coimbatore District, Tamil Nadu, India. *Agricultural and Forest Meteorology*, 112, 133–137.
- Karsak, E.E., Sozer, S., Alptekin, S.E. (2002). Product planning in quality function deployment using a combined analytic network process and goal programming approach. *Computers and Industrial Engineering*, 44, 171–190.

- Kasuga, M., Liu, Q., Miura, S., Yamaguchi-Shinozaki, K., Shinozaki, K. (1999). Improving plant drought, salt and freezing tolerance by gene transfer of a single stressinducible transcriptional factor. *Nat. Biotechnol.* 17, 287–291.
- Katerji, N., Mastrorilli, M., Rana, G. (2008). Water use efficiency of crops cultivated in the Mediterranean regions: review and analysis. *Eur. J. Agron.* 28, 493–507.
- Kawy, W.A.M.A., Islam, H., and El-Magd, A. (2012). Use of satellite data and GIS for assessing the agricultural potentialty of the soil South Farafra Oasis, Western Desert, Egypt. *Arabian Journal of Geosciences.* 6, 2299–2311.
- Keshavarzi, A., Sarmadian, F., Heidari, A., and Omid, M. (2010). Land suitability evaluation using fuzzy continuous classification (a case study: Ziaran region). *Modern Applied Science,* 4(7), 72–81.
- Kheirkhah, M., Almasi, N., and Taghizadeh, F. (2011). Ecotourism Land Capability Evaluation Using Spatial Multi Criteria Evaluation. *Research Journal of Applied Science, Engineering and Technology,* 3(7), 693–700.
- Khoi, D.D., and Murayama, Y. (2010). Delineation of Suitable Cropland Areas Using a GIS Based Multi-Criteria Evaluation Approach in the Tam Dao National Park Region, Vietnam. *Sustainability,* 2(7), 2024–2043.
- Khoram, M.R., Shariat, M., Moharamnejad, N., Azar, A., and Mahjub, H. (2005). Ecological Capability evaluation for aquaculture activities By GIS. *Iranian Journal of Environmental Health, Science and Engineering,* 2(3), 183–188.
- Khurshid, T. and Hutton, R.J. (2004). Heat unit mapping a decision support system for selection and evaluation of citrus cultivars. *Acta Horticulturae,* 694, 265–269.
- Kometa, S.T. Olomolaiye, P.O. and Harris, F.C. (1995) Attributes of UK construction clients influencing protect consultants' performance. *Construction Management and Economics.* 12(3). 433–443.
- Kravchenko, A.N., and Bullock, D.G. (2002). Correlation of corn and soybean yield with topography and soil properties. *Agronomy Journal,* 75, 75–83.
- Kremen, C., Iles, A., Bacon, C. (2012). Diversified Farming Systems: An Agroecological, Systems-based Alternative to Modern Industrial Agriculture, *Ecology and Society,* 17(4), 44. <http://dx.doi.org/10.5751/ES-05103-170444>.
- Kumar, R. Mehra, P.K. Singh, Jassal, H.S. and Sharma, B.D. (2010). Geostatistical and Visualization Analysis of Crop Suitability for Diversification in Submountain Area of Punjab, North-West India. *Indian society of Remote Sensing,* 38, 211–226.

- Kurtener, D., Torbert, H.A., and Krueger, E. (2008). Evaluation of Agricultural Land Suitability: Application of Fuzzy Indicators. *Computational Science and Its Applications—Lecture Notes in Computer Science*, Volume 5072, pp. 475–490.
- Lang, P., Zhang, C.K., Ebel, R.C., Dane, F., Dozier, W.A. (2005). Identification of cold acclimated genes in leaves of Citrus unshiu by mRNA differential display. *Gene*, 359, 111–118.
- Lee, H., Kim, C., Cho, H., and Park, Y. (2009). An ANP-based technology network for identification of core technologies: A case of telecommunication technologies. *Expert Systems with Applications*, 36(1), 894–908.
- Lee, H., Seol, H., Sung, N., Hong, Y.S., and Park, Y. (2010). An analytic network process approach to measuring design change impacts in modular products. *Journal of Engineering Design*, 21 (1), 75–91.
- Levitt, J. (1972). *Responses of Plants to Environmental Stresses*. Academic Press, New York.
- Li, A., Wang, A., Liang, S., and Zhou, W. (2006). Eco-environmental vulnerability evaluation in mountainous region using remote sensing and GIS—A case study in the upper reaches of Minjiang River, China. *Ecological Modelling*, 192(1-2), 175–187.
- Li, B., Huang, J., Han, N., Xu, K., Wang, K., and Jin, Z. (2012). Integrating GIS and multi-criteria evaluation for analyzing land ecological suitability for *Torreya grandis merrillii*, an endangered plant endemic to China. *Journal of Zhejiang University*, 1581, 1–11.
- Li, L., Zhao, J., and Yuan, T. (2011). Study on Approaches of Land Suitability Evaluation for Crop Production Using GIS. *IFIP*, 587–596. Retrieved from <http://www.springerlink.com/index/BG33736376V78549.pdf>.
- Lidaniya, M. (2008). Growth, maturity, grade standards and physico-mechanical characteristics of fruit. Chapter 7. Citrus Fruit, Technology and Evaluation, Academic press, New Delhi, India.
- Ligmann-Zielinska, A., and Jankowski, P. (2010). Impact of proximity-adjusted preferences on rank-order stability in geographical multicriteria decision analysis. *Journal of Geographical Systems*, 14(2), 167–187.
- Lillesand, T.M., Kiefer, R.W. (1994). *Remote Sensing and Image Interpretation*. John Wiley & Sons, New York, USA.

- Lillesand, T.M., Kiefer, R.W., and Chipman, J.W. (2004). *Remote Sensing and Image Interpretation*, 5th Edition, John Wiley & Sons.
- Lin, Z.C., and Wu, W.J. (1999). Multiple linear regression analysis of the overlay accuracy model, *IEEE Trans. Semicond. Manuf.* 12, 229–237.
- Liu, Y., Lv, X., Qin, X., Guo, H., Yu, Y., Wang, J., and Mao, G. (2007). An integrated GIS-based analysis system for land-use management of lake areas in urban fringe. *Landscape and Urban Planning*, 82(4), 233–246.
- Liu, H., Liu, T., Liu, L., et al. (2010). Integrated simulation and optimization approach for studying urban transportation-environment systems in Beijing. *Journal of Environmental Informatics*, 15 (2), 99–110.
- Lobell, D.B., Cahill, K.M., and Field, C.B. (2007). Historical effects of temperature and precipitation on California crop yields. *Climate Change*, 81, 187–203.
- Lobell, D.B., Cassman, K.G., and Field, C.B. (2009). Crop yield gaps: Their importance, magnitudes and causes. *Annual Review of Environment and Resources*. 34, 1-26.
- Løken, E. (2007). Use of multicriteria decision analysis methods for energy planning problems. *Renew. Sust. Energ. Rev.* 11 (7), 1584–1595.
- Lomax, R.G., and Hahs-Vaughn, D.L. *Statistical Concepts: A Second Course* (Routledge Academic, London, 2007).
- Longley, P.A., Goodchild, M.F., and Maguire, D.J. (1999). *Geographic information systems—Principle and technical issues*, Second edition. New York: John Wiley & Sons.
- Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W. (2005). *Geographic Information Systems and Science*, 2nd Edition: John Wiley & Sons.
- Lu, H.W., Huang, G.H., He, L. (2009). Inexact rough-interval two-stage stochastic programming for conjunctive water allocation problems. *Journal of Environmental Management*, 91 (1), 261–269.
- Lu, D., Batistella, M., Moran, E., de Miranda, E.E. (2008). A comparative study of Landsat TM and SPOT HRG images for vegetation classification in the Brazilian Amazon. *Photogrammetric Engineering and Remote Sensing*, 74, 311–321.
- Lucieer, V., Hill, N.A., Barrett, N.S., Nichol, S. (2013) Do marine substrates ‘look’ and ‘sound’ the same? Supervised classification of multibeam acoustic data

- using autonomous underwater vehicle images. *Estuarine, Coastal and Shelf Science*, 117, 94–106.
- Madu, C.N., Kuei, C., and Madu, I.E. (2002). A hierarchic metric approach for integration of green issues in manufacturing: A paper recycling application. *Journal of Environmental Management*, 64, 261–272.
- Makropoulos, C.K., and Butler, D. (2006). Spatial ordered weighted averaging: incorporating spatially variable attitude towards risk in spatial multi-criteria decision-making. *Environmental Modelling and Software*, 21, 69–84.
- Malczewski, J. (1996). A GIS-based approach to multiple criteria group decision making. *International Journal of Geographic Information System*, 10, 955–971.
- Malczewski, J. (1999). *GIS and Multi criteria Decision Analysis*. John Wiley & Sons.
- Malczewski, J., Chapman, T., Flegel, C., Walters, D., Shrubsole, D., and Healy, M. A. (2003). GIS-multicriteria evaluation with ordered weighted averaging (OWA): Case study of developing management strategies. *Environmental Planning*, 35(10), 1769–1784.
- Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview. *Progress in Planning*, 62(1), 3–65.
- Malczewski, J. (2006). GIS-based multicriteria decision analysis: a survey of the literature. *International Journal of Geographical Information Science*, 20(7), 703–726.
- Manning, A.D., Fischer, J., Lindenmayer, D.B. (2006). Scattered trees are keystone structures—Implications for conservation. *Biol Conserv.* 132, 311–321.
- Marquínez, J., Lastra, J., and García, P. (2003). Estimation models for precipitation in mountainous regions: the use of GIS and multivariate analysis. *Journal of hydrology*, 270(1), 1–11.
- Marra, F.P., Lo Bianco, R., La Mantia, M., Caruso, T. (2013). Growth, yield and fruit quality of ‘Tropic Snow’ peach on size-controlling rootstocks under dry Mediterranean climates. *Scientia Horticulturae*, 160, 274–282.
- Maracchi, G., Perarnaud, V., and Kleschenko, A.D. (2000). Applications of geographical information systems and remote sensing in agrometeorology. *Agricultural and Forest Meteorology*, 103, 119–136.

- Martin, D., and Saha, S. (2009). Land evaluation by integrating remote sensing and GIS for cropping system analysis in a watershed. *Current Science*, 96(4), 569–575. Retrieved from <http://www.ias.ac.in/currsci/feb252009/569.pdf>.
- Mashayekhan, A., and Mahini, A.S. (2011). A Multi-Criteria Evaluation approach to Delineation of Suitable Areas for Planting Trees (Case Study : Juglans regia in Gharnaveh Watershed of Golestan Province). *Journal of Rangeland Science*, 1(2), 225–234.
- McClung, C.R., 2014. Making hunger yield. *Science*, 344, 699–700.
- McGee, T.G. (2010). Building liveable cities in Asia in the twenty-first century research and policy challenges for the urban future of Asia. *Malaysian J. Environ. Manage*, 11 (1), 14–28.
- McKeown, A., Warland, J., McDonald, M.R. (2005). Long-term marketable yields of horticultural crops in Southern Ontario in relation to seasonal climate. *Can. J. Plant Sci.* 85 (2), 431–438.
- McMaster, G.S., Smika, D.E. (1988). Estimation and evaluation of winter wheat phenology in the central Great Plains. *Agric. For.Meteorol.* 43, 1–18.
- Meade, L.M., and Sarkis, J. (1999). Analyzing organizational project alternatives for agile manufacturing processes: An analytical network approach. *International Journal of Production Research*, 37, 241–261.
- Medina, C.L., Souza, R.P., Machado, E.C., Ribeiro, R.V., Silva, J.A.B. (2002). Photosynthetic response of citrus grown under reflective aluminized polypropylene shading nets. *Sci. Hortic.* 96, 115–125.
- Mendoza, G.A., and Prabhu, R. (2000). Multiple criteria decision making approaches to assessing forest sustainability using criteria and indicators: a case study. *Forest Ecology and Management*. 131(1–3), 107–126.
- Miina, J., Hotanen, J.P., Salo, K. (2009). Modelling the abundance and temporal variation in the production of bilberry (*Vaccinium myrtillus* L.) in Finnish mineral soil forest. *Silva Fenn.* 43 (4), 577–593.
- Modarres, R. and Da Silva, V. (2007), Rainfall trends in arid and semi-arid regions of Iran. *Journal of Arid Environments*, 70, 344–355.
- Moriondo, M., Bindi, M., Fagarazzi, C., Ferrise, R., Trombi, G. (2010). Framework for high-resolution climate change impact assessment on grapevines at a regional scale. *Reg. Environ. Change*. <http://dx.doi.org/10.1007/s10113-010-0171-z>.

- Motha, R.P. (2007). Development of an agricultural weather policy. *Agricultural and Forest meteorology*, 142, 303–313.
- Murray, T. (1976). "Alternative power transmission corridors: Dickey/Lincoln School hydroelectric project" US Department of the Interior, Bonneville Power Administration, Portland, ME.
- Neaupane, K.M., and Piantanakulchai, M. (2006). Analytic network process model for landslide hazard zonation. *Engineering Geology*, 85, 281–294.
- Nefeslioglu, H.A., Sezar, E.A., Gokceoglu, C., Ayas, Z. (2013). A modified analytical hierarchy process (M-AHP) approach for decision support systems in natural hazard assessments. *Computers & Geosciences*, 59, 1–8.
- Nekhay, O., Arriaza, M., Guzmán-Álvarez, J.R. (2009). Spatial analysis of the suitability of olive plantations for wildlife habitat restoration. *Computers and Electronics in Agriculture*, 65 (1), 49–64.
- Nguyen, H., Dawal, S.Z.M., Nukman, Y., and Aoyama, H. (2014). A hybrid approach for fuzzy multi-attribute decision making in machine tool selection with consideration of the interactions of attributes. *Expert Systems with Applications*, 41, 3078–3090.
- Niemura, M.P., Saaty, T.L. (2004). An analytic network process model for financial-crisis forecasting. *International Journal of Forecasting*, 20 (4), 573–587.
- Nigatu, W., Dick, Ø.B., and Tveite, H. (2014). GIS based mapping of land cover changes utilizing multi-temporal remotely sensed image data in Lake Hawassa Watershed, Ethiopia, *Environ. Monit. Assess.* 186, 1765–1780.
- Nijkamp, P. and Spronk, J. (1981). Multiple criteria analysis: operational methods. Aldershot: Gower.
- Nijkamp, P. and Van Delft, A. (1977). Multi criteria analysis and regional decision making. Leiden: Marti-mus Nijho and Social Sciences Division.
- Nishiyama, I. (1995). Damage due to extreme temperatures. In: Matsuo, T., Kumazawa, K., Ishii, R., Ishihara, H., Hirata, H. (Eds.), *Science of the Rice Plant*. Food and Agriculture Policy Research Center, Tokyo, Japan, pp. 769–812.
- Nouri, J., Sharifipour, R., and Babaei, A.A. (2006). Ecological capability of land use planning for rural development. *Journal of Biological Sciences*, 6(1), 35–39.
- Nuzzo, R. (2014). Scientific method: Statistical errors. *Nature*, 506 (7487), 150–152

- Nyeko, M. (2012). GIS and Multi-Criteria Decision Analysis for Land Use Resource Planning. *Journal of Geographic Information System*, 4, 341–348.
- Odindi, J.O. and Mhangara, P. (2012). Green Spaces Trends in the City of Port Elizabeth from 1990 to 2000 using Remote Sensing. *Int. J. Environ. Res.*, 6 (3), 653–662.
- Odum, E.P. and Barrett, G.W. (2004). *Fundamentals of Ecology*. Fifth edition. Thomson Publication.
- Oliver, M.A. (1990). Kriging: A Method of Interpolation for geographical information systems. *International Journal of Geographical Information Systems*, 4, 313–332.
- Olomolaiye, P.O., Wahab, K.A. and Price, A.D.F. (1987) Problems influencing craftsmen' s productivity in Nigeria. *Building and Environment*. 22(4), 317–323.
- Olson, C.F. (1995). Probabilistic indexing for object recognition. *Transactions on Pattern Analysis and Machine Intelligence*, 17, 518–522.
- Pabi, O. (2008). Land Type and Sustainable Cocoa Production: Lessons from GIS Application. *West African Journal of Applied Ecology*, 14, 1–12.
- Palaniswami, C., Gopalasundaram, P., and Bhaskaran, A. (2011). Application of GPS and GIS in Sugarcane Agriculture. *Sugar Tech*, 13(4), 360–365.
- Paliwal, A., and Mathur, V.B. (2014). Spatial pattern analysis for quantification of landscape structure of Tadoba-Andhari Tiger Reserve, Central India. *Journal of Forestry Research*, 25, 185–192.
- Palmer, T.N., Alessandri, A., Andersen, U. (2004). Development of a European multimodal Ensemble System for Seasonal to Inter-annual Prediction (DEMETER). *Bulletin of American Meteorological Society*, 85, 853–872.
- Panda, S.S., Hoogenboom, G.J.P., and Paz, J. (2009). Distinguishing blueberry bushes from mixed vegetation land use using high resolution satellite imagery and geospatial techniques. *Computer and Electronics in Agriculture*, 67, 51–59.
- Panda, S.S., Hoogenboom, G.J.P. (2011). Blueberry crop growth analysis using climatologic factors and multi-temporal remotely sensed imagery. In: Proceedings of the 2011, Georgia Water Resources Conference held at the University of Georgia.
- Parsons, L.R., and Beck, H.W. (2004). Weather data for citrus irrigation management. Circular 950. IFAS, Fla. Coop. Ext. Serv., University of Florida, Gainesville.

- Parry, M.A.J., Flexas, J., Medrano, H. (2005). Prospects for crop production under drought: research priorities and future directions. *Ann. Appl. Biol.* 147, 211–226.
- Partovi, F.Y. (2006). An analytic model for locating facilities strategically. *Omega*, 34 (1), 41–55.
- Passioura, J. (2007). The drought environment: physical, biological and agricultural perspectives. *J. Exp. Bot.* 58, 113–117.
- Pearce, D.W., and Atkinson, G. (1993). Capital theory and the measurement of sustainable development: An indicator of weal sustainability, *ecological economics*, 8, 103–108.
- Penfield, S. (2008). Temperature perception and signal transduction in plants. *New Phytol.* 179, 615–628.
- Perveen, F. Nagasawa, R. Uddin, I. and Delowar Hossain, K.M. (2007). Crop- land suitability analysis using multi-criteria evaluation and GIS approach. *5th international symposium on digital earth.*
- Piantanakulchai, M. (2005). *Analytic network process model for highway corridor planning.* Proc of the International Symposium on the Analytic Hierarchy Process (ISAHP), Hawaii
- Pietrini, F., Chaudhuri, D., Thapliyal, A.P., and Massacci, A. (2005). Analysis of chlorophyll fluorescence transients in mandarin leaves during a photo-oxidative cold shock and recovery. *Agriculture, Ecosystems and Environment*, 106(2-3), 189–198.
- Pindyck, R.S., Rubinfeld, D.L. (1991). *In: Econometric Models and Economic Forecasts.* McGraw Hill Inc., New York.
- Plessis, S.F.Du. (1982). Yield forecating for citrus in the western Cape. *Crop Protection*, 11, 101–104.
- Pomeroy, J.W., Toth, B., Granger, R.J., Hedstrom, N.R., Essery, R.L.H. (2003) Variation in surface energetics during snowmelt in a subarctic mountain catchment. *Journal of Hydrometeorology*, 4(4),702–719.
- Pontius, Jr, R.G., and Millones, M. (2011). "Death to Kappa: birth of quantity disagreement and allocation disagreement for accuracy assessment." *International Journal of Remote Sensing.* 32 (15), 4407–4429.
- Porter, J. and Semenov, M. (2005). Crop responses to climatic variation. *Philosophical Transactions: Biological Sciences*, 360(1463), 2021–2035.

- Pourebrahim, S., Hadipour, M., and Mokhtar, M.B. (2011). Integration of spatial suitability analysis for land use planning in coastal areas; case of Kuala Langat District, Selangor, Malaysia. *Landscape and Urban Planning*, 10, 84–97.
- Poursaeed, A., Mirdamadi, M., Malekmohammadi, I., and Hosseini, J.F. (2010). The partnership models of agricultural sustainable development based on Multiple Criteria Decision Making (MCDM) in Iran. *African Journal of Agricultural Research*, 5(23), 3185–3190.
- Prasad, P.V.V., Boote, K.J., Allen Jr., L.H., Thomas, J.M.G. (2002). Effects of elevated temperature and carbon dioxide on seed-set and yield of kidney bean (*Phaseolus vulgaris* L.). *Global Change Biol.* 8, 710–721.
- Preda, M., Bubb, K.A., and Cox, M.E. (2007). GIS-based tools for management of pine plantations , Queensland , Australia. *Australian Forestry*, 70(1), 61–69.
- Pregitzer, K.S., King, J.S. (2005). Effect of soil temperature on nutrient uptake. In: Rad, H.B. (Ed.), *Nutrient Acquisition by Plants: An Ecological Perspective*. Springer-Verlag, Berlin, Heidelberg, pp. 277–310.
- Priya, S., and Shibasaki, R. (2001). National spatial crop yield simulation using GIS based crop production model. *Ecological Modelling*, 136, 2–3, 113–129.
- Quiroga, S., Iglesias, A. (2009). A comparison of the climate risks of cereal, citrus, grapevine and olive production in Spain. *Agric. Syst.* 101 (1–2), 91–100.
- Radiarta, I.N., Saitoh, S.I., and Miyazono, A. (2008). GIS-based multi-criteria evaluation models for identifying suitable sites for Japanese scallop (*Mizuhopecten yessoensis*) aquaculture in Funka Bay, southwestern Hokkaido, Japan. *Aquaculture*, 284(1–4), 127–135.
- Ramsar Agriculture Organization, Census Bureau, (2010).
- Ramsar Synoptic Station Statistics, (2010).
- Rana, G., Katerji, N., Lorenzi, F. (2005). Measurement and modelling of evapotranspiration of irrigated citrus orchard under Mediterranean conditions. *Agricultural and Forest Meteorology*, 128, (3–4), 199–209.
- Rasheed, S., and Venugopal, K. (2009). Land Suitability Assessment for Selected Crops in Vellore District Based on Agro-ecological Characterisation. *Journal of the Indian society of Remote Sensing*, 36, 615–629.
- Ravi, V., Ravi, S., and Tiwari, M.K. (2005). Analyzing alternatives in reverse logistics for end-of-life computers: ANP and balanced scorecard approach. *Computers and Industrial Engineering*, 48(2), 327–356.

- Ray, S.S. Sood, A. Das, G. Panigrahy, S. Aharma, P.K. and Parihar, J.S. (2005). Use of GIS and Remote Sensing for Crop Diversification-A Case study for Punjab State. *Journal of the Indian Society of Remote Sensing*, 33 (1), 181–188.
- Repo, T., Mononen, K., Alvila, L., Pakkanen, T.T., Hanninen, H. (2008). Cold acclimation of pedunculate oak (*Quercus robur* L.) at its northernmost distribution range. *Environ. Exp. Bot.*, 63, 59–70.
- Research Systems Inc, ENVI user's guide. ENVI version 3.4, Research System Inc., USA, pp. 1154 (2000a).
- Riebau, A.R. and Fox, D.G. (2005). Damage Assessment of Agrometeorological Relevance from Natural Disasters: Economic and Social Consequences. *Natural Disasters and Extreme Events in Agriculture*. pp. 119–135.
- Rodiek, J. (2008). Landscape and urban planning cover for 2009. *Landscape Urban Planning*, 89 (1), 1–2.
- Rodrigo, J. (2000). Spring frosts in deciduous fruit trees—morphological damage and flower hardiness. *Scientia Horticulturae*, 85, pp. 155–173.
- Rodriguez, J.C., Duchemin, B., Hadria, R., Watts, C., Garatuza, J., Chehbouni, A., Khabba, S., Boulet, G., Palacios, E., Lahrouni, A. (2004). Wheat yield estimation using remote sensing and the STICS model in the semiarid Yaqui valley, Mexico. *Agronomie*, 24, 295–304.
- Rogerson, P.A. (2001). *Statistical Methods for Geography*. Sage, London.
- Ross, T.J. (1995). *Fuzzy Logic with Engineering Applications*. McGraw-Hill, New York.
- Root, T., Price, J., Hall, K., Schneider, S., Rosenzweig, C. and Pounds, J. (2003). Fingerprints of global warming on wild animals and plants. *Nature*, 421, 57–60.
- Roose, M.L., Soost, R.K. and Cameron, J.W. (1995). *Citrus*. In *Evolution of Crop Plants*, 2nd edn, 443–448 (Eds J. Smart and N.W. Simmonds), Harlow, UK: Longman.
- Rosenzweig, C., Phillips, J., Goldberg, R., Carroll, J. and Hodges, T. (1996). Potential impacts of climate change on citrus and potato production in the US. *Agricultural Systems*, 52, 455–479.
- Roy, R., and Chan, N.W. (2012). An assessment of agriculture sustainability indicators in Bangladesh: Review and synthesis. *Environmentalist*, 32, 99–110.

- Saaty, T.L. (1980). *The Analytical Hierarchy Process*. McGraw-Hill, Suffolk.
- Saaty, T.L. (1996). *The analytic network process-decision making with dependence and feedback*. Pittsburgh, PA: RWS Publications.
- Saaty, T.L. (1997). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, 15, 234–281.
- Saaty, T.L. (2001). *Decision Making with Dependence and Feedback: The Analytic Network Process*, RWS Publications, Pittsburgh.
- Saaty, T.L. (2003). *Decision Making in Complex Environments*. Pittsburgh, Pa: Creative Decision Foundation.
- Saaty, T.L. (2004). *The Analytic Network Process: Dependence and Feedback in Decision Making (Part 1) Theory and Validation Examples*. MCDM. Whistler, B.C., Canada.
- Saaty, T.L. (2005). “The analytic hierarchy and analytic network processes for the measurement of intangible criteria and for decision-making”, *Process: What the AHP is and what it is not*. In: Figueira, J., Greco, S., Ehgott, M. (Eds.), *Multiple Criteria Decision Analysis: State of the Art Surveys*. Springer, New York, pp. 345–407.
- Saaty, T. L., and Sodenkamp, M. (2008). Making decisions in hierarchic and network systems. *International Journal of Applied Decision Sciences*, 1, 24–79.
- Sadeghi, H., and Ghanbari, A. (2008). A survey of damage of citrus in the Mazandaran region of Iran following the January 2008 freeze. *ISHS Acta Horticulturae* 903: *IX international symposium on integrating canopy, rootstock and environmental physiology in orchard systems*.
- Saffarinia, M., Tavakkoli, S. and Alipor, A. (2012). Effects of Environmental Design Inspired by nature on Psychological and Physiological Responses of Clients in Medical Spaces. *Int. J. Environ. Res.*, 6 (3), 689–694.
- Sahin-Cevik, M., and Moore, G.A. (2006). Two AP2 domain containing genes isolated from the cold-hardy Citrus relative *Poncirus trifoliata* are induced in response to cold. *Functional Plant Biology*, 33, 863–875.
- Sahnoun, H., Serbaji, M.M., Karray, B., and Medhioub, K. (2012). GIS and multi-criteria analysis to select potential sites of agro-industrial complex. *Environmental Earth Sciences*, 66, 2477–2489.

- Scherer, T.F, Seelig, B. and Franzen, D. (1996). Soil, water and plant characteristics important to irrigation; <http://www.ag.ndsu.edu/pubs/ageng/irrigate/eb66w.htm> [last accesses 10.05.12].
- Schlenker, W., and Roberts, M.J. (2006). Nonlinear effects of weather on corn yields. *Applied Economic Perspectives and Policy*, 28, 391–398.
- Schumann, A.W., Zaman, Q.U. (2003). Using electromagnetic induction methods to map groundwater in Florida Citrus soils. In: American Society of Agronomy Annual Meeting Abstracts, p.1.
- Shash, A.A. (1993) Factors considered in tendering decisions by top UK contractors. *Construction Management and Economics*. 11 (2), 111 –118.
- Shalhevet, J. and Levy, Y. (1990), *Citrus trees*. In Irrigation of Agricultural Crops, pp. 951–986 (Eds B. A. Stewart and D. R. Nielsen), Wisconsin: American Society of Agronomy.
- Sharifan, H., Saffar, M., Movahedi, N. and Asady, M. (2010). Evaluation of relationship between soil and air temperatures in semi-wet climate. *Geophysical Research*, 12, 14547.
- Silveira de Jasa, M.I. (1986). *A markov chain model for cotton yield forecasting*, Ph.D. Dissertation, Texas A&M University, Texas.
- Shu, Y., Lam, N.S.N. (2011). Spatial disaggregation of carbon dioxide emissions from road traffic based on multiple linear regression model. *Atmos. Environ.* 45, 634– 640.
- Shuff, T., Thomas, J.F. (1993). Normal floral ontogeny and cool temperature-induced aberrant floral development in *Glycine max* (Fabaceae). *Am. J. Bot.* 80, 429–448.
- Shyur, H.J. (2006). COTS evaluation using modified TOPSIS and ANP. *Applied Mathematics and Computation*, 177, 251–259.
- Singh, A., and Grover, A. (2010). Plant Hsp100/ClpB-like proteins: poorly-analyzed cousins of yeast ClpB machine, *Plant Mol. Biol.* 74, 395–404.
- Singh, S.H., Shivanker, V.J., Shrivastava, A.K., and Singh, I.P. (2004). Climate and soil for citriculture. *Advances in Citriculture*, 78–79.
- Slaughter, D.C., Obenland, D.M., Thompson, J.F., Arpaia, M.L., Margosan, D.A. (2008). Non-destructive freeze damage detection in oranges using machine vision and ultraviolet fluorescence. *Postharvest Biology and Technology*, 48, 341–346.

- Smiths, P.C., Dellepiane, S.G., and Schowengerdt, R.A. (1999). Quality assessment of image classification algorithms for land-cover mapping: a review and proposal for cost-based approach. *International Journal of Remote Sensing*, 20, 1461–1486.
- Smith, J, Pearce, B.D., Wolfe, M.S., (2013). Reconciling productivity with protection of the environment: Is temperate agroforestry the answer? *Renew Agr. Food. Syst.* 28, 80–92.
- Snyder, R.L., and de Melo-Abreu, J.P. (2005). Frost Protection: Fundamentals, Practice and Economics. Food and Agriculture Organization of the United Nations, Rome.
- Song, G., Chen, Y., Tian, M., Lv, S., Zhang, S., and Liu, S. (2010). The Ecological Vulnerability Evaluation in Southwestern Mountain Region of China Based on GIS and AHP Method. *Procedia Environmental Sciences*, 2, 465–475.
- Srivastava, A., Singh, S. and Huchche, A. (2000). An analysis on citrus flowering –a review. *Agricultural Review*, 21(1), 1–15.
- Stage, A., Salas, C. (2007). Interactions of elevation, aspect, and slope in models of forest species composition and productivity. *For. Sci.* 53, 486–492
- Star, J. and Estes, J. (1990). *Geographic information systems an introduction*, Prentice Hall, Englewood Cliffs, New Jersey.
- Statistical Center of Iran, 2010. Archives bureau.
- Steel, C., 2008. *Hungry City: How Food Shapes our Lives*. Chatto and Windus, London.
- Stegman, E.C. (1988). Corn crop curve comparisons for the central and Northern Plains of the U.S. *Applied Engineering in Agriculture*. Amer. Soc. Agric. Eng, 4, 226–233.
- Steiner, F., McSherry, L., and Cohen, J. (2000). Land suitability analysis for the upper Gila River watershed. *Landscape Urban Planning*, 50 (4), 199–214.
- Steffen, K.L., Arora, R., Palta, J.P. (1989). Relative sensitivity of photosynthesis and respiration to freeze-thaw stress in herbaceous species. *Plant Physiol.* 89, 1372–1379.
- Store, R., and Kangas, J. (2001). Integrating spatial multi-criteria evaluation and expert knowledge for GIS-based habitat suitability modelling. *Landscape and Urban Planning*, 55(2), 79–93.

- Strahler, A.H., Boschetti, L., Foody, G.M., Friedl, M.A., Hansen, M.C., and Herold, M. (2006). Global land cover validation: Recommendation for evaluation and accuracy assessment of global land cover maps, Technical Report, Joint Research Center, Ispra, EUR 22156 EN, pp. 48.
- Sun, S., Wu, P., Wang, Y., Zhao, X., Liu, J., Zhang, X. (2013). The impacts of interannual climate variability and agricultural inputs on water footprint of crop production in an irrigation district of China. *Sci. Total Environ.* 444, 498–507.
- Sundqvist, P., Andersson, L. (2006). A study of the impacts of land fragmentation on agricultural productivity in the Northern of Vietnam. Uppsala University (thesis).
- UNCTAD, (2005). Citrus fruit market. [online]. Market information in the commodities area. Retrieved on October 26, 2012 from r0.uctad.org/infocomm/anglais/orange/market.htm.
- Tan, F. and Swain, S. (2006). Genetics of flower initiation and development in annual and perennial plants. *Physiologia Plantarum*, 128, 8–17.
- Tao, T., Tan, Z., and He, X. (2007). Integrating environment into land-use planning through strategic environmental assessment in China: Towards legal frameworks and operational procedures. *Environmental Impact Assessment Review*, 27 (3), 243–265.
- Tang, T., Zhu, H., and Xu, H. (2007). Integrating environment into land-use planning through strategic environmental assessment in China: Towards legal frameworks and operational procedures. *Environmental Impact Assessment Review*, 27(3), 243–265.
- Tenerlli, P. and Carver, S. (2012). Multi-Criteria, Multi-Objective and Uncertainty for Agro-Energy Spatial Modelling. *Applied Geography*, 32, 724–736.
- Thakuria Das, P., Tajo, L., and Goswami, J. (2009). Assessment of Citrus Crop Condition in Umling Block of Ri-bhoi District Using RS and GIS Technique. *Indian social and Remote Sensing*, 37, 317–324.
- Thornton, P.K., Jones, P.G., Alagarwamy, G., Andresen, J. (2009). Spatial variation of crop yield response to climate change in East Africa. *Global Environ. Change*, 19, 54–65.
- Tignor, M.E., F.S. Davies, and W.B. Sherman. (1998). Freezing tolerance and growth characteristics of USDA intergeneric citrus hybrids US 119 and Selection 17-11. *HortScience*, 33,744–748.

- Tittonell, P., Shepherd, K.D., Vanlauwe, B., Giller, K.E., 2008b. Unravelling the effects of soil and crop management on maize productivity in smallholder agricultural systems of western Kenya – an application of classification and regression tree analysis. *Agric. Ecosyst. Environ.* 123, 137–150.
- Tran, L. T., O'Neill, R.V., and Smith, E.R. (2010). Spatial pattern of environmental vulnerability in the Mid-Atlantic region, USA. *Applied Geography*, 30(2), 191–202.
- Tropsha, A. Gramatica, P. and Gombar, V.K. (2003). The importance of being earnest: validation is the absolute essential for successful application and interpretation of QSPR models. *Molecular Informatics*, 22(1), 69–77.
- Tseng, M.L., and Lin, Y.H. (2008). Selection of competitive advantage in TQM implementation using fuzzy AHP and sensitivity analysis. *Asia Pacific Management Review*, 13(3), 583–599.
- Ulutas, B.H. (2005). Determination of the appropriate energy policy for Turkey. *Energy*, 30 (7), 1146–1161.
- United Nations (UN), (2008). World Urbanisation Population Prospects: The 2007 Revision Population Database (accessed 15.05.08).
- Uno, Y., Prasher, S.O., Lacroix, R., Goel, P.K., Karimi, Y., Viau, A.A., Patel, R.M. (2005). Artificial neural networks to predict corn yield from Compact Airborne Spectrographic Imager data. *Computers and Electronics in Agriculture*, 47, 149–161.
- Usha, K., and Bhupinder, S. (2013). Potential applications of remote sensing in horticulture- A review. *Scientia Horticulturae*, 153, 71–83.
- Vadrevu, K.P., Eaturu, A., and Badarinath, K.V.S. (2010). Fire risk evaluation using multicriteria analysis-a case study. *Environmental Monitoring and Assessment*, 166, 223–239.
- Van Calster, H., Vandenbergh, R., Ruysen, M., Verheyen, K., Hermy, M., and Decocq, G. (2008). Unexpectedly high 20th century floristic losses in a rural landscape in northern France. *Journal of Ecology*, 96(5), 927–936.
- Viglizzo, E.F., Pordomingo, A.J., Castro, M.G., and Lertora, F.A. (2003). Environmental assessment of agriculture at a regional scale in the Pampas of Argentina. *Environmental monitoring and assessment*, 87(2), 169–95. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/12943263>.

- Villa, F., and McLeod, H. (2002). Environmental vulnerability indicators for environmental planning and decision-making: Guidelines and applications. *Environmental Management*, 29, 335–348.
- Voogd, H. (1983). *Multi criteria evaluation for urban and regional planning*. London: Pion.
- Vrolijk, H.C.J., Poppe, K.J., Wisman, J.H. (2007). Volatility of farm incomes, prices and yields in the European Union. Working Paper (WP2, Income Stabilisation). LEIDLO. Den Haag.
- Wagesho, N. (2004). GIS based irrigation suitability analysis: a case study of abaya-chamo basin, southern rift valley of Ethiopia. *Lake Abaya Research Symposium Proceedings*, 4, 79–8.
- Wahba, M.M. Darwish, K.M. and Awad, F. (2007) Suitability of specific crops using micro LEIS Program in Sahal Baraka, Farafra Oasis, Egypt. *Journal of Applied Science Research*, 3(7), 531–539.
- Walke, N., Obi Reddy, G.P., Maji, A.K., and Thayalan, S. (2012). GIS-based multicriteria overlay analysis in soil-suitability evaluation for cotton (*Gossypium* spp.). *Computer and Geosciences*, 41, 108–118.
- Walker, G.K. (1989). Model for operational forecasting of Western Canada wheat yield. *Agricultural and Forest Meteorology*, 44(3–4), 339–351.
- Walther, G., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T., Fromentin, J., Hoegh-Guldberg, O., and Bairlein, F. (2002). Ecological responses to recent climate change. *Nature*, 416, 389–395.
- Wang, F., Hall, G.B., Subaryono. (1990). Fuzzy information representation and processing in conventional GIS software: database design and applications. *International Journal of Geographical Information systems*, 4, 261–283.
- Wang, J.J., and Yang, D.L. (2007). Using a hybrid multi-criteria decision aid method for information systems outsourcing. *Computers & Operations Research*, 34, 3691 – 3700.
- Wang, Y., Wang, Y., Wang, J., Yuan, Y., Zhang, Z. (2015). An ontology-based approach to integration of hilly citrus production knowledge. *Computers and Electronics in Agriculture*, 113, 24–43.
- Washington-Ottombre, C., Pijanowski, B., Campbell, D., Olson, J., Maitima, J., Musili, a., Kibaki, T. (2010). Using a role-playing game to inform the

- development of land-use models for the study of a complex socio-ecological system. *Agricultural Systems*, 103 (3), 117–126.
- Westwood, M.N. (1978). *Fruit and nut species*. In M.N. Westwood, ed., *Temperate-Zone Pomology*, pp. 41-76. W.H. Freeman, San Francisco, CA.
- Wezel, A., Bellon, S., Dore, T., Francis, C., Vallod, D., David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*, Springer Verlag (Germany), 29 (4), 503–515.
- Wheeler, T.R., Craufurd, P.Q., Ellis, R.H., Porter, J.R., Vara Prasad, P.V. (2000). Temperature variability and the annual yield of crops. *Agric. Ecosyst. Environ.* 82, 159–167.
- Wilson, R.J., Thomas, C.D., Fox, R., Roy, D.B., Kunin, W.E.S. (2004). Spatial patterns in species distributions reveal biodiversity change. *Nature*, 432, 393–396.
- Willmott, C.J. (1984). *On the evaluation of model performance in physical geography*. in Gaile, G.L. Willmott, C. eds., *spatial statistics and models*. D. Reidel Publishing Company, Dordrecht, 1984, pp. 443–460.
- Whitaker, R. (2004). Validation examples of the Analytic Hierarchy Process and Analytic Network Process. *Mathematical and Computer Modelling* . 46, 840–859.
- Wolfslehner, B., Vacik, H., Lexer, M.J. (2004). Application of the analytic network process in multi-criteria analysis of sustainable forest management. *Forest Ecology and Management*, 207 (1–2), 157–170.
- Wu, W., Liu, H.B., Dai, H.L., Li, W., and Sun, P.S. (2011). The management and planning of citrus orchards at a regional scale with GIS. *Precision Agriculture*, 12, 44–54.
- Xu, M., and Wei, C. (2012). Remotely sensed image classification by complex network eigenvalue and connected degree. *Computational and mathematical methods in medicine*, 2012, 9.
- Yaakup, A., Zalina, S., and Sulaiman, S. (2004). Integrated land use assessment (ILA) for planning and monitoring urban development. *World Conference on Environmental Management. Facing the Changing Conditions*. Bangi, Malaysia.
- Yaakup, A., Ludin, A.N.M., Susilawati, S., and Bajuri, H. (2005). GIS in urban planning and management: Malaysian experience. *International Symposium*

and Exhibition on Geoinformation, Geospatial Solutions for Managing the Borderless World. Pulau Pinang, Malaysia.

- Yager, R. (1988). On ordered weighted averaging aggregation operators in multi-criteria decision making. *IEEE Transactions on Systems, Man and Cybernetics*, 18(1), 183–190.
- Yager, R., and Kelman, A. (1999). An extension of the analytical hierarchy process using OWA operators. *Journal of Intelligent and Fuzzy Systems*, 7 (4), 401–417.
- Yan, P., Khan, S.M., and Shah. M. (2007). 3D model based object class detection in an arbitrary view. In International Conference on Computer Vision.
- Yan, X.P., Ma, X.F., Huang, G.H. (2010). An inexact transportation planning model for supporting vehicle emissions management. *Journal of Environmental Informatics*, 15 (2), 87–98.
- Yang, C.H., Everitt, J., Bradford, J., Murden, D. (2003). Airborne hyperspectral imagery and yield monitor data for mapping cotton yield variability. *Precision Agriculture*, 5(5), 445–461.
- Yang, F., Zeng, G.G., Du, C.Y., Tang, L., Zhou, J.F. and Li, Z.W. (2008). Spatial analyzing system for urban land-use management based on GIS and multi-criteria assessment modeling. *Progress Nat. Sci.* 18, 1279–1284.
- Ying, X., Zeng, G.M., Chen, G.Q., Tang, L., Wang, K.L., and Huang, D.Y. (2007). Combining AHP with GIS in synthetic evaluation of eco-environment quality—A case study of Hunan Province, China. *Ecological Modelling*, 209(2-4), 97–109.
- Yoder, R.E., Odhiambo, L.O., Wright, W.C. (2005). Evaluation of methods for estimating daily reference crop evapotranspiration at a site in the humid Southeast United States. *ASAE*, 21(2), 197–202.
- Yoe, C. (2013). *Introduction to natural Resources Planning*. CRC Press, Taylor & Francis Group.
- Young, R. (1970). Induction of dormancy and cold hardiness in citrus. *HortScience*, 5, 411–413.
- Young, L.W., Wilen, R.W., Bonham-Smith, P.C. (2004). High temperature stress of *Brassica napus* during flowering reduces micro- and megagametophyte fertility, induces fruit abortion, and disrupts seed production. *J. Exp. Bot.* 55, 485–495.

- Yun, Z., Gao, H.J., Liu, P., Liu, S.Z., Luo, T., Jin, S., Xu, Q., Xu, J., Cheng, Y.J., Deng, X.X. (2013). Comparative proteomic and metabolomic profiling of citrus fruit with enhancement of disease resistance by postharvest heat treatment. *BMC Plant Biol.* 13, 44.
- Yüksel, I., and Dağdeviren, M. (2007). Using the analytic network process (ANP) in a SWOT analysis—A case study for a textile firm. *Information Sciences*, 177, 3364–3382.
- Zabihi, H. (2008). Citrus personal photography archives.
- Zabihi, H., Ahmad, A., and Nor Said, M. (2014). Assessment of three spatial interpolation models to obtain the best one for cumulative rainfall estimation (Case study: Ramsar district, Iran). *International Journal of Engineering Research & Technology*, 3 (8), 1018–1022.
- Zadeh, L.A. (1965). Fuzzy sets. *Inf. Control*, 8, 338–353.
- Zadeh, L.A. (1973). Outline of a New Approach to the Analysis of Complex Systems and Decision Processes. *IEEE Trans. Syst. Man Cybern SMC-3* (1), 28–46.
- Zelalem, A. (2007). Land Use/Land Cover Dynamics and Vegetation Vulnerability Analysis: A Case Study of Arsi Negele Wereda. Unpublished Masters Thesis, Addis Ababa University, Addis Ababa, Ethiopia.
- Zhang, W., Ricketts, T.H., Kremen, C., Carney, K., Swinton, S.M. (2007). Ecosystem services and dis-services to agriculture. *Ecol. Econ.* 64, 253–260.
- Zhang, C.K., Lang, P., Dane, F., Ebel, R.C., Singh, N.K., Locy, R.D., and Dozier, W. A. (2005). Cold acclimation induced genes of trifoliolate orange (*Poncirus trifoliata*). *Plant Cell Report*. Springer. 23, 764–769.
- Zeng, J., and Yi, G., 2013. Illustrated the improved varieties and good methods for citrus. Science and Technology Literature Press, Beijing.
- <http://www.Amar.org.ir>. Statistical Centre of Iran. (2010).
- <http://www.esri.com>. Agriculture, GIS for Agriculture, June, (2009).
- <http://www.esri.com>. Agriculture, GIS for Agriculture, understanding our world, (2011).
- <http://www.FAO/WHO.org>, (2002). Human Vitamin and Mineral Requirements. Chapter 6: Vitamin C.
- <http://www.havairan.com/meteorological/Mazandaran/Ramsar>.
- <http://Tree Pictures Online.com>. 2010, 2013.

<http://www.tradiotionaltree.org>. (2006).