UNIVERSITI PUTRA MALAYSIA

SWAT BASED GIS MODELLING AND IMPACT ASSESSMENT OF DAM PROJECT IN KARKHEH RIVER BASIN AND WETLAND USING SPATIO-TEMPORAL SATELLITE DATA

YASSER GHOBADI

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By

YASSER GHOBADI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

May 2015

DEDICATION

I am dedicating this thesis to two beloved people who have meant and continue to mean so much to me. First and foremost, I lovingly dedicate this thesis to my wife, Nafiseh, who supported me each step of the way and for her love and patience, and understanding that allow me to spend most of the time on this thesis and to my parents for their endless love, support and encouragement.

Abstract of thesis presented to the Senate of the Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman: Biswajeet Pradhan, PhD

Faculty: Engineering

Water shortages in the arid parts of the world are affecting the human welfare, economic activity, and political stability of these areas. Faced with overpopulation problems and demand for development of new agricultural lands to support increasing population, many countries of the arid world are adopting aggressive policies to develop new agricultural communities without careful analysis of the environmental and hydrologic impacts of these projects. Dust storms in the Middle East and south-west Asia are the major natural hazards and the Tigris-Euphrates alluvial plain has been recognized as the main dust source in this area. The dust originating from this area can be transported over large distances. Therefore, the dust storms from the Middle East also have important impacts on the neighbouring countries like Iran. The dust activities have intensified in the Mesopotamian areas in recent years, partly due to the development of the dam construction projects on Tigris and Euphrates rivers as well as Karkheh River. The main contribution of this thesis is to assess the hydrologic impact of engineering project in the Karkheh River Basin (KRB) and simulation of hydrologic process in the watershed and its wetland, Al Hawizeh.

The first objective of this thesis is to analyse the changes in the landuse/landcover (LULC) over the study area due to the engineering project during 1985-2013 by use of multi-temporal satellite data. In this regard, four Landsat satellite images were selected and corrected prior to accomplishing the main analysis. In this part, the focus of study was to analyse the changes in vegetation and agricultural activities in the KRB. Therefore, a subset of study area in downstream of Karkheh dam which involved the agricultural field was selected for analysis. Supervised Classification

was applied on all images and change detection analysis was performed to detect the changes in the LULC. The second objective to study the effect of engineering project in the study area is assessment of land surface temperature (LST) over the study region. Therefore, two Landsat images in the before and after developing dam were selected. For that, Landsat TM5 for 1998 and Landsat ETM+7 for the year 2002 were selected for the analysis of LST in the study area. The third objective of this study is evaluation of wetland shrinkage during 1985 to 2013. To do this, four Landsat Images for the years 1985, 1998, 2002, and 2013 were selected to analyse the shrinkage and change detection. Finally, as fourth objective, simulation of hydrologic process in the KRB and al Hawizeh wetland was performed by Soil and Water Assessment Tools (SWAT). In this regard, we constructed a catchment-based continuous (1987-2010) rainfall–runoff model for the entire KRB watershed (area ~50,760 km^2) using the SWAT model to understand the natural flow system, and to investigate the impacts of reduced overall flow and the related land cover and landuse change downstream in the wetland. Calibration, validation, and uncertainty analysis were performed using Sequential Uncertainty Fitting Ver. 2 (SUFI2). The calibration periods (1987-1990) and validation period (1991-1994) was selected. The results of calibration and validation are also used to simulate the two downstream flow gauge stations. For this purpose two scenarios were determined for this section, the flow with dam and without dam. Using the calibrated model the annual flow volume (AFV) was calculated for the Karkheh into the wetland throughout the modelled setup for Pay e Pol and Hamidiyeh Stations.

The results show that, the LULC in the study area have changed and the agricultural activity in the study area have increased from 5900 ha to 71000 ha due to the construction of engineering project. As LST analysis results, after dam operation, and change LULC in the study area, the overall LST is increased especially near the Al Hawizeh wetland (Hoor al Azim) by 2-7 Kelvin. Additionally, the results obtained from the detection of desiccation in Al Hawizeh wetland shows that the area of wetland decreases dramatically from 3386 to 925 km^2 in year 2002. It means that the wetland lost ~73% of its surface area from 1985 to 2002. Finally, by using SWAT model, the model shows that the flows during 1987 to 2000 (before dam construction) and 2001 to 2010 (after dam construction) were significantly reduced after the Karkheh dam construction. The corresponding AFVs for the Hamidiyeh and Pay e pol stations were 8.92×10^{11} and 1.04×10^{12} m^3 in 1987–2000 and 2.57×10^{11} to 3.94×10^{11} m^3 in 2001–2010. Thus, the AFVs before and after dam construction were reduced to 6.34×10^{11} and 6.53×10^{11} m^3 for the Hamidiyeh and Pay e Pol gauges, respectively.

Consequently, it is concluded and founded that flow reduction and discharge to the wetland, affected the wetland area, in which the surface area of the wetland was reduced and the risk of dust storm is increased. Using a relationship that describes the impact of reduced AFV on the areal extent of the wetland, it evaluated the impact of additional reductions in flow that will result from the implementation of the planned engineering projects on the Tigris–Euphrates system and Karkheh River over the next few years.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMODELAN GIS BERASASKAN SWAT DAN PENILAIAN KESAN PROJEK EMPANGAN DI LEMBANGAN SUNGAI KARKHEH DAN TANAH LEMBABNYA MENGGUNAKAN DATA SATELIT SPATIO-TEMPORAL

Oleh

YASSER GHOABDI

Mei 2015

Pengerusi: Biswajeet Pradhan, PhD

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Kekurangan air di bahagian gersang di dunia memberi kesan kepada kebajikan manusia, aktiviti ekonomi dan kestabilan politik kawasan-kawasan ini. Berhadapan dengan masalah lebihan penduduk dan permintaan bagi pembangunan tanah pertanian yang baru untuk menyokong penduduk yang semakin meningkat, banyak negara di dunia gersang yang mengguna pakai dasar-dasar yang agresif untuk membangunkan masyarakat pertanian baru tanpa analisis berhati-hati dengan kesan alam sekitar dan hidrologi projek-projek ini. Ribut debu di Timur Tengah dan selatan-barat Asia adalah bahaya alam dan Tigris-Euphrates dataran lanar telah diiktiraf sebagai sumber debu utama di kawasan ini. Debu yang berasal dari kawasan ini boleh dihantar melalui jarak yang jauh.

Oleh itu, ribut debu dari Timur Tengah juga mempunyai kesan penting ke atas negara-negara jiran seperti Iran. Aktiviti debu telah dipergiatkan di kawasan Mesopotamia pada tahun-tahun kebelakangan ini, sebahagiannya disebabkan oleh pembangunan projek-projek pembinaan empangan di Sungai Tigris dan Euphrates dan juga Karkheh River. Sumbangan utama tesis ini adalah menilai kesan hidrologi projek kejuruteraan di Lembangan Sungai Karkheh (KRB) dan simulasi proses hidrologi di kawasan tadahan air dan tanah lembap, di Al Hawizeh.

Objektif pertama karya ini adalah untuk analisis perubahan dalam guna tanah / landcover (LULC) di kawasan kajian dengan menyiasat projek kejuruteraan semasa 1985-2013 dengan menggunakan data satelit berbilang duniawi. Dalam hal ini, empat imej satelit Landsat telah diperbetulkan geometri dan radiometrically sebelum

mencapai analisis utama. Di bahagian ini, kajian, fokus kajian adalah mengenai perubahan dalam tumbuhan dan aktiviti pertanian di KRB. Oleh itu, satu subset kawasan kajian di hilir empangan Karkheh yang melibatkan bidang pertanian telah dipilih untuk analisis. Klasifikasi diselia telah digunakan pada semua imej dan pengesanan perubahan analisis telah dijalankan untuk mengesan perubahan dalam LULC. Objektif kedua untuk mengkaji kesan projek kejuruteraan di kawasan kajian adalah penilaian suhu permukaan tanah (LST) dan perubahan dalam iklim. Oleh itu, kedua-dua imej Landsat dalam sebelum dan selepas membangunkan empangan telah dipilih. Untuk tujuan ini, Landsat TM5 untuk 1998 dan Landsat ETM + 7 bagi tahun 2002 telah dipilih untuk analisis LST dan perubahan iklim di kawasan kajian. Objektif ketiga kajian ini adalah penilaian pengecutan tanah lembap sepanjang tahun 1985 hingga 2013. Untuk melakukan ini, empat Imej Landsat bagi tahun-tahun 1985, 1998, 2002, dan 2013 telah dipilih untuk menganalisis pengecutan dan perubahan pengesanan. Akhir sekali, sebagai objektif keempat, simulasi proses hidrologi dalam KRB dan al Hawizeh tanah lembap telah dilakukan oleh Tanah dan Alat Penilaian Air (SWAT). Dalam hal ini, telah membentuk satu model yang berterusan (1987-2010) hujan-air larian berdasarkan tadahan-untuk seluruh kawasan tadahan air yang KRB (kawasan ~ 50.760 km^2) menggunakan model SWAT untuk memahami sistem aliran semulajadi, dan untuk menyiasat kesan aliran keseluruhan dikurangkan dan perlindungan tanah dan kegunaan tanah perubahan berkaitan hiliran dalam paya. Penentukuran, pengesahan, dan analisis ketidakpastian dijalankan menggunakan Ketidakpastian Sequential Pemasangan Ver. 2 (SUFI2). The tempoh penentukuran (1987-1990) dan tempoh sah (1991-1994) telah dipilih. Keputusan kalibrasi dan validasi juga digunakan untuk mensimulasikan dua stesen tolok aliran hiliran. Untuk tujuan ini dua senario telah ditentukan untuk bahagian ini, aliran dengan empangan dan tanpa empangan. Menggunakan model yang ditentukur jumlah aliran tahunan (AFV) telah dikira untuk Karkheh ke dalam tanah lembap sepanjang persediaan dimodelkan untuk Bayar e Pol dan Stesen Hamidiyeh.

Hasil kajian menunjukkan bahawa, LULC di kawasan kajian yang telah berubah dan aktiviti pertanian di kawasan kajian meningkat dari 5900 kepada 71000 ha ha disebabkan pembinaan projek kejuruteraan. Sebagai LST dan berubah dalam hasil analisis iklim, selepas operasi empangan, dan menukar LULC di kawasan kajian, keseluruhan LST bertambah terutama berhampiran paya Al Hawizeh (Hoor al Azim) dengan 2-7 Kelvin. Selain itu, keputusan yang diperolehi daripada pengesanan kekeringan dalam Al Hawizeh tanah lembap menunjukkan bahawa kawasan tanah lembap berkurangan secara dramatik 3386-925 km2 pada tahun 2002. Ini bermakna bahawa tanah lembap yang hilang ~ 73% daripada kawasan permukaannya dari tahun 1985 hingga tahun 2002. Akhir sekali, dengan menggunakan model SWAT, model menunjukkan bahawa aliran semasa 1987-2000 (sebelum pembinaan empangan) dan 2001-2010 (selepas pembinaan empangan) adalah berkurangan selepas Karkheh pembinaan empangan. The AFVs sepadan untuk Hamidiyeh dan Bayar e stesen pol ialah 8.92 × 1011 dan 1.04 × 1012 m3 pada 1987-2000 dan 2.57 × 1.011-3,94 × 1.011 m3 dalam 2001-2010. Oleh itu, AFVs sebelum dan selepas pembinaan empangan telah dikurangkan kepada 6.34 × 1011 dan 6.53 × 1011 m3 untuk Hamidiyeh dan Bayar e tolok Pol, masing-masing.

Oleh itu, ia membuat kesimpulan dan mengasaskan bahawa pengurangan aliran dan pelepasan kepada tanah lembap, terjejas kawasan tanah lembap, di mana kawasan permukaan tanah lembap telah dikurangkan dan risiko ribut debu bertambah. Menggunakan hubungan yang menerangkan kesan dikurangkan AFV kepada sejauh areal tanah lembap, ia dinilai kesan pengurangan tambahan dalam aliran yang terhasil daripada pelaksanaan projek-projek kejuruteraan dirancang pada sistem Tigris-Euprates dan Karkheh Sungai lebih seterusnya beberapa tahun.

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At the outset, I would like to express my deepest appreciation to my supervisor, Assoc. Prof. Dr. Biswajeet Pradhan, for his advice during my Doctoral research. As my supervisor, he has constantly forced me to remain focused on achieving my goal. His observations and comments helped me to establish the overall direction of the research and to move forward with investigation in depth.

I would like to thank my co-supervisors, Assoc. Prof. Dr. Helmi, Assoc. Prof. Dr Noordin B. Ahmad, and Assoc. Prof. Dr. Gh. A. Sayyad for their scientific comments and suggestions during the research.

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Last but not least, I heartily thankful Mr. M. A. Kelay and S. H. Tabatabaei whose support to collect the data which is used in this thesis.

I certify that a Thesis Examination Committee has met on 14 May 2015 to conduct the final examination of Yasser Ghobadi on his PhD thesis entitled “SWAT Based GIS Modelling and Impact Assessment of Dam Project in Karkheh River Basin and its Wetland Using Spatio-Temporal Satellite Data “in accordance with Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the PhD in GIS and Geomatic Engineering.

APPROVAL

Members of the Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follow:

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Declaration by graduate student

I hereby confirm that:

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Name and Matric No.: _____Yasser Ghobadi, GS26244_____________

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LIST OF ABBREVIATIONS

AVHRR	Advance Very High Resolution Radiometer
ASTER	Advanced Spaceborne Thermal Emissivity and Reflection Radiometer
AFV	Annual Flow Volume
CVA	Change Vector Analysis
DGPS	Differential GPS
DOS	Dark Object Subtraction
DI	Differential Imaging
DN	Digital Number
ETM+	Enhance Thematic Mapper plus
FCC	False Colour Composite
FLAASH	Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes
GCPs	Ground Control Points
GIS	Geospatial Information System
GPS	Global Positioning System
HRUs	Hydrologic Response Units
IR	Infrared
IRIMO	Iran Meteorological Organization
IDE	Iran Department of Environment
IWRC	Iran Water Resource Company
KRB	Karkheh River Basin
KTMP	Kish Transverse Mercator Projection
LST	Land Surface Temperature
LSE	Land Surface Emissivity
LULC	Landuse/Landcover

MODIS	Moderate Resolution Imaging Spectroradiometer
MSL	Mean Sea Level
MSS	Multi-spectral Scanner
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NCC	National Cartographic Centre
NIR	Near Infrared
NOAA	National Oceanic and Atmospheric Administration
NSE	Nash-Sutcliff Efficiency coefficient
MLC	Maximum Likelihood Classification
PCA	Principal Component Analysis
PCC	Post Classification Comparison
PCP	Precipitation
PBIAS	Percent Bias
RMSE	Root Mean Squire Error
SUFI-2	Sequential Uncertainty Fitting
SKS	South Karkheh Sub-basin
SPOT	Système Pour l'Observation de la Terre
SWAT	Soil and Water Assessment Tool
SWAT-CUP	Soil Calibration and Uncertainty Programs
TM	Thematic Mapper
TIR	Thermal Infrared
TOA	Top of Atmosphere
UNEP	United Nations Environment Programme
TERB	Tigris-Euphrates River Basin

UTM	Universal Transverse Mercator
VIIRS	Visible Infrared Imaging Radiometer Suite
WGS	World Geographic System

CHAPTER ONE

INTRODUCTION

1.1 Background

One of the atmospheric phenomena in the arid and semi-arid part of the world is dust storm. In arid and semi-arid parts of the Asia dust storm occurs frequently (Miri *et al.*, 2009). Asian dust storms have a major impact on the air quality of the densely populated areas of China, Korea and Japan, and are important to the global dust cycle (Shao and Dong, 2006; Xu *et al.*, 2006). Material with particle size less than 1000 µm are defined as powders, when particles have a diameter less than 76 µm, they are referred to as “dust”. Dust is any finely divided soiled, 420 µm or less in diameter (Abbasi and Abbasi, 2007). Dust particles are fine airborne soil and/or weathered or transported rock particles removed from the Earth’s surface as a result of wind erosion under certain climatic, meteorological and soil conditions. The Earth’s surface is composed of a large number of minerals, which occur in heterogeneous mixtures within rocks and weathering mantles (Rashki *et al.*, 2013). Dust aerosols are naturally produced by wind erosion of the Earth’s crust, a complicated process affected by numerous meteorological and surface conditions including surface wind speed, friction velocity, soil temperature, soil moisture, soil texture, landuse type, and snow and vegetation cover (Ku and Park, 2011). Airborne dust can ascend from a wide variety of anthropogenic sources, are includes the following:

- wind-blown dust from exposed surfaces such as bare land and construction sites
- wind-blown dust from stockpiles of dusty materials such as sawdust, coal, fertilizer, sand and other minerals
- dust caused by vehicle movements on sealed or unsealed roads
- agriculture and forestry activities
- mines and quarries
- road works and road construction
- housing developments
- municipal landfills and other waste handling facilities
- dry abrasive blasting
- Numerous industrial operations, including grain drying and storage, timber mills, stonemasons, mineral processing, cement handling and batching, and fertiliser storage and processing.
- Dry river

Dust storms have a number of impacts upon the environment including radiative obliging, and biogeochemical cycling. They transport substance over many thousands of kilometres. They also have a range of impacts on humans, not least on human health (Goudie, 2009). There were seven major sources of dust storm trajectories in the world including the west and south Sahara Desert, the east of Sahara Desert, east Sudan and Ethiopia, the northern Arabia, Gobi Desert, Taklimakan Desert, and Australian Desert (Najafi *et al.*, 2013). The Middle East deserts are subjected often to dust, which reduces horizontal visibility to 5 km, and sometimes even to less than 100 m. The severe and prolong drought recently affecting the west Asia region has been suggested to be instrumental in producing an increased output of dust into the atmosphere from the region (Zoljoodi *et al.*, 2013). Dust storm is one of the most important environmental problems in the west of Iran (Najafi *et al.*, 2013). Iran is located in the mid-latitude belt of arid and semi-arid regions of the Earth therefore it frequently faced with dust storm (Modarres and de Paulo Rodrigues da Silva, 2007). To this issues west and south west part of Iran are affected by dust storms and as a results this is important to study this issue in different context.

1.2 Dust phenomenon

Natural mineral aerosol (dust) is an active component of the climate system and plays multiple roles in mediating physical and biogeochemical exchanges between the atmosphere, land surface and ocean. Changes in the amount of dust in the atmosphere are caused both by changes in climate precipitation, wind strength, regional moisture balance. And also, changes in the extent of dust sources caused by either anthropogenic or climatically induced changes in vegetation cover (Harrison *et al.*, 2001). The dust cycle is an integral part of the Earth system. Annually, an estimated 2000 Mt dust is emitted into the atmosphere, 75% of which is deposited to the land and 25% to the ocean (Shao *et al.*, 2011). The dust cycle involves dust emission, transport, transformation, deposition and stabilization (Figure 1.1). It involve a range of processes which occur on spatial scale from local to global and time scales from seconds to millions of years (Steffen *et al.*, 2006).

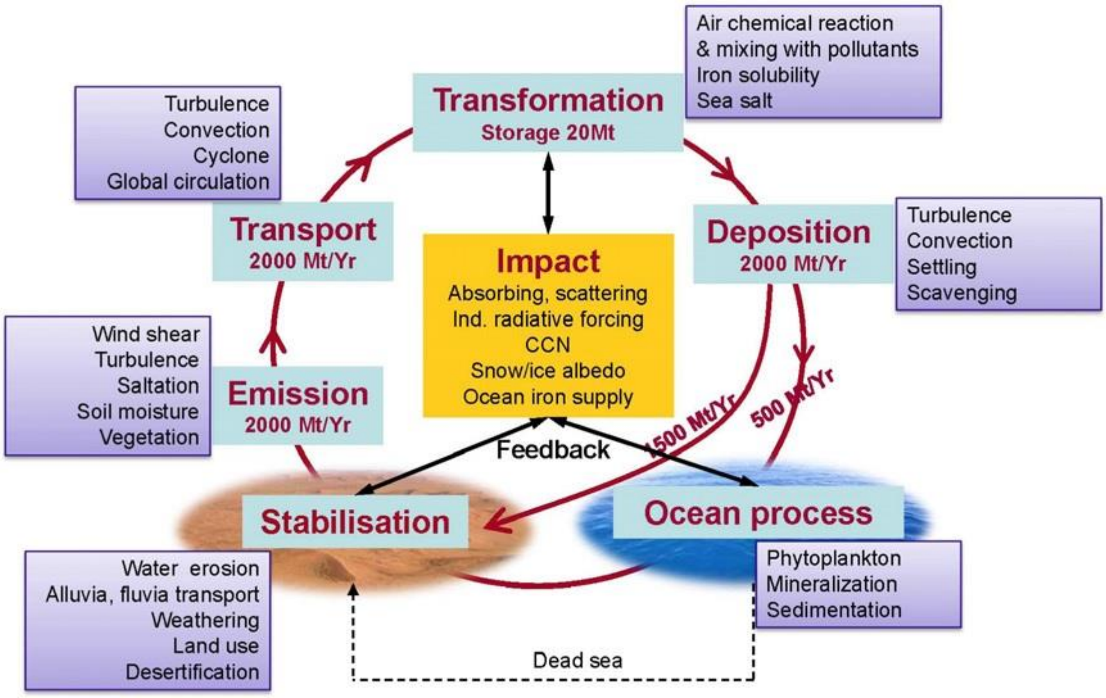

Figure 1.1 An illustration of the dust cycle in the Earth system and the main processes in which dust plays an important role. Source: (Steffen *et al.*, 2006).

Saharan dust has four main trajectories: (i) southward transport over the Sahel and the Gulf of Guinea (60% of the Saharan dust emission, but <5% of the dust reaches 5° N); (ii) westward transport to the Atlantic (25% of emissions); (iii) the northward transport to Europe (10%); and (iv) the eastward transport to the Middle East (5%) (Engelstaedter and Washington, 2007; Klose *et al.*, 2010; Knippertz and Todd, 2010). The emission and transport of dust from the Middle East and the Indian Subcontinent are associated with the Indian monsoon trough. The monsoon low located over the subcontinent and the high located to the northeast of the Mediterranean can generate strong northerly winds which produce dust storms and transport dust towards the Indian Ocean (Shao *et al.*, 2011). The global pattern of dust transport is depicted in Figure 1.2.

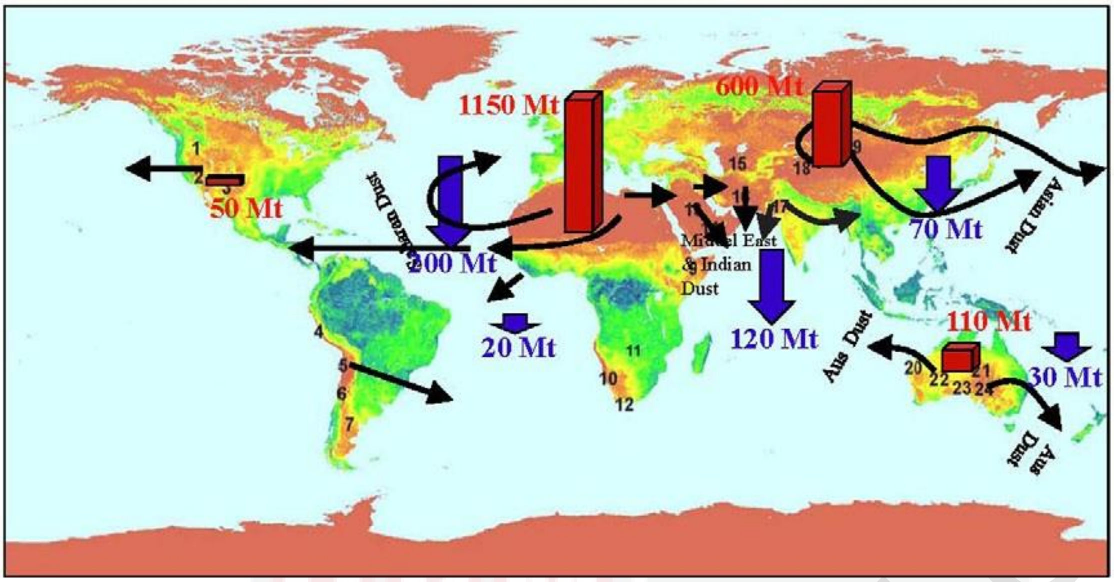

Figure 1.2. Main routes of dust transport (arrows) and locations of the world's major deserts, including: (1) Great Basin, (2) Sonoran, (3) Chihuahua, (4) Peruvian, (5) Atacama, (6) Monte, (7) Patagonia, (8) Sahara, (9) Somali-Chabli, (10) Namib, (11) Kalahari, (12) Karroo, (13) Arabian, (14) Rub al Khali, (15) Turkestan, (16) Iranian, (17) Thar, (18) Taklimakan, (19) Gobi, (20) Great Sandy, (21) Simpson, (22) Gibson, (23) Great Victoria and (24) Sturt. The magnitudes of dust emission from different regions are given in Mt and indicated using bars and the depositions to the oceans are also given in Mt and indicated by thick arrows. Source (Shao et al., 2011)

In this decade, the frequent of dust storm has increased in Iran especially in west and southwest part of Iran. The dust often blows towards the southeast, spreading into Iran or traveling over the Persian Gulf. In early March 2011, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite captured the progression of one such storm (http://modis.gsfc.nasa.gov/). Figure 1.3 shows a one of the dust storm transported into Iran for two different dates.

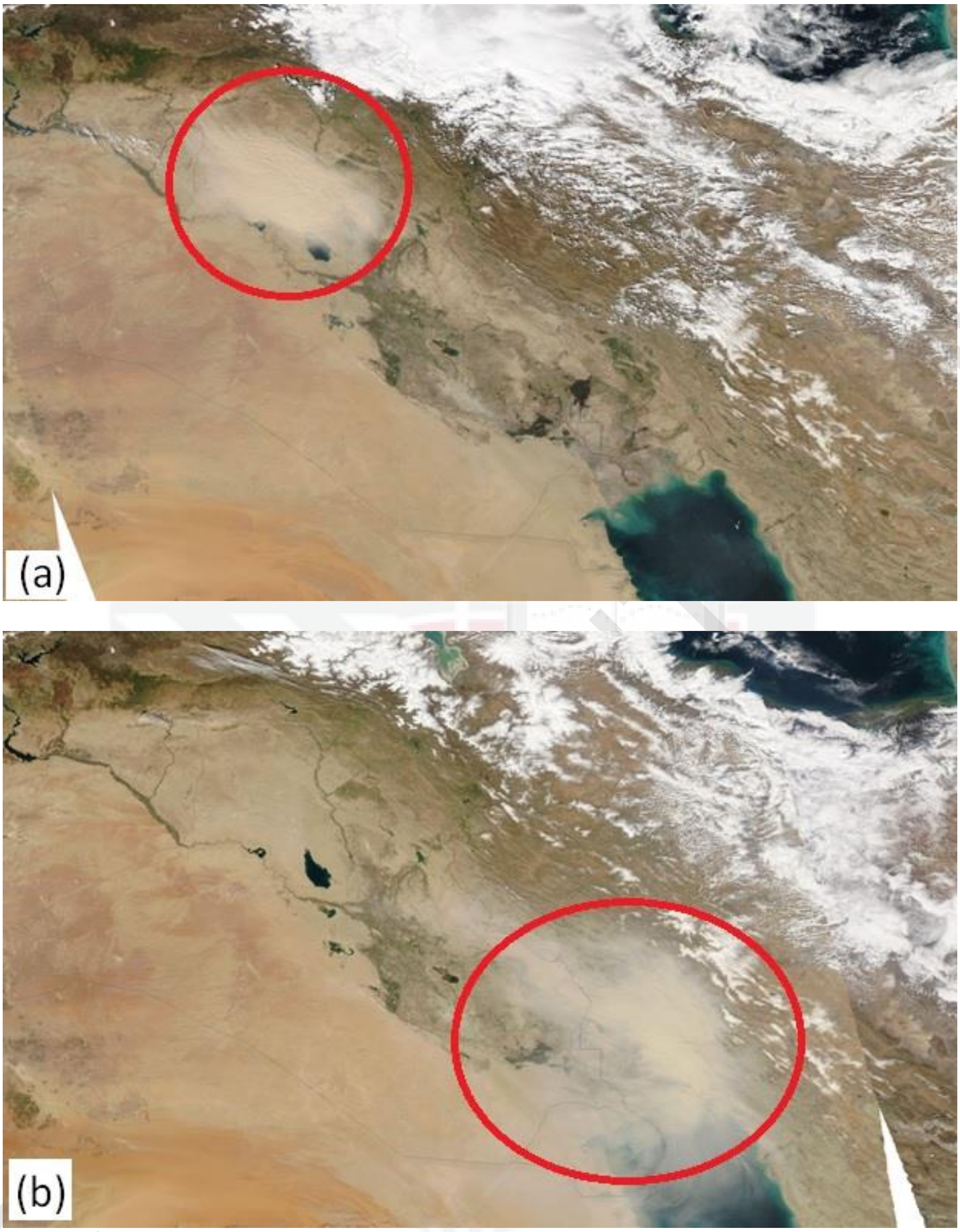

Figure 1.3. (a) Early stage of dust storm over the Iraq on the 3rd march 2011 and (b) transport and deposition in the south west of Iran and northern part of Persian Gulf on 4th march 2011 captured by Aqua MODIS. Source: http://modis.gsfc.nasa.gov/

As well as, Figure 1.4 shows the frequency and concentration of dust storm during 2001 to 2011 over the south west of Iran.

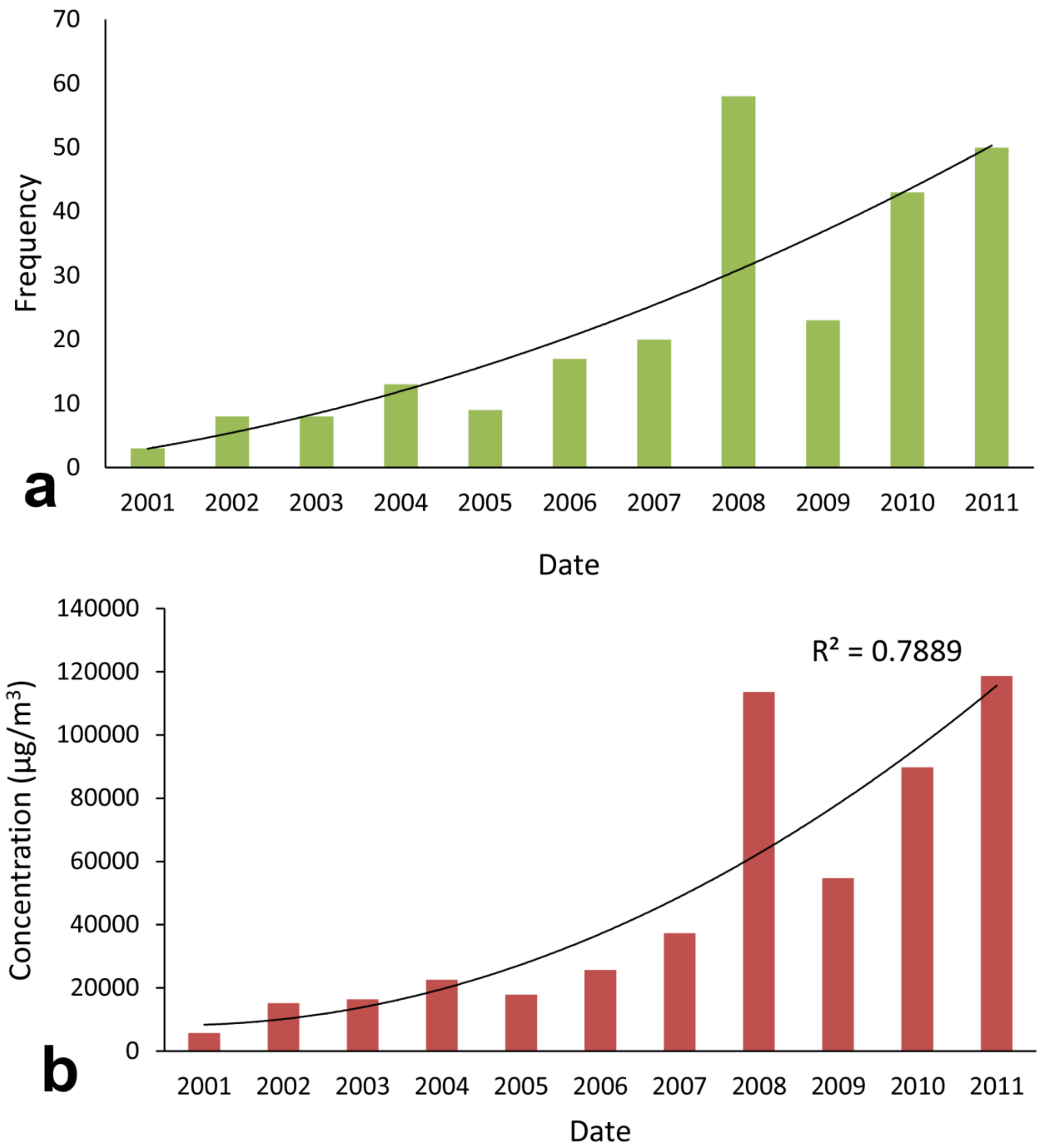

Figure 1.4. (a) occurrence of dust storm and (b) concentration of dust storm during 2001-2011. Source (IDE)

1.3 Wetlands

Wetlands of the world occupied an area of approximately 5%-8% of the world's land surface (7-10 million km^2), and contain 10%-20% of the global terrestrial carbon (Mitsch, 2009; Song *et al.*, 2012). Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface (Cowardin *et al.*, 1979; Lehner and Döll, 2004; Mwita *et al.*, 2013). On the other hand, wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly un-drained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Lichvar and Kartesz, 2009).

Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Indeed, wetlands are found from the tundra to the tropics and on every continent except Antarctica (Lichvar and Kartesz, 2009). They have several echo-environmental social and economic benefits. Wetlands play an important role in the global carbon cycle. Thus, they must be conserved for carbon cycling as well as for their importance as natural habitats (Rebelo *et al.*, 2009b). Wetland ecosystems are associated with a diverse and complex array of direct and indirect uses depending on the type of wetlands, soil and water characteristics, and associated biotic influences. Direct uses include water supply source and harvesting of wetland products such as fish and plant resources. Indirect benefits are derived from environmental functions such as floodwater retention, ground- water recharge/discharge, climate mitigation, and nutrient abatement (Smith *et al.*, 2009).

Some global programs such as Ramsar Convention (adoption in 1971 in Iran), The United Nations Educational, Scientific and Cultural Organization (UNESCO), International Waterfowl and Wetlands Research Bureau (IWRB), and United Nation Environment Programme (UNEP) are an international treaty designed to address global concerns regarding wetland loss and degradation and international cooperation for the conservation of wetland habitats. IWRB is the only independent global organization concerned primarily with the conservation of wetland ecosystems. IWRB's goal is to promote the conservation of wetlands and wetland biodiversity, particularly water birds, by stimulating and coordinating international technical cooperation (Scott, 1995).The primary purposes of the treaty are to list wetlands of international importance and to promote their wise use, with the ultimate goal of preserving the world's wetlands. Methods include restricting access to the majority portion of wetland areas, as well as educating the public to combat the misconception that wetlands are wastelands (Rubec, 1996).

Figure 1.5 illustrates the distributed areas covered by Wetland. According to this map, U.S department of Agriculture (USAD) wetland are divided into six classes including: upland, lowland, organic, salt affected, permafrost affected inland water bodies.

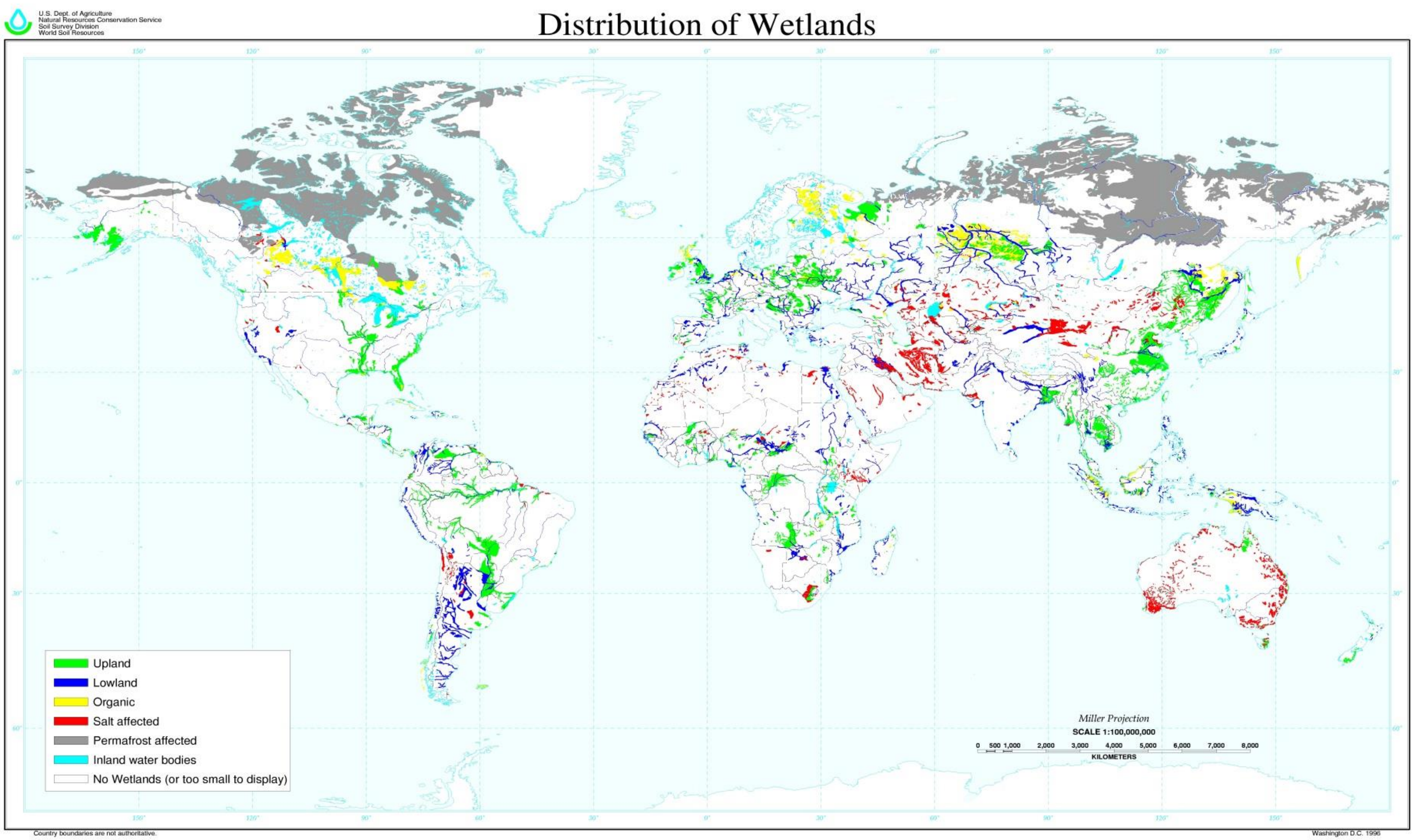

Figure 1.5. The Distribution of different type of wetland in worldwide (source: U.S. department of Agriculture, USDA,)

1.4 Al Hawizeh Wetland

The Al Hawizeh wetland is part of the Mesopotamian marshlands. Mesopotamian marshlands are part of a major international river system, the Tigris and Euphrates as largest river system in the southwest of Asia. The Mesopotamian mashes are covering an area between 15000-2000 square kilometres. The al Hawizeh wetland located in the border of Iran-Iraq. Eastern part of it is known as Hoor Al Azim wetland (Partow, 2001; Basgall, 2003). These wetlands eventually drain south-eastwards into the Persian Gulf via the Shatt al Arab waterway. Al Hawizeh is one of the most important wetlands the region for breeding and wintering waterfowl (Scott, 1995). This wetland is one of the biggest wetland in the world. This wetland prevents flooding by holding water. By doing so, Al Hawizeh wetland help keep Karkheh and Tigris River as well as filter and purify the surface water. Figure 1.6 shows a part of the al Hawizeh wetland.

Figure 1.6. A typical Al Hawizeh wetland landscape

1.5 Remote sensing and GIS studies on wetlands

Extensive losses of wetlands have occurred in many countries throughout the world. As the value of wetland to society has become recognized, it is now important to conserve these valuable resources. To prevent further loss of wetlands, and conserve existing wetland ecosystems for biodiversity and ecosystem services and goods, it is important to inventory and monitor wetlands and their adjacent uplands.

For inventorying and monitoring of the wetlands, satellite remote sensing and GIS has many advantages. Satellite data has repeat coverage so that wetlands can be monitored seasonally or yearly. Satellite remote sensing can also provide information on surrounding land uses and their change over time. Satellite data are in digital format and relatively easy to integrate into a geographic information system (GIS). Satellite remote sensing can be especially appropriate for wetland inventories and monitoring in developing countries, where funds are limited and where little information is available on wetland areas, surrounding land uses, and wetland losses over time. Moreover, using satellite remote sensing data together with more detailed maps or aerial photography can give greater information than either source alone. To gather they can be used to monitor changes in water levels in wetlands and land cover change on adjacent uplands. Satellite data can be used to determine where more detailed maps should be update frequently. Satellite remote sensing has been used to study and map all types of wetlands.

Satellite remote sensing sensors used in wetland identification, monitoring and classification are different. These sensors are: Landsat Multi-scanner sensor (MSS), Landsat Thematic mapper (TM), Landsat Enhanced Thematic Mapper (ETM+), System Pour l'Observation de la Terre (SPOT), Indian Remote Sensing satellite (IRS-1B), and Advance Very high Resolution Radiometer (AVHRR). Radar Systems, which transmit and receive radiation in the microwave portion of the electromagnetic spectrum, have also been used to study wetlands.

In addition, currently, there are several satellites in polar and geostationary orbits that are capable of monitoring aerosols and dust storm over land from global to regional scales with moderate spatial and temporal resolution. Satellite sensors such as Moderate Resolution Imaging Spectrometer (MODIS) on Terra and Aqua satellites, Multi-angle Imaging Spectroradiometer (MISR), Polarization and Directionality of the Earth's Reflectances (POLDER), and Ozone Monitoring Instrument (OMI) are examples of polar orbiting sensors, which provide Aerosol Optic Thickness (AOT) at 10 to 20 km spatial resolution. Geostationary satellites such as GOES and METEOSAT have also shown the potential of providing aerosol information on much higher temporal resolution (Prados *et al.*, 2007). However, most studies use MODIS data, due to its good spatial resolution, excellent ability to mask clouds, and due to its near-daily global coverage. Although MISR derived AOT values proved to be better than MODIS over land (Abdou *et al.*, 2005), MISR's main limitation is its narrow swath (360 km), allowing for global coverage only every 8 to 9 days thereby limiting its use for air quality studies that require information on daily time scales. Although the MODIS has near daily global coverage, cloud cover and changes in surface properties with season limits the aerosol retrieval on a daily basis (Gupta and Christopher, 2008).

1.6 Water crisis

Amongst global resources, water is emerging as the most critical and misused natural resource. Limited water supply is a major constraint on development and agricultural activities in many parts of the world. This is particularly relevant in arid and semi-arid regions where scarcity poses a severe constraint on food production (Rijsberman, 2006; Muthuwatta *et al.*, 2010). It is an important input to agricultural production and an essential requirement for domestic, industrial and municipal activities. Increasing population and standards of living are contributing to a steep rise in demand for fresh water. The consequent wastage, over-exploitation, pollution and depletion of fresh water pose a serious threat to the food security of an increasing population. Recent studies indicate that one-third of the population of developing countries live in absolute water scarcity, in the sense that they will not have sufficient water resources to meet their agricultural, domestic, industrial and environmental requirements in the year 2025 (Seckler *et al.*, 1999). Irrigated agriculture has played an important role since the 1960s in feeding the growing world population and is expected to continue in the future as well (Cai and Rosegrant, 2003). However, water availability for irrigation in developing countries (over 90% of water resources are used for irrigation) has had to be reduced due to increasing demand of water from non-agricultural sectors (Qureshi *et al.*, 2010).

Iran is a land-abundant and water-short country. It has 1% of the world’s population and 1.1% of its land, but less than 0.4% of the world’s freshwater. The country already uses 74% of its annual total renewable freshwater, a figure placing it far into any definition of a water-scarce state (Ahmad and Giordano, 2010).

1.7 Karkheh River Basin and Karkheh Dam

Karkheh River Basin (KRB) is a part of Tigris-Euphrates River Basin (TERB). The TERB with their tributaries, from a major river system in western Asia from Sources in the Taurus Mountain of eastern Turkey they follow by Syria through Iraq and finally discharge into the Persian Gulf. The system is part pf the Palearctic Tigris-Euphrates ecoregion which includes Iraq and parts of Turkey, Syria, Iran, Saudi Arabia, Kuwait, and Jordan (Kavvas *et al.*, 2011). Table 1.1 is summarized the area of TERB which occupied by each country.

Table 1.1. Area of the Tigris-Euphrates drainage basin in rapiran country (km^2)

Country	Euphrates Basin	%	Tigris Basin	%
Iran*	-	-	175,386	47.2
Iraq	282,532	48.8	142,175	38
Saudi Arabia*	77,090	13.3	-	-
Syria	95,405	16.5	948	0.3
Turkey	121,787	21	53,052	14.0
Total	579,314	100.0	371562	100.0

(*The country included part of the catchment but the main river does not flow through it.)

Figure 1.7 shows the geographically distributed of TERB and its watershed. As seen here KRB is located in the south-west part of the Iran. It is the third largest and most productive river basin and agricultural activities in Iran. It is one of the best endowed river basins in the Iran as well as, it has seen extensive development and further planned exploitation of its water resources, with major consequences unfolding for the core remnants of the renowned Mesopotamian marshes (Marjanizadeh *et al.*, 2009). KRB covers an area of 51000 km^2 (Shahram *et al.*, 2004).

Figure 1.7. Sub basin of Tigris-Euphrates watershed and the location of KRB (catchment No.6). Source: (Partow, 2001)

Accounting for 16% of the electricity production worldwide, hydropower is one of the most popular energy resources because of its low cost, near-zero greenhouse gas emissions, and the flexibility it provides in operations (Madani, 2011). In Iran, the second largest country in the Middle East hydropower production has a key role in supplying the peak power demand. Additionally, Irrigated agriculture has played an important role since 1960s in feeding the growing world population and is expected to continue in future as well. The Karkheh Dam constructed on the Karkheh River (third biggest river in terms of discharge in the country) is an embankment dam with a central clay core, a maximum height of 127 m, and a crest length of 3030 m (Figure 1.8). The Karkheh dam having a designed storage capacity of 7800 million m^3 and live storage capacity of about $4.7 \times 10^9 m^3$. It is a multi-purpose dam aimed for providing irrigation water to about 350,000 hectares (ha) in the Khuzestan plains (in the Lower Karkheh region) besides the other objectives of hydropower generation and flood control (Soroush and Rayati, 2004; Masih *et al.*, 2009; Pakbaz *et al.*, 2009).

Figure 1.8. Schematic view of the Karkheh Dam. Source: Iran Water Resource Management Company (IWRMC).

1.8 Problem statement

New finding of researches during 10 years show that dust particle in the atmosphere, more than what was thought are dangerous for public health. Dust storms and air pollution that recently had infected the most of Iran's provinces particularly western and southwest provinces of Iran, and even extended to the capital of Iran, Tehran, has been created due to the influence of high- pressure system in southern Iraq and northern parts of Saudi Arabia. This phenomenon rise via recent drought in central and southern area of Iraq and north of Saudi Arabia which causes marshes and pastures field dried up and converted to desert. On the other hand the eight-year Iran-Iraq war led to many of the groves of Abadan and Khorramshahr in Iran and Basra province in Iraq (fifteen million palm trees) was removed that they have the role of windbreak and aerosols, and meetings such as the filter, dust size arose from the Sahara and Saudi Arabian neutral zone will be reduced, to be served, eliminated. Of course, overlook of the Arab countries to the Convention of desertification, particularly the Iraqi government's inability to deal with desertification and this phenomenon was not considered. Recently Turkey and Syria with the construction of 30 dams on the sources of Tigris and Euphrates rivers causing water shortage in two rivers inside the Iraq. And also causing the Mesopotamia wetland dried up and now formed an area with 500 hectare. It should be noted that part of dust storm in the region which it's due to recently drought in this province (Karimi et al. 2010). And also this is important to identify the role of wetlands in prevent of dust emission and their efficiency as filter to do that. It has to assessment all area and factors that affected wetlands and also some engineering project which can affected wetlands. As well as, changes in land use from previous years till yet in upstream of wetlands have to assess. There are several studies have been carried out to assess the source detection of dust, simulation and mapping the dust storm as well as the dust containment.

In this regard, this is a very important issue to know recognize the role of wetland, marsh and swamp in reducing the amount of dust storm, the impact of engineering project on the watershed system with simulation of stream flow as well. In addition, it is also important to study the impact of engineering project and its effects on landuse, wetland area, changing in temperature and finally the changes in hydrologic point of view. Several studies have attempted to monitoring, transport and sedimentation of dust, mineralogy of dust, and dust source detection. However it is important to identify the reason or reasons of producing and increasing of frequency and amount of dust storms. Therefore, this is necessary to assess the factors that provide a bed for this issue. Consequently, this study is an attempt to answer the following questions:

- Does is the Engineering project affect the landuse/cover change?
- Is there any affect by engineering project on changing in climate?
- What is the role of engineering project in disappearing of wetland and marshland area and changing on them?
- How engineering project affect the hydrology in the system?
- Does engineering project have any effect on the increasing dust storm?
- Can wetland area and marshland reduce the frequency and amount of dust storm?

1.9 Objective of the thesis

The first objective of this research is to evaluate the landuse/cover and vegetation change in the study area for assessment of changes in the agricultural and cropland before and after the constructions. To do this, multi-temporal satellite images, MSS, TM, ETM+, and OLI images, in different years of the period were chosen and analysed. This objective will clear the issue to identify the percentage and area of changes in the different classes due to dam construction.

The other significant target of this study is to monitoring and mapping the Al Hawizeh wetland during 1985-2013. This is finding the shrinkage, degradation and disappears of the wetland by construction of engineering projects. To do this used remotely sensed data and ancillary data and also used GIS spatial analysis.

The other goal of this research, estimate the land surface temperature variation. This analysis was done because of the role of engineering project on changing climate over the study area.

The simulation hydrologic part of study area can become more clear the hydrologic of the study area before and after construction; therefore the fourth objective is that investigation and simulation of stream flow on the different gauge station. Particularly, for this research Soil and Water Assessment Tool (SWAT) were chosen to model the watershed and evaluate the hydrologic process.

It is possible to summarize the above-mentioned four objectives of the thesis as follow.

i. To identify the impact of LULC change in Karkheh catchment using multi-temporal and multi-spectral Landsat images due to the construction of engineering projects.

ii. To assess the change and distribution of Land Surface Temperature over the SKS using remotely sensed data.

iii. To evaluate the shrinkage, fragmentation, and degradation of the wetland possibly due to the engineering projects using spatio-temporal satellite data.

iv. To simulate and analyse the hydrological process of the Karkheh River Basin using GIS based SWAT model due to construction of the engineering projects.

1.10 Scope and limitation of the thesis

The scope of this thesis is to identify the impact of engineering projects in the Karkheh watershed in order to find the reason of increasing of frequency and amount of dust storm. Therefore, role of wetland on the filtration and reduce the amount of dust storm assessing of different methods in order to identify the changes and mapping the wetland changes, as well as assess the impacts of engineering project on the downstream of watershed by hydrological modelling the Karkheh river basin. The studied area for the first phase is between 1985 and 2013 as well as for simulation the hydrologic process is between 1987 and 2010. In comparison with the scope of the thesis, some limitation are recognise the performed the thesis. One of these limitations is growth in population and urbanization during the past three decades. Therefore, it is more accurate in the future study to address this part and assess the impact of urbanization. Figure 1.9 shows the overall methodology of this thesis.

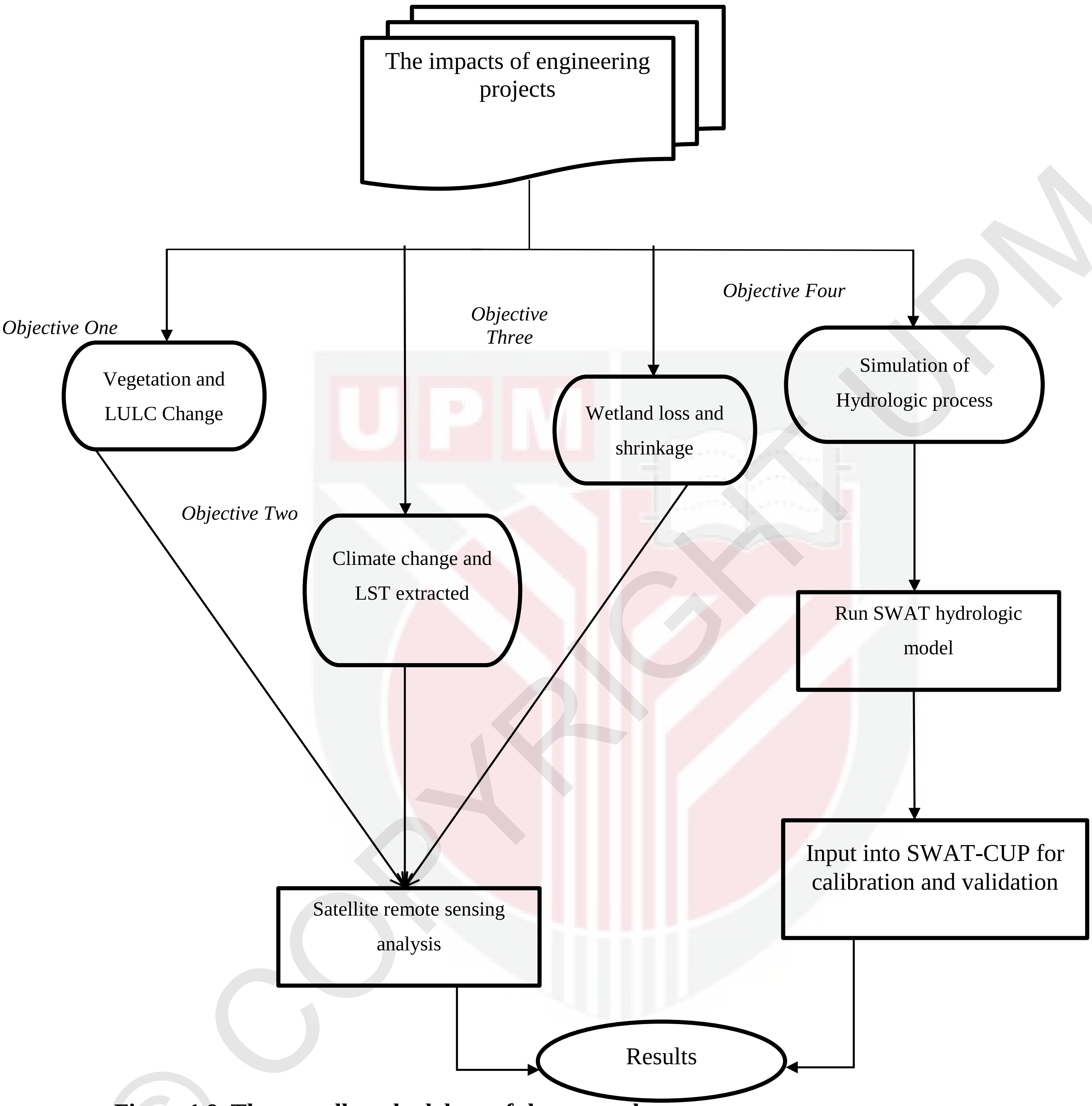

Figure 1.9. The overall methodology of the research

1.11 Thesis organization

This thesis is divided into seven chapters, including;

CHAPTER 1: A general introduction regarding the importance, problem statement, research objectives and contribution of the study.

CHAPTER 2: An overview of background of research regarding dust storm and emission, vegetation and LULC change, climate change and land surface temperature, wetland lost and shrinkage, and hydrologic modelling in the study area.

CHAPTER 3: This chapter describes the vegetation change in the study area during the 1985-2013 using multi-temporal data throughout the subset of the study area.

Chapter 4: In this chapter the climate change and land surface temperature assess to evaluate the effect of dam on the changing in climate. LSE and LST extracted using TIR Landsat images. And the relationship between LST and LULC determine.

CHAPTER 5: In this chapter the shrinkage of wetland during 1985 to 2013 assesses and the effect of engineering project evaluate using multi-temporal satellite data.

CHAPTER 6: In the last chapter, the hydrologic condition in the study area simulated using Soil and Water Assessment Tool. Calibration and validation for flow gauge station perform by SWAT-CUP and the discharge water to the wetland evaluated with two scenarios, with and without dam.

CHAPTER 7: The conclusions and recommendations are presented.

BIBLIOGRAPHY

Abbasi, T., and Abbasi, S. (2007). Dust explosions–Cases, causes, consequences, and control. *Journal of Hazardous Materials* 140 (1), 7-44.

Abbaspour, K. (2007). User manual for SWAT-CUP, SWAT calibration and uncertainty analysis programs. *Swiss Federal Institute of Aquatic Science and Technology, Eawag, Duebendorf, Switzerland*.

Abbaspour, K., Johnson, C., and Van Genuchten, M. T. (2004). Estimating uncertain flow and transport parameters using a sequential uncertainty fitting procedure. *Vadose Zone Journal* 3 (4), 1340-1352.

Abbaspour, K., Vejdani, M., and Haghighat, S. (2007a). SWAT-CUP calibration and uncertainty programs for SWAT. *MODSIM 2007 International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand* 1596-1602.

Abbaspour, K. C. (2009). SWAT-CUP2. *SWAT calibration and uncertainty programs, Version* 2.

Abbaspour, K. C., Yang, J., Maximov, I., Siber, R., Bogner, K., Mieleitner, J., Zobrist, J., and Srinivasan, R. (2007b). Modelling hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. *Journal of Hydrology* 333 (2), 413-430.

Abbott, M. B., Bathurst, J. C., Cunge, J. A., O'Connell, P. E., and Rasmussen, J. (1986). An introduction to the European Hydrological System—Systeme Hydrologique Europeen,“SHE”, 1: History and philosophy of a physically-based, distributed modelling system. *Journal of Hydrology* 87 (1), 45-59.

Abd El-Kawy, O., Rød, J., Ismail, H., and Suliman, A. (2011). Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data. *Applied Geography* 31 (2), 483-494.

Abdou, W. A., Diner, D. J., Martonchik, J. V., Bruegge, C. J., Kahn, R. A., Gaitley, B. J., Crean, K. A., Remer, L. A., and Holben, B. (2005). Comparison of coincident Multiangle Imaging Spectroradiometer and Moderate Resolution Imaging Spectroradiometer aerosol optical depths over land and ocean scenes containing Aerosol Robotic Network sites. *Journal of Geophysical Research: Atmospheres (1984–2012)* 110 (D10).

Agam, N., Kustas, W. P., Anderson, M. C., Li, F., and Neale, C. M. (2007). A vegetation index based technique for spatial sharpening of thermal imagery. *Remote Sensing of Environment* 107 (4), 545-558.

Ahlqvist, O. (2008). Extending post-classification change detection using semantic similarity metrics to overcome class heterogeneity: A study of 1992 and 2001 US National Land Cover Database changes. *Remote Sensing of Environment* 112 (3), 1226-1241.

Ahmad, M.-u.-D., and Giordano, M. (2010). The Karkheh River basin: the food basket of Iran under pressure. *Water International* 35 (5), 522-544.

Ahmad, M.-U.-D., Islam, M. A., Masih, I., Muthuwatta, L., Karimi, P., and Turral, H. (2009). Mapping basin-level water productivity using remote sensing and secondary data in the Karkheh River Basin, Iran. *Water international* 34 (1), 119-133.

Akhavan, S., Abedi-Koupai, J., Mousavi, S.-F., Afyuni, M., Eslamian, S.-S., and Abbaspour, K. C. (2010). Application of SWAT model to investigate nitrate leaching in Hamadan–Bahar Watershed, Iran. *Agriculture, Ecosystems & Environment* 139 (4), 675-688.

Alberti, M. (2005). The effects of urban patterns on ecosystem function. *International Regional Science Review* 28 (2), 168-192.

Altinbilek, D. (2004). Development and management of the Euphrates–Tigris basin. *International Journal of Water Resources Development* 20 (1), 15-33.

Amiri, R., Weng, Q., Alimohammadi, A., and Alavipanah, S. K. (2009). Spatial–temporal dynamics of land surface temperature in relation to fractional vegetation cover and land use/cover in the Tabriz urban area, Iran. *Remote sensing of environment* 113 (12), 2606-2617.

Armenakis, C., Leduc, F., Cyr, I., Savopol, F., and Cavayas, F. (2003). A comparative analysis of scanned maps and imagery for mapping applications. *ISPRS Journal of Photogrammetry and Remote Sensing* 57 (5), 304-314.

Arnold, J., Allen, P., Volk, M., Williams, J., and Bosch, D. (2010). Assessment of different representations of spatial variability on SWAT model performance. *Trans. ASABE* 53 (5), 1433-1443.

Arnold, J., Kiniry, J., Srinivasan, R., Williams, J., Haney, E., and Neitsch, S. (2011). Soil and Water Assessment Tool input/output file documentation, version 2009. *US Department of Agriculture-Agricultural Research Service, Grassland, Soil and Water Research Laboratory, Temple, TX and Blackland Research and Extension Centre, Texas AgriLife Research, Temple, TX Texas Water Resources Institute Technical Report* (365).

Arnold, J., Muttiah, R. S., Srinivasan, R., and Allen, P. (2000). Regional estimation of base flow and groundwater recharge in the Upper Mississippi river basin. *Journal of Hydrology* 227 (1), 21-40.

Arnold, J. G., Srinivasan, R., Muttiah, R. S., and Allen, P. M. (1999). Continental scale simulation of the hydrologic balance1. Wiley Online Library.

Arnold, J. G., Srinivasan, R., Muttiah, R. S., and Williams, J. R. (1998a). Large area hydrologic modeling and assessment part I: Model development1. *JAWRA Journal of the American Water Resources Association* 34 (1), 73-89.

Arnold, J. G., Srinivasan, R., Muttiah, R. S., and Williams, J. R. (1998b). Large area hydrologic modeling and assessment part I: Model development1. Wiley Online Library.

Augusteijn, M., and Warrender, C. (1998). Wetland classification using optical and radar data and neural network classification. *International Journal of Remote Sensing* 19 (8), 1545-1560.

Badarinath, K., Kharol, S. K., Kaskaoutis, D., Sharma, A. R., Ramaswamy, V., and Kambezidis, H. (2010). Long-range transport of dust aerosols over the Arabian Sea and Indian region—A case study using satellite data and ground-based measurements. *Global and Planetary Change* 72 (3), 164-181.

Baddock, M. C., Bullard, J. E., and Bryant, R. G. (2009). Dust source identification using MODIS: A comparison of techniques applied to the Lake Eyre Basin, Australia. *Remote Sensing of Environment* 113 (7), 1511-1528.

Badreldin, N., and Goossens, R. (2013). Monitoring land use/land cover change using multi-temporal Landsat satellite images in an arid environment: a case study of El-Arish, Egypt. *Arabian Journal of Geosciences*, 1-11.

Bain, D. J., and Brush, G. S. (2005). Placing the pieces: Reconstructing the original property mosaic in a warrant and patent watershed. *Landscape Ecology* 19 (8), 843-856.

Baker, C., Lawrence, R., Montagne, C., and Patten, D. (2006). Mapping wetlands and riparian areas using Landsat ETM+ imagery and decision-tree-based models. *Wetlands* 26 (2), 465-474.

Baker, C., Lawrence, R. L., Montagne, C., and Patten, D. (2007). Change detection of wetland ecosystems using Landsat imagery and change vector analysis. *Wetlands* 27 (3), 610-619.

Ball, J. B. (2001). Global forest resources: history and dynamics. *The Forests Handbook, Volume 1: An Overview of Forest Science*, 3-22.

Bannwarth, M., Hugenschmidt, C., Sangchan, W., Lamers, M., Ingwersen, J., Ziegler, A., and Streck, T. (2014). Simulation of stream flow components in a mountainous catchment in northern Thailand with

SWAT, using the ANSELM calibration approach. *Hydrological Processes*.

Barsi, J. A., Schott, J., Palluconi, F. D., Helder, D., Hook, S., Markham, B., Chander, G., and O'Donnell, E. (2003). Landsat TM and ETM+ thermal band calibration. *Canadian Journal of Remote Sensing* 29 (2), 141-153.

Basgall, M. (2003). DUWC joins iraqi marsh restoration project. *Wetland Wire* 6 (2), 1-3.

Bayarjargal, Y., Karnieli, A., Bayasgalan, M., Khudulmur, S., Gandush, C., and Tucker, C. (2006). A comparative study of NOAA–AVHRR derived drought indices using change vector analysis. *Remote Sensing of Environment* 105 (1), 9-22.

Beasley, D., and Hyggins, L. (1995). ANSWERS-User's Manual. US Environmental Protection Agency, Chicago. EPA-905/9-82-001, p54.

Becker, F., and Li, Z.-L. (1990). Temperature-independent spectral indices in thermal infrared bands. *Remote Sensing of Environment* 32 (1), 17-33.

Benaman, J., Shoemaker, C. A., and Haith, D. A. (2005). Calibration and validation of soil and water assessment tool on an agricultural watershed in upstate New York. *Journal of Hydrologic Engineering* 10 (5), 363-374.

Berberoglu, S., and Akin, A. (2009). Assessing different remote sensing techniques to detect land use/cover changes in the eastern Mediterranean. *International Journal of Applied Earth Observation and Geoinformation* 11 (1), 46-53.

Berk, A., Bernstein, L., Anderson, G., Acharya, P., Robertson, D., Chetwynd, J., and Adler-Golden, S. (1998). MODTRAN cloud and multiple scattering upgrades with application to AVIRIS. *Remote Sensing of Environment* 65 (3), 367-375.

Berk, A., Bernstein, L. S., and Robertson, D. C. (1987). MODTRAN: A moderate resolution model for LOWTRAN. DTIC Document.

Beven, K., and Binley, A. (1992). The future of distributed models: model calibration and uncertainty prediction. *Hydrological Processes* 6 (3), 279-298.

Blöschl, G., and Sivapalan, M. (1995). Scale issues in hydrological modelling: a review. *Hydrological processes* 9 (3-4), 251-290.

Boorman, D. B. (2003). Climate, Hydrochemistry and Economics of Surface-water Systems (CHESS): adding a European dimension to the catchment modelling experience developed under LOIS. *Science of The Total Environment* 314, 411-437.

Bradley, B. A., and Mustard, J. F. (2006). Characterizing the landscape dynamics of an invasive plant and risk of invasion using remote sensing. *Ecological Applications* 16 (3), 1132-1147.

Brink, A. B., and Eva, H. D. (2009). Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach. *Applied Geography* 29 (4), 501-512.

Brown, P. H., and Lant, C. L. (1999). The effect of wetland mitigation banking on the achievement of no-net-loss. *Environmental Management* 23 (3), 333-345.

Bruland, G. L., Hanchey, M. F., and Richardson, C. J. (2003). Effects of agriculture and wetland restoration on hydrology, soils, and water quality of a Carolina bay complex. *Wetlands Ecology and Management* 11 (3), 141-156.

Bugaets, A., and Gonchukov, L. (2014). Application of WRF-SWAT OpenMI 2.0 based models integration for real time hydrological modelling and forecasting. *EGU General Assembly Conference Abstracts* 4712.

Bwangoy, J.-R. B., Hansen, M. C., Roy, D. P., Grandi, G. D., and Justice, C. O. (2010). Wetland mapping in the Congo Basin using optical and radar remotely sensed data and derived topographical indices. *Remote Sensing of Environment* 114 (1), 73-86.

Cai, X., and Rosegrant, M. W. (2003). 10 World Water Productivity: Current Situation and Future Options. *Water productivity in agriculture: limits and opportunities for improvement* 1, 163.

Cao, W., Bowden, W. B., Davie, T., and Fenemor, A. (2006). Multi-variable and multi-site calibration and validation of SWAT in a large mountainous catchment with high spatial variability. *Hydrological Processes* 20 (5), 1057-1073.

Carlson, T. N., and Ripley, D. A. (1997). On the relation between NDVI, fractional vegetation cover, and leaf area index. *Remote Sensing of Environment* 62 (3), 241-252.

Caselles, V., Coll, C., Valor, E., and Rubio, E. (1995). Mapping land surface emissivity using AVHRR data application to La Mancha, Spain. *Remote Sensing Reviews* 12 (3-4), 311-333.

Chander, G., Markham, B. L., and Helder, D. L. (2009). Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors. *Remote Sensing of Environment* 113 (5), 893-903.

Chase, T., Pielke Sr, R., Kittel, T., Nemani, R., and Running, S. (2000). Simulated impacts of historical land cover changes on global climate in northern winter. *Climate Dynamics* 16 (2-3), 93-105.

Chen, X., Vierling, L., Rowell, E., and DeFelice, T. (2004). Using lidar and effective LAI data to evaluate IKONOS and Landsat 7 ETM+ vegetation cover estimates in a ponderosa pine forest. *Remote Sensing of Environment* 91 (1), 14-26.

Chu, T., and Shirmohammadi, A. (2004). Evaluation of the SWAT model's hydrology component in the Piedmont physiographic region of Maryland. *Transactions of the ASAE* 47 (4), 1057-1073.

Co-operation, D. A. C. O. f. E., and Development (1996). *Guidelines for aid agencies for improved conservation and sustainable use of tropical and sub-tropical wetlands*. OECD.

Coll, C., Caselles, V., Galve, J. M., Valor, E., Niclos, R., Sánchez, J. M., and Rivas, R. (2005). Ground measurements for the validation of land surface temperatures derived from AATSR and MODIS data. *Remote Sensing of Environment* 97 (3), 288-300.

Congalton, R. G., and Green, K. (2008). *Assessing the accuracy of remotely sensed data: principles and practices*. CRC press.

Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B., and Lambin, E. (2004). Review ArticleDigital change detection methods in ecosystem monitoring: a review. *International Journal of Remote Sensing* 25 (9), 1565-1596.

Coulibaly, L., and Goïta, K. (2006). Evaluation of the potential of various spectral indices and textural features derived from satellite images for surficial deposits mapping. *International Journal of Remote Sensing* 27 (20), 4567-4584.

Cowardin, L. M., Carter, V., Golet, F. C., and LaRoe, E. T. (1979). *Classification of wetlands and deepwater habitats of the United States*. Fish and Wildlife Service, US Department of the Interior Washington, DC.

Cracknell, A. P. (2001). The exciting and totally unanticipated success of the AVHRR in applications for which it was never intended. *Advances in Space Research* 28 (1), 233-240.

Dash, P., Göttsche, F.-M., Olesen, F.-S., and Fischer, H. (2002). Land surface temperature and emissivity estimation from passive sensor data: theory and practice-current trends. *International Journal of Remote Sensing* 23 (13), 2563-2594.

Dewan, A. M., and Yamaguchi, Y. (2009a). Land use and land cover change in Greater Dhaka, Bangladesh: using remote sensing to promote sustainable urbanization. *Applied Geography* 29 (3), 390-401.

Dewan, A. M., and Yamaguchi, Y. (2009b). Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka

Metropolitan of Bangladesh during 1960–2005. *Environmental Monitoring and Assessment* 150 (1-4), 237-249.

Di Luzio, M., Arnold, J., and Srinivasan, R. (2004a). Integration of SSURGO maps and soil parameters within a geographic information system and nonpoint source pollution model system. *Journal of Soil and Water Conservation* 59 (4), 123-133.

Di Luzio, M., Arnold, J. G., and Srinivasan, R. (2005). Effect of GIS data quality on small watershed stream flow and sediment simulations. *Hydrological Processes* 19 (3), 629-650.

Di Luzio, M., Srinivasan, R., and Arnold, J. G. (2004b). A GIS-coupled hydrological model system for the watershed assessment of agricultural nonpoint and point sources of pollution. *Transactions in GIS* 8 (1), 113-136.

Dinpashoh, Y., Fakheri-Fard, A., Moghaddam, M., Jahanbakhsh, S., and Mirnia, M. (2004). Selection of variables for the purpose of regionalization of Iran's precipitation climate using multivariate methods. *Journal of Hydrology* 297 (1), 109-123.

Douglas-Mankin, K., Srinivasan, R., and Arnold, J. (2010). Soil and Water Assessment Tool (SWAT) model: Current developments and applications. *Trans. ASABE* 53 (5), 1423-1431.

Du, B., Saleh, A., Jaynes, D., and Arnold, J. (2006). Evaluation of SWAT in simulating nitrate nitrogen and atrazine fates in a watershed with tiles and potholes. *Transactions of the ASAE* 49 (4), 949-959.

Du, J., Rui, H., Zuo, T., Li, Q., Zheng, D., Chen, A., Xu, Y., and Xu, C.-Y. (2013). Hydrological simulation by SWAT model with fixed and varied parameterization approaches under land use change. *Water Resources Management* 27 (8), 2823-2838.

Ehrenfeld, J. G. (2000). Evaluating wetlands within an urban context. *Ecological Engineering* 15 (3), 253-265.

Engelstaedter, S., and Washington, R. (2007). Atmospheric controls on the annual cycle of North African dust. *Journal of Geophysical Research: Atmospheres (1984–2012)* 112 (D3).

Erwin, K. L. (2009). Wetlands and global climate change: the role of wetland restoration in a changing world. *Wetlands Ecology and Management* 17 (1), 71-84.

FAO, J., and FOODS, M. H. I. (2004). Food and Agriculture organization of the United Nations. *Rome, URL: http://faostat. fao. org*.

Faramarzi, M., Abbaspour, K. C., Ashraf Vaghefi, S., Farzaneh, M. R., Zehnder, A. J., Srinivasan, R., and Yang, H. (2013). Modeling impacts of climate change on freshwater availability in Africa. *Journal of Hydrology* 480, 85-101.

Faramarzi, M., Abbaspour, K. C., Schulin, R., and Yang, H. (2009). Modelling blue and green water resources availability in Iran. *Hydrological Processes* 23 (3), 486-501.

Feng, X., Zhang, G., and Xu, Y. J. (2013). Simulation of hydrological processes in the Zhalong wetland within a river basin, Northeast China. *Hydrology & Earth System Sciences* 17 (7), 2797-2807.

Ficklin, D. L., Luo, Y., Luedeling, E., and Zhang, M. (2009). Climate change sensitivity assessment of a highly agricultural watershed using SWAT. *Journal of Hydrology* 374 (1), 16-29.

Fischer, S., Pluntke, T., Pavlik, D., and Bernhofer, C. (2014). Hydrologic effects of climate change in a sub-basin of the Western Bug River, Western Ukraine. *Environmental Earth Sciences*, 1-18.

Fleiss, J. L., Levin, B., and Paik, M. C. (1981). The measurement of interrater agreement. *Statistical methods for rates and proportions* 2, 212-236.

Fohrer, N., Haverkamp, S., and Frede, H. G. (2005). Assessment of the effects of land use patterns on hydrologic landscape functions: development of sustainable land use concepts for low mountain range areas. *Hydrological Processes* 19 (3), 659-672.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., and Gibbs, H. K. (2005). Global consequences of land use. *science* 309 (5734), 570-574.

Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote sensing of environment* 80 (1), 185-201.

Franczyk, J., and Chang, H. (2009). The effects of climate change and urbanization on the runoff of the Rock Creek basin in the Portland metropolitan area, Oregon, USA. *Hydrological Processes* 23 (6), 805-815.

Franke, J., Becker, M., Menz, G., Misana, S., Mwita, E., and Nienkemper, P. (2009). Aerial imagery for monitoring land use in East African wetland ecosystems. *Geoscience and Remote Sensing Symposium, 2009 IEEE International, IGARSS 2009* V-288-V-291.

Fu, P., Huang, J., Li, C., and Zhong, S. (2008). The properties of dust aerosol and reducing tendency of the dust storms in northwest China. *Atmospheric Environment* 42 (23), 5896-5904.

Furman, H. K. H. (2003). Dust storms in the Middle East: sources of origin and their temporal characteristics. *Indoor and Built Environment* 12 (6), 419-426.

Gao, J., and Liu, Y. (2010). Determination of land degradation causes in Tongyu County, Northeast China via land cover change detection. *International Journal of Applied Earth Observation and Geoinformation* 12 (1), 9-16.

Gassman, P. W., Reyes, M. R., Green, C. H., and Arnold, J. G. (2007). *The soil and water assessment tool: historical development, applications, and future research directions*. Center for Agricultural and Rural Development, Iowa State University, pp. 1211-1250.

Ghaffari, G., Keesstra, S., Ghodousi, J., and Ahmadi, H. (2010). SWAT-simulated hydrological impact of land-use change in the Zanjanrood basin, Northwest Iran. *Hydrological Processes* 24 (7), 892-903.

Ghermay, L., Rochon, H. S., West, B., and Abdullah, S. (2000). Utilizing archival remotely sensed data in support of wetland resource management. *Geoscience and Remote Sensing Symposium, 2000. Proceedings. IGARSS 2000. IEEE 2000 International* 1921-1923.

Gikas, G. D., Yiannakopoulou, T., and Tsihrintzis, V. A. (2006). Modeling of non-point source pollution in a Mediterranean drainage basin. *Environmental Modeling & Assessment* 11 (3), 219-233.

Gillespie, A., Rokugawa, S., Matsunaga, T., Cothern, J. S., Hook, S., and Kahle, A. B. (1998). A temperature and emissivity separation algorithm for Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images. *Geoscience and Remote Sensing, IEEE Transactions on* 36 (4), 1113-1126.

Gillespie, A. R. (1986). Lithologic mapping of silicate rocks using TIMS. *The TIMS Data User's Workshop p 29-44(SEE N 87-17111 09-43).*

Goldstein, H. L., Reynolds, R. L., Reheis, M. C., Yount, J. C., and Neff, J. C. (2008). Compositional trends in aeolian dust along a transect across the southwestern United States. *Journal of Geophysical Research: Earth Surface (2003–2012)* 113 (F2).

Gong, P., Niu, Z., Cheng, X., Zhao, K., Zhou, D., Guo, J., Liang, L., Wang, X., Li, D., and Huang, H. (2010). China's wetland change (1990–2000) determined by remote sensing. *Science China Earth Sciences* 53 (7), 1036-1042.

Gong, Y., Shen, Z., Hong, Q., Liu, R., and Liao, Q. (2011). Parameter uncertainty analysis in watershed total phosphorus modeling using the GLUE methodology. *Agriculture, Ecosystems & Environment* 142 (3), 246-255.

Goudie, A. S. (2009). Dust storms: Recent developments. *Journal of Environmental Management* 90 (1), 89-94.

Guerzoni, S., Molinaroli, E., and Chester, R. (1997). Saharan dust inputs to the western Mediterranean Sea: depositional patterns, geochemistry and sedimentological implications. *Deep Sea Research Part II: Topical Studies in Oceanography* 44 (3), 631-654.

Gupta, P., and Christopher, S. (2008). Seven year particulate matter air quality assessment from surface and satellite measurements. *Atmospheric Chemistry and Physics* 8 (12), 3311-3324.

Hansell, R., Ou, S., Liou, K., Roskovensky, J., Tsay, S., Hsu, C., and Ji, Q. (2007). Simultaneous detection/separation of mineral dust and cirrus clouds using MODIS thermal infrared window data. *Geophysical Research Letters* 34 (11).

Hao, Z., Gong, F., Tu, Q., and Mao, Z. (2011). A detection algorithm for Asian dust aerosol over China Seas based on MODIS observations. *SPIE Remote Sensing* 817714-817714-817717.

Harrison, S. P., Kohfeld, K. E., Roelandt, C., and Claquin, T. (2001). The role of dust in climate changes today, at the last glacial maximum and in the future. *Earth-Science Reviews* 54 (1), 43-80.

Hartemink, A. E., Veldkamp, T., and Bai, Z. (2008). Land Cover Change and Soil Fertility Decline in Tropical Regions. *Turkish Journal of Agriculture & Forestry* 32 (3).

Haverkamp, S., Fohrer, N., and Frede, H. G. (2005). Assessment of the effect of land use patterns on hydrologic landscape functions: A comprehensive GIS-based tool to minimize model uncertainty resulting from spatial aggregation. *Hydrological Processes* 19 (3), 715-727.

He, C., Wei, A., Shi, P., Zhang, Q., and Zhao, Y. (2011). Detecting land-use/land-cover change in rural–urban fringe areas using extended change-vector analysis. *International Journal of Applied Earth Observation and Geoinformation* 13 (4), 572-585.

Herkert, J. R., Reinking, D. L., Wiedenfeld, D. A., Winter, M., Zimmerman, J. L., Jensen, W. E., Finck, E. J., Koford, R. R., Wolfe, D. H., and Sherrod, S. K. (2003). Effects of prairie fragmentation on the nest success of breeding birds in the midcontinental United States. *Conservation Biology* 17 (2), 587-594.

Hladil, J., Cejchan, P., Babek, O., Koptikova, L., Navratil, T., and Kubinova, P. (2010). Dust–A geology-orientated attempt to reappraise the natural components, amounts, inputs to sediment, and importance for correlation purposes. *Geologica Belgica* 13 (4), 367-384.

Hörmann, G., Köplin, N., Cai, Q., and Fohrer, N. (2009). Using a simple model as a tool to parameterise the SWAT model of the Xiangxi river in China. *Quaternary International* 208 (1), 116-120.

Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., van der Linden, P. J., Dai, X., Maskell, K., and Johnson, C. (2001). *Climate change 2001: the scientific basis*. Cambridge university press Cambridge.

Houghton, R. A. (2003). Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850–2000. *Tellus B* 55 (2), 378-390.

Huang, C., Davis, L., and Townshend, J. (2002). An assessment of support vector machines for land cover classification. *International Journal of Remote Sensing* 23 (4), 725-749.

Huang, S., Dahal, D., Young, C., Chander, G., and Liu, S. (2011). Integration of Palmer Drought Severity Index and remote sensing data to simulate wetland water surface from 1910 to 2009 in Cottonwood Lake area, North Dakota. *Remote Sensing of Environment* 115 (12), 3377-3389.

Huang, Z., Xue, B., and Pang, Y. (2009). Simulation on stream flow and nutrient loadings in Gucheng Lake, Low Yangtze River Basin, based on SWAT model. *Quaternary International* 208 (1), 109-115.

Huete, A., Didan, K., Miura, T., Rodriguez, E. P., Gao, X., and Ferreira, L. G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. *Remote Sensing of Environment* 83 (1), 195-213.

Huszar, P. C., and Piper, S. L. (1986). Estimating the off-site costs of wind erosion in New Mexico. *Journal of Soil and Water Conservation* 41 (6), 414-416.

Imhoff, M. L., Zhang, P., Wolfe, R. E., and Bounoua, L. (2010). Remote sensing of the urban heat island effect across biomes in the continental USA. *Remote Sensing of Environment* 114 (3), 504-513.

Irish, R. (2000). Landsat 7 science data users handbook. *National Aeronautics and Space Administration, Report*, 430-415.

Islam, M. A., Thenkabail, P., Kulawardhana, R., Alankara, R., Gunasinghe, S., Edussriya, C., and Gunawardana, A. (2008). Semi-automated methods for mapping wetlands using Landsat ETM+ and SRTM data. *International Journal of Remote Sensing* 29 (24), 7077-7106.

Jacobs, J., Angerer, J., Vitale, J., Srinivasan, R., and Kaitho, R. (2007). Mitigating economic damage in Kenya’s upper Tana River basin: an application of Arc-View SWAT. *Journal of Spatial Hydrology* 7 (1), 23-46.

Jayakrishnan, R., Srinivasan, R., Santhi, C., and Arnold, J. (2005). Advances in the application of the SWAT model for water resources management. *Hydrological Processes* 19 (3), 749-762.

Jeganathan, C., Hamm, N., Mukherjee, S., Atkinson, P. M., Raju, P., and Dadhwal, V. (2011). Evaluating a thermal image sharpening model over a mixed agricultural landscape in India. *International Journal of Applied Earth Observation and Geoinformation* 13 (2), 178-191.

Jensen, J. R. (1996). *Introductory digital image processing: a remote sensing perspective*. Prentice-Hall Inc.

Jiang, Z., Huete, A. R., Chen, J., Chen, Y., Li, J., Yan, G., and Zhang, X. (2006). Analysis of NDVI and scaled difference vegetation index retrievals of vegetation fraction. *Remote Sensing of Environment* 101 (3), 366-378.

Jiménez-Muñoz, J. C., Sobrino, J. A., Gillespie, A., Sabol, D., and Gustafson, W. T. (2006). Improved land surface emissivities over agricultural areas using ASTER NDVI. *Remote Sensing of Environment* 103 (4), 474-487.

Jiménez-Muñoz, J. C., and Sobrino, J. A. (2003). A generalized single-channel method for retrieving land surface temperature from remote sensing data. *Journal of Geophysical Research: Atmospheres (1984–2012)* 108 (D22).

Jin, M., and Liang, S. (2006). An improved land surface emissivity parameter for land surface models using global remote sensing observations. *Journal of Climate* 19 (12), 2867-2881.

Johansen, N., Imhoff, J., Kittle, J., and Donigian, A. (1984). Hydrological simulation program–FORTRAN (HSPF): User's manual for release 8. *EPA-600*, 3-84.

Jones, C., Sultan, M., Yan, E., Milewski, A., Hussein, M., Al-Dousari, A., Al-Kaisy, S., and Becker, R. (2008). Hydrologic impacts of engineering projects on the Tigris–Euphrates system and its marshlands. *Journal of Hydrology* 353 (1), 59-75.

Jones, K., Lanthier, Y., van der Voet, P., van Valkengoed, E., Taylor, D., and Fernández-Prieto, D. (2009). Monitoring and assessment of wetlands using Earth Observation: The GlobWetland project. *Journal of Environmental Management* 90 (7), 2154-2169.

Julien, Y., and Sobrino, J. A. (2009). The Yearly Land Cover Dynamics (YLCD) method: An analysis of global vegetation from NDVI and LST parameters. *Remote Sensing of Environment* 113 (2), 329-334.

Kabiri, K., Pradhan, B., Samimi-Namin, K., and Moradi, M. (2013). Detecting coral bleaching, using QuickBird multi-temporal data: a feasibility study at Kish Island, the Persian Gulf. *Estuarine, Coastal and Shelf Science* 117, 273-281.

Kalin, L., and Hantush, M. M. (2006). Hydrologic modeling of an eastern Pennsylvania watershed with NEXRAD and rain gauge data. *Journal of Hydrologic Engineering* 11 (6), 555-569.

Kannan, N., White, S., Worrall, F., and Whelan, M. (2007). Sensitivity analysis and identification of the best evapotranspiration and runoff options for hydrological modelling in SWAT-2000. *Journal of Hydrology* 332 (3), 456-466.

Karimi, N., Moridnejad, A., Golian, S., Vali Samani, J. M., Karimi, D., and Javadi, S. (2012). Comparison of dust source identification techniques over land in the Middle East region using MODIS data. *Canadian Journal of Remote Sensing* 38 (5), 586-599.

Karnieli, A., Bayasgalan, M., Bayarjargal, Y., Agam, N., Khudulmur, S., and Tucker, C. (2006). Comments on the use of the vegetation health index over Mongolia. *International Journal of Remote Sensing* 27 (10), 2017-2024.

Kashaigili, J. J., Mbilinyi, B. P., Mccartney, M., and Mwanuzi, F. L. (2006). Dynamics of Usangu plains wetlands: Use of remote sensing and GIS as management decision tools. *Physics and Chemistry of the Earth, Parts A/B/C* 31 (15), 967-975.

Kaskaoutis, D., Kambezidis, H., Nastos, P., and Kosmopoulos, P. (2008). Study on an intense dust storm over Greece. *Atmospheric Environment* 42 (29), 6884-6896.

Kavouras, I. G., Etyemezian, V., and DuBois, D. W. (2009). Development of a geospatial screening tool to identify source areas of windblown dust. *Environmental Modelling & Software* 24 (8), 1003-1011.

Kavvas, M. L., Chen, Z., Anderson, M. L., Ohara, N., Yoon, J., and Xiang, F. (2011). A study of water balances over the Tigris–Euphrates watershed. *Physics and Chemistry of the Earth, Parts A/B/C* 36 (5), 197-203.

Kayranli, B., Scholz, M., Mustafa, A., and Hedmark, Å. (2010). Carbon storage and fluxes within freshwater wetlands: a critical review. *Wetlands* 30 (1), 111-124.

Kazem, A. A., Chaichan, M. T., and Kazem, H. A. (2014). Dust effect on photovoltaic utilization in Iraq: Review article. *Renewable and Sustainable Energy Reviews* 37, 734-749.

Keith, D. A., Rodoreda, S., and Bedward, M. (2010). Decadal change in wetland–woodland boundaries during the late 20th century reflects climatic trends. *Global Change Biology* 16 (8), 2300-2306.

Khoi, D. N., and Suetsugi, T. (2014). The responses of hydrological processes and sediment yield to land-use and climate change in the Be River Catchment, Vietnam. *Hydrological Processes* 28 (3), 640-652.

Kilic, S., Evrendilek, F., Berberoglu, S., and Demirkesen, A. (2006). Environmental monitoring of land-use and land-cover changes in a Mediterranean region of Turkey. *Environmental Monitoring and Assessment* 114 (1-3), 157-168.

Kim, N., Shin, A., and Lee, J. (2010a). Effects of streamflow routing schemes on water quality with SWAT. *Transactions of the ASABE* 53 (5), 1457-1468.

Kim, S.-W., Yoon, S.-C., Kim, J., Kang, J.-Y., and Sugimoto, N. (2010b). Asian dust event observed in Seoul, Korea, during 29–31 May 2008: Analysis of transport and vertical distribution of dust particles from lidar and surface measurements. *Science of the Total Environment* 408 (7), 1707-1718.

Kintz, D. B., Young, K. R., and Crews-Meyer, K. A. (2006). Implications of land use/land cover change in the buffer zone of a national park in the tropical Andes. *Environmental Management* 38 (2), 238-252.

Klemas, V. (2011). Remote sensing of wetlands: case studies comparing practical techniques. *Journal of Coastal Research* 27 (3), 418-427.

Klose, M., Shao, Y., Karremann, M. K., and Fink, A. H. (2010). Sahel dust zone and synoptic background. *Geophysical Research Letters* 37 (9).

Klüser, L., and Schepanski, K. (2009). Remote sensing of mineral dust over land with MSG infrared channels: A new Bitemporal Mineral Dust Index. *Remote Sensing of Environment* 113 (9), 1853-1867.

Knippertz, P., and Todd, M. C. (2010). The central west Saharan dust hot spot and its relation to African easterly waves and extratropical disturbances. *Journal of Geophysical Research: Atmospheres (1984–2012)* 115 (D12).

Koch, S., Bauwe, A., and Lennartz, B. (2013). Application of the SWAT model for a tile-drained lowland catchment in North-Eastern Germany on subbasin scale. *Water Resources Management* 27 (3), 791-805.

Kouki, J., Löfman, S., Martikainen, P., Rouvinen, S., and Uotila, A. (2001). Forest fragmentation in Fennoscandia: linking habitat requirements of wood-associated threatened species to landscape and habitat changes. *Scandinavian Journal of Forest Research* 16 (S3), 27-37.

Ku, B., and Park, R. J. (2011). Inverse modeling analysis of soil dust sources over East Asia. *Atmospheric Environment* 45 (32), 5903-5912.

Kuczera, G., and Parent, E. (1998). Monte Carlo assessment of parameter uncertainty in conceptual catchment models: the Metropolis algorithm. *Journal of Hydrology* 211 (1), 69-85.

Kuemmerle, T., Radeloff, V. C., Perzanowski, K., and Hostert, P. (2006). Cross-border comparison of land cover and landscape pattern in Eastern Europe using a hybrid classification technique. *Remote Sensing of Environment* 103 (4), 449-464.

La Peyre, M. K., Reams, M. A., and Mendelssohn, I. A. (2001). Linking actions to outcomes in wetland management: an overview of US state wetland management. *Wetlands* 21 (1), 66-74.

Lal, R. (2009). Soil degradation as a reason for inadequate human nutrition. *Food Security* 1 (1), 45-57.

Lambin, E. F., and Geist, H. J. (2006). Land-use and land-cover change. *Local Processes and Global Impacts*, 222.

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O. T., Dirzo, R., Fischer, G., and Folke, C. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change* 11 (4), 261-269.

Lang, M. W., and McCarty, G. W. (2009). Lidar intensity for improved detection of inundation below the forest canopy. *Wetlands* 29 (4), 1166-1178.

Lee, T.-M., and Yeh, H.-C. (2009). Applying remote sensing techniques to monitor shifting wetland vegetation: A case study of Danshui River estuary mangrove communities, Taiwan. *Ecological Engineering* 35 (4), 487-496.

Lehner, B., and Döll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of Hydrology* 296 (1), 1-22.

Lehner, B., Verdin, K., and Jarvis, A. (2008). New global hydrography derived from spaceborne elevation data. *EOS, Transactions American Geophysical Union* 89 (10), 93-94.

Lei, F., Huang, C., Shen, H., and Li, X. (2014). Improving the estimation of hydrological states in the SWAT model via the ensemble Kalman smoother: Synthetic experiments for the Heihe River Basin in northwest China. *Advances in Water Resources* 67, 32-45.

Lepers, E., Lambin, E. F., Janetos, A. C., DeFRIES, R., Achard, F., Ramankutty, N., and Scholes, R. J. (2005). A synthesis of information on rapid land-cover change for the period 1981–2000. *BioScience* 55 (2), 115-124.

Li, X., Wang, Z., Song, K., Zhang, B., Liu, D., and Guo, Z. (2007). Assessment for salinized wasteland expansion and land use change using GIS and remote sensing in the west part of Northeast China. *Environmental Monitoring and Assessment* 131 (1-3), 421-437.

Li, Z.-L., Wu, H., Wang, N., Qiu, S., Sobrino, J. A., Wan, Z., Tang, B.-H., and Yan, G. (2013). Land surface emissivity retrieval from satellite data. *International Journal of Remote Sensing* 34 (9-10), 3084-3127.

Li, Z., Liu, W.-z., Zhang, X.-c., and Zheng, F.-l. (2009). Impacts of land use change and climate variability on hydrology in an agricultural catchment on the Loess Plateau of China. *Journal of Hydrology* 377 (1), 35-42.

Lichvar, R. W., and Kartesz, J. T. (2009). North American Digital Flora: National Wetland Plant List, version 2.4. 0 (https://wetland_plants. usace. army. mil). US Army Corps of Engineers, Engineer Research and Development Center. *Cold Regions Research and Engineering Laboratory, Hanover, NH, and BONAP, Chapel Hill, NC*.

Lillesand, T. M., Kiefer, R. W., and Chipman, J. W. (2004). *Remote sensing and image interpretation*. John Wiley & Sons Ltd.

Liu, H., and Weng, Q. (2008). Seasonal variations in the relationship between landscape pattern and land surface temperature in Indianapolis, USA. *Environmental Monitoring and Assessment* 144 (1-3), 199-219.

Liu, J., Liu, M., Tian, H., Zhuang, D., Zhang, Z., Zhang, W., Tang, X., and Deng, X. (2005). Spatial and temporal patterns of China's cropland during 1990–2000: an analysis based on Landsat TM data. *Remote Sensing of Environment* 98 (4), 442-456.

Liu, Y., Hiyama, T., and Yamaguchi, Y. (2006). Scaling of land surface temperature using satellite data: A case examination on ASTER and MODIS products over a heterogeneous terrain area. *Remote Sensing of Environment* 105 (2), 115-128.

Lu, D., Mausel, P., Brondizio, E., and Moran, E. (2004). Change detection techniques. *International Journal of Remote Sensing* 25 (12), 2365-2401.

Lu, D., and Weng, Q. (2007). A survey of image classification methods and techniques for improving classification performance. *International Journal of Remote Sensing* 28 (5), 823-870.

MacAlister, C., and Mahaxay, M. (2009). Mapping wetlands in the Lower Mekong Basin for wetland resource and conservation management using Landsat ETM images and field survey data. *Journal of Environmental Management* 90 (7), 2130-2137.

Madani, K. (2011). Hydropower licensing and climate change: insights from cooperative game theory. *Advances in Water Resources* 34 (2), 174-183.

Maisongrande, P., Duchemin, B., and Dedieu, G. (2004). VEGETATION/SPOT: an operational mission for the Earth monitoring; presentation of new standard products. *International Journal of Remote Sensing* 25 (1), 9-14.

Mallick, J., Kant, Y., and Bharath, B. (2008). Estimation of land surface temperature over Delhi using Landsat-7 ETM+. *J Indian Geophys Union* 12 (3), 131-140.

Mallick, J., Singh, C. K., Shashtri, S., Rahman, A., and Mukherjee, S. (2012). Land surface emissivity retrieval based on moisture index from LANDSAT TM satellite data over heterogeneous surfaces of Delhi city. *International Journal of Applied Earth Observation and Geoinformation* 19, 348-358.

Mango, L., Melesse, A., McClain, M., Gann, D., and Setegn, S. (2011). Land use and climate change impacts on the hydrology of the upper Mara River Basin, Kenya: results of a modeling study to support better resource management. *Hydrology & Earth System Sciences* 15 (7), 2245-2258.

Marjanizadeh, S., Qureshi, A. S., Turral, H., and Talebzadeh, P. (2009). *From Mesopotamia to the third millennium: the historical trajectory of water development and use in the Karkheh River Basin, Iran*. IWMI.

Markham, B. L., and Barker, J. L. (1987). Radiometric properties of US processed Landsat MSS data. *Remote Sensing of Environment* 22 (1), 39-71.

Masih, I., Ahmad, M.-u.-D., Uhlenbrook, S., Turral, H., and Karimi, P. (2009). Analysing streamflow variability and water allocation for sustainable management of water resources in the semi-arid Karkheh river basin, Iran. *Physics and Chemistry of the Earth, Parts A/B/C* 34 (4), 329-340.

Masih, I., Maskey, S., Uhlenbrook, S., and Smakhtin, V. (2011). Impact of upstream changes in rain-fed agriculture on downstream flow in a semi-arid basin. *Agricultural Water Management* 100 (1), 36-45.

Mausbach, M. J., and Dedrick, A. R. (2004). The length we go measuring environmental benefits of conservation practices. *Journal of Soil and Water Conservation* 59 (5), 96A-103A.

McCauley, L. A., Jenkins, D. G., and Quintana-Ascencio, P. F. (2013). Isolated wetland loss and degradation over two decades in an increasingly urbanized landscape. *Wetlands* 33 (1), 117-127.

Melendez-Pastor, I., Navarro-Pedreno, J., Gómez, I., and Koch, M. (2010). Detecting drought induced environmental changes in a Mediterranean wetland by remote sensing. *Applied Geography* 30 (2), 254-262.

Miller, J. D., and Yool, S. R. (2002). Mapping forest post-fire canopy consumption in several overstory types using multi-temporal Landsat TM and ETM data. *Remote Sensing of Environment* 82 (2), 481-496.

Miri, A., Ahmadi, H., Ekhtesasi, M. R., Panjehkeh, N., and Ghanbari, A. (2009). Environmental and socio-economic impacts of dust storms in Sistan Region, Iran. *International Journal of Environmental Studies* 66 (3), 343-355.

Mishra, A., Froebrich, J., and Gassman, P. W. (2007). Evaluation of the SWAT model for assessing sediment control structures in a small watershed in India. *Transactions of the ASAE* 50 (2), 469-477.

Mitsch, W. J. (2005). Invitational at the Olentangy River Wetland Research Park. *Wetland Creation, Restoration, and Conservation: The State of Science* 24, 243-251.

Mitsch, W. J. (2009). *Wetland Ecosystems*. John Wiley & Sons.

Mitsch, W. J., and Gosselink, J. G. (2000). The value of wetlands: importance of scale and landscape setting. *Ecological economics* 35 (1), 25-33.

Mitsch, W. J., Lefeuvre, J.-C., and Bouchard, V. (2002). Ecological engineering applied to river and wetland restoration. *Ecological Engineering* 18 (5), 529-541.

Modarres, R., and de Paulo Rodrigues da Silva, V. (2007). Rainfall trends in arid and semi-arid regions of Iran. *Journal of Arid Environments* 70 (2), 344-355.

Moon, J., Srinivasan, R., and Jacobs, J. (2004). Stream flow estimation using spatially distributed rainfall in the Trinity River basin, Texas. *Transactions of the ASAE* 47 (5), 1445-1451.

Moriasi, D., Arnold, J., Van Liew, M., Bingner, R., Harmel, R., and Veith, T. (2007). Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. *Trans. ASABE* 50 (3), 885-900.

Mozumder, C., Tripathi, N., and Tipdecho, T. (2014). Ecosystem evaluation (1989–2012) of Ramsar wetland Deepor Beel using satellite-derived indices. *Environmental Monitoring and Assessment* 186 (11), 7909-7927.

Munyati, C. (2000). Wetland change detection on the Kafue Flats, Zambia, by classification of a multitemporal remote sensing image dataset. *International Journal of Remote Sensing* 21 (9), 1787-1806.

Murphy, P. N., Ogilvie, J., Connor, K., and Arp, P. A. (2007). Mapping wetlands: a comparison of two different approaches for New Brunswick, Canada. *Wetlands* 27 (4), 846-854.

Muthuwatta, L., Bos, M., and Rientjes, T. (2010). Assessment of water availability and consumption in the Karkheh River Basin, Iran—Using remote sensing and geo-statistics. *Water Resources Management* 24 (3), 459-484.

Mutie, S., Mati, B., Gadain, H., Gathenya, J., (2006). Evaluating land use change effects on river flow using USGS geospatial stream flow model in Mara River basin, Kenya.

Mwita, E., Menz, G., Misana, S., Becker, M., Kisanga, D., and Boehme, B. (2013). Mapping small wetlands of Kenya and Tanzania using remote sensing techniques. *International Journal of Applied Earth Observation and Geoinformation* 21, 173-183.

Myint, S. W., Gober, P., Brazel, A., Grossman-Clarke, S., and Weng, Q. (2011). Per-pixel vs. object-based classification of urban land cover extraction using high spatial resolution imagery. *Remote Sensing of Environment* 115 (5), 1145-1161.

Najafi, M. S., Khoshakhllagh, F., Zamanzadeh, S. M., Shirazi, M. H., Samadi, M., and Hajikhani, S. (2013). Characteristics of TSP loads during the Middle East springtime dust storm (MESDS) in Western Iran. *Arabian Journal of Geosciences*, 1-15.

Nash, J., and Sutcliffe, J. (1970). River flow forecasting through conceptual models part I—A discussion of principles. *Journal of Hydrology* 10 (3), 282-290.

Neitsch, S., Arnold, J., Kiniry, J., Williams, J., and King, K. (2002). Soil and Water Assessment Tool (Version 2000)—theoretical documentation. *College Station, TX, Texas Water Research Institute*.

Neitsch, S., Arnold, J., Kiniry, J., Williams, J., and King, K. (2005). Soil and water assessment tool: theoretical documentation, version 2005. *Texas, USA*.

Nie, Y., and Li, A. (2011). Assessment of Alpine Wetland Dynamics from 1976–2006 in the Vicinity of Mount Everest. *Wetlands* 31 (5), 875-884.

Nielsen, E. M., Prince, S. D., and Koeln, G. T. (2008). Wetland change mapping for the US mid-Atlantic region using an outlier detection technique. *Remote Sensing of Environment* 112 (11), 4061-4074.

Norman, J. M., and Becker, F. (1995). Terminology in thermal infrared remote sensing of natural surfaces. *Agricultural and Forest Meteorology* 77 (3), 153-166.

Oetter, D. R., Cohen, W. B., Berterretche, M., Maiersperger, T. K., and Kennedy, R. E. (2001). Land cover mapping in an agricultural setting using multiseasonal Thematic Mapper data. *Remote Sensing of Environment* 76 (2), 139-155.

Olang, L. O., Kundu, P., Bauer, T., and Fürst, J. (2011). Analysis of spatio-temporal land cover changes for hydrological impact assessment within the Nyando River Basin of Kenya. *Environmental Monitoring and Assessment* 179 (1-4), 389-401.

Olivera, F., Valenzuela, M., Srinivasan, R., Choi, J., Cho, H., Koka, S., and Agrawal, A. (2006). ARCGIS-SWAT: A geodata model and GIS interface for SWAT1. *JAWRA Journal of the American Water Resources Association* 42 (2), 295-309.

Oltra-Carrió, R., Sobrino, J., Franch, B., and Nerry, F. (2012). Land surface emissivity retrieval from airborne sensor over urban areas. *Remote Sensing of Environment* 123, 298-305.

Owen, T., Carlson, T., and Gillies, R. (1998). An assessment of satellite remotely-sensed land cover parameters in quantitatively describing the climatic effect of urbanization. *International Journal of Remote Sensing* 19 (9), 1663-1681.

Ozesmi, S. L., and Bauer, M. E. (2002). Satellite remote sensing of wetlands. *Wetlands Ecology and Management* 10 (5), 381-402.

Pakbaz, M., Dardaei, A., and Salahshoor, J. (2009). Evaluation of Performance of Plastic Concrete Cutoff Wall in Karkheh Dam Using 3-D Seepage Analysis and Actual Measurement. *Journal of Applied Sciences* 9 (4).

Pal, M., and Mather, P. M. (2003). An assessment of the effectiveness of decision tree methods for land cover classification. *Remote Sensing of Environment* 86 (4), 554-565.

Parmenter, A. W., Hansen, A., Kennedy, R. E., Cohen, W., Langner, U., Lawrence, R., Maxwell, B., Gallant, A., and Aspinall, R. (2003). Land use and land cover change in the Greater Yellowstone Ecosystem: 1975-1995. *Ecological Applications* 13 (3), 687-703.

Partow, H. (2001). *The Mesopotamian marshlands: demise of an ecosystem*.

Pelorosso, R., Leone, A., and Boccia, L. (2009). Land cover and land use change in the Italian central Apennines: A comparison of assessment methods. *Applied Geography* 29 (1), 35-48.

Pielke, R. A. (2005). Land use and climate change. *Science* 310 (5754), 1625-1626.

Prados, A. I., Kondragunta, S., Ciren, P., and Knapp, K. R. (2007). GOES aerosol/smoke product (GASP) over North America: comparisons to

AERONET and MODIS observations. *Journal of Geophysical Research: Atmospheres (1984–2012)* 112 (D15).

Price, J. C. (1984). Land surface temperature measurements from the split window channels of the NOAA 7 Advanced Very High Resolution Radiometer. *Journal of Geophysical Research: Atmospheres (1984–2012)* 89 (D5), 7231-7237.

Pu, R., Gong, P., Tian, Y., Miao, X., Carruthers, R. I., and Anderson, G. L. (2008). Using classification and NDVI differencing methods for monitoring sparse vegetation coverage: a case study of saltcedar in Nevada, USA. *International Journal of Remote Sensing* 29 (14), 3987-4011.

Qi, C., and Grunwald, S. (2005). GIS-based hydrologic modeling in the Sandusky watershed using SWAT. *Transactions of the ASAE* 48 (1), 169-180.

Qin, Z.-h., Karnieli, A., and Berliner, P. (2001). A mono-window algorithm for retrieving land surface temperature from Landsat TM data and its application to the Israel-Egypt border region. *International Journal of Remote Sensing* 22 (18), 3719-3746.

Qin, Z., and Karnieli, A. (1999). Progress in the remote sensing of land surface temperature and ground emissivity using NOAA-AVHRR data. *International Journal of Remote Sensing* 20 (12), 2367-2393.

Qureshi, A. S., Oweis, T., Karimi, P., and Porehemmat, J. (2010). Water productivity of irrigated wheat and maize in the Karkheh River basin of Iran. *Irrigation and Drainage* 59 (3), 264-276.

Rahman, K., Maringanti, C., Beniston, M., Widmer, F., Abbaspour, K., and Lehmann, A. (2013). Streamflow modeling in a highly managed mountainous glacier watershed using SWAT: the Upper Rhone River watershed case in Switzerland. *Water Resources Management* 27 (2), 323-339.

Ramsey III, E., Rangoonwala, A., Nelson, G., and Ehrlich, R. (2005). Mapping the invasive species, Chinese tallow, with EO1 satellite Hyperion hyperspectral image data and relating tallow occurrences to a classified Landsat Thematic Mapper land cover map. *International Journal of Remote Sensing* 26 (8), 1637-1657.

Rao, M., Fan, G., Thomas, J., Cherian, G., Chudiwale, V., and Awawdeh, M. (2007). A web-based GIS Decision Support System for managing and planning USDA's Conservation Reserve Program (CRP). *Environmental Modelling & Software* 22 (9), 1270-1280.

Rashki, A., Eriksson, P., Rautenbach, C. d. W., Kaskaoutis, D., Grote, W., and Dykstra, J. (2013). Assessment of chemical and mineralogical characteristics of airborne dust in the Sistan region, Iran. *Chemosphere* 90 (2), 227-236.

Rebelo, L.-M., Finlayson, C., and Nagabhatla, N. (2009a). Remote sensing and GIS for wetland inventory, mapping and change analysis. *Journal of Environmental Management* 90 (7), 2144-2153.

Rebelo, L.-M., Finlayson, C. M., and Nagabhatla, N. (2009b). Remote sensing and GIS for wetland inventory, mapping and change analysis. *Journal of Environmental Management* 90 (7), 2144-2153.

Rembold, F., Carnicelli, S., Nori, M., and Ferrari, G. A. (2000). Use of aerial photographs, Landsat TM imagery and multidisciplinary field survey for land-cover change analysis in the lakes region (Ethiopia). *International Journal of Applied Earth Observation and Geoinformation* 2 (3), 181-189.

Reynolds, J. F., and Stafford Smith, D. (2002). Do humans cause deserts. *Global desertification: do humans cause deserts*, 1-21.

Richards, J. A. (2013). *Remote Sensing Digital Image Analysis*. Springer, pp. 247-318.

Rijsberman, F. R. (2006). Water scarcity: fact or fiction? *Agricultural Water Management* 80 (1), 5-22.

Ringrose, S., Jellema, A., Huntsman-Mapila, P., Baker, L., and Brubaker, K. (2005). Use of remotely sensed data in the analysis of soil-vegetation changes along a drying gradient peripheral to the Okavango Delta, Botswana. *International Journal of Remote Sensing* 26 (19), 4293-4319.

Roberts, D. A., Keller, M., and Soares, J. V. (2003). Studies of land-cover, land-use, and biophysical properties of vegetation in the Large Scale Biosphere Atmosphere experiment in Amazonia. *Remote Sensing of Environment* 87 (4), 377-388.

Rodriguez-Galiano, V., Pardo-Iguzquiza, E., Sanchez-Castillo, M., Chica-Olmo, M., and Chica-Rivas, M. (2012). Downscaling Landsat 7 ETM+ thermal imagery using land surface temperature and NDVI images. *International Journal of Applied Earth Observation and Geoinformation* 18, 515-527.

Rogan, J., Franklin, J., and Roberts, D. A. (2002). A comparison of methods for monitoring multitemporal vegetation change using Thematic Mapper imagery. *Remote Sensing of Environment* 80 (1), 143-156.

Rostamian, R., Jaleh, A., Afyuni, M., Mousavi, S. F., Heidarpour, M., Jalalian, A., and Abbaspour, K. C. (2008). Application of a SWAT model for estimating runoff and sediment in two mountainous basins in central Iran. *Hydrological Sciences Journal* 53 (5), 977-988.

Roy, D. P., Borak, J. S., Devadiga, S., Wolfe, R. E., Zheng, M., and Descloitres, J. (2002). The MODIS land product quality assessment approach. *Remote Sensing of Environment* 83 (1), 62-76.

Rozenstein, O., and Karnieli, A. (2011). Comparison of methods for land-use classification incorporating remote sensing and GIS inputs. *Applied Geography* 31 (2), 533-544.

Rubec, C. (1996). Status of national wetland policy development in ramsar nations. *Proc. Sixth Netting of the Conference of the Contracting Parties. Convention on Wetlands* 22-29.

Sakané, N., Alvarez, M., Becker, M., Böhme, B., Handa, C., Kamiri, H. W., Langensiepen, M., Menz, G., Misana, S., and Mogha, N. G. (2011). Classification, characterisation, and use of small wetlands in East Africa. *Wetlands* 31 (6), 1103-1116.

Saleh, A., and Du, B. (2004). Evaluation of SWAT and HSPF within BASINS program for the upper North Bosque River watershed in central Texas. *Transactions of the ASAE* 47 (4), 1039-1049.

Sánchez-Cuervo, A. M., Aide, T. M., Clark, M. L., and Etter, A. (2012). Land cover change in Colombia: surprising forest recovery trends between 2001 and 2010. *PloS one* 7 (8), e43943.

Santhi, C., Arnold, J. G., Williams, J. R., Dugas, W. A., Srinivasan, R., and Hauck, L. M. (2001). Validation of the swat model on a large river basin with point and nonpoint sources1. Wiley Online Library. pp. 1169-1188.

Santhi, C., Srinivasan, R., Arnold, J. G., and Williams, J. (2006). A modeling approach to evaluate the impacts of water quality management plans implemented in a watershed in Texas. *Environmental Modelling & Software* 21 (8), 1141-1157.

Schmugge, T., French, A., Ritchie, J. C., Rango, A., and Pelgrum, H. (2002). Temperature and emissivity separation from multispectral thermal infrared observations. *Remote Sensing of Environment* 79 (2), 189-198.

Schulz, J. J., Cayuela, L., Echeverria, C., Salas, J., and Rey Benayas, J. M. (2010). Monitoring land cover change of the dryland forest landscape of Central Chile (1975–2008). *Applied Geography* 30 (3), 436-447.

Schuol, J., Abbaspour, K. C., Srinivasan, R., and Yang, H. (2008). Estimation of freshwater availability in the West African sub-continent using the SWAT hydrologic model. *Journal of Hydrology* 352 (1), 30-49.

Scott, D. A. (1995). *A directory of wetlands in the Middle East*. IUCN Gland, Switzerland.

Seckler, D., Barker, R., and Amarasinghe, U. (1999). Water scarcity in the twenty-first century. *International Journal of Water Resources Development* 15 (1-2), 29-42.

Seidl, A. F., and Moraes, A. S. (2000). Global valuation of ecosystem services: application to the Pantanal da Nhecolandia, Brazil. *Ecological Economics* 33 (1), 1-6.

Serra, P., Pons, X., and Sauri, D. (2003). Post-classification change detection with data from different sensors: some accuracy considerations. *International Journal of Remote Sensing* 24 (16), 3311-3340.

Serra, P., Pons, X., and Saurí, D. (2008). Land-cover and land-use change in a Mediterranean landscape: a spatial analysis of driving forces integrating biophysical and human factors. *Applied Geography* 28 (3), 189-209.

Setegn, S. G., Rayner, D., Melesse, A. M., Dargahi, B., and Srinivasan, R. (2011). Impact of climate change on the hydroclimatology of Lake Tana Basin, Ethiopia. *Water Resources Research* 47 (4), 1-13.

Setegn, S. G., Srinivasan, R., and Dargahi, B. (2008). Hydrological modelling in the Lake Tana Basin, Ethiopia using SWAT model. *The Open Hydrology Journal* 2 (2008), 49-62.

Setegn, S. G., Srinivasan, R., Melesse, A. M., and Dargahi, B. (2010). SWAT model application and prediction uncertainty analysis in the Lake Tana Basin, Ethiopia. *Hydrological Processes* 24 (3), 357-367.

Shahraiyni, H. T., Karimi, K., Nokhandan, M. H., and Moghadas, N. H. (2014). Monitoring of dust storm and estimation of aerosol concentration in the Middle East using remotely sensed images. *Arabian Journal of Geosciences*, 1-16.

Shahram, A., Qureshi, A., and Gichuki, F. (2004). Karkheh basin profile: strategic research for enhancing agricultural water productivity. *Challenge Program on Water and Food*.

Shaikh, M., Green, D., and Cross, H. (2001). A remote sensing approach to determine environmental flows for wetlands of the Lower Darling River, New South Wales, Australia. *International Journal of Remote Sensing* 22 (9), 1737-1751.

Shao, Y., and Dong, C. (2006). A review on East Asian dust storm climate, modelling and monitoring. *Global and Planetary Change* 52 (1), 1-22.

Shao, Y., Wyrwoll, K.-H., Chappell, A., Huang, J., Lin, Z., McTainsh, G. H., Mikami, M., Tanaka, T. Y., Wang, X., and Yoon, S. (2011). Dust cycle: An emerging core theme in Earth system science. *Aeolian Research* 2 (4), 181-204.

Shepherd, I., Wilkinson, G., and Thompson, J. (2000). Monitoring surface water storage in the north Kent marshes using Landsat TM images. *International Journal of Remote Sensing* 21 (9), 1843-1865.

Shi, P., Chen, C., Srinivasan, R., Zhang, X., Cai, T., Fang, X., Qu, S., Chen, X., and Li, Q. (2011). Evaluating the SWAT model for hydrological modeling in the Xixian watershed and a comparison with the XAJ model. *Water Resources Management* 25 (10), 2595-2612.

Sim, J., and Wright, C. C. (2005). The kappa statistic in reliability studies: use, interpretation, and sample size requirements. *Physical Therapy* 85 (3), 257-268.

Singh, A., Imtiyaz, M., Isaac, R., and Denis, D. (2014). Assessing the performance and uncertainty analysis of the SWAT and RBNN models for simulation of sediment yield in the Nagwa watershed, India. *Hydrological Sciences Journal* (ahead-of-print), 1-14.

Singh, J., Knapp, H. V., Arnold, J., and Demissie, M. (2005a). Hydrological modeling of the iroquois river watershed using HSPF and SWAT1. Wiley Online Library.

Singh, J., Knapp, H. V., Arnold, J., and Demissie, M. (2005b). Hydrological modeling of the iroquois river watershed using HSPF and SWAT1. *JAWRA Journal of the American Water Resources Association* 41 (2), 343-360.

Singh, V. (1989). Hydrologic Systems: Watershed Modeling, vol. 2. *IIPrentice Hall*.

Singh, V. P. (1995). *Computer models of watershed hydrology*. Water Resources Publications.

Smeeton, N. C. (1985). Early history of the kappa statistic. International biometric soc 808 17th st nw suite 200, washington, dc 20006-3910. pp. 795-795.

Smith, J. B., Schneider, S. H., Oppenheimer, M., Yohe, G. W., Hare, W., Mastrandrea, M. D., Patwardhan, A., Burton, I., Corfee-Morlot, J., and Magadza, C. H. (2009). Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC)"reasons for concern". *Proceedings of the National Academy of Sciences* 106 (11), 4133-4137.

Snyder, W. C., Wan, Z., Zhang, Y., and Feng, Y.-Z. (1998). Classification-based emissivity for land surface temperature measurement from space. *International Journal of Remote Sensing* 19 (14), 2753-2774.

Sobrino, J., Caselles, V., and Becker, F. (1990). Significance of the remotely sensed thermal infrared measurements obtained over a citrus orchard. *ISPRS Journal of Photogrammetry and Remote Sensing* 44 (6), 343-354.

Sobrino, J., El Kharraz, J., and Li, Z.-L. (2003). Surface temperature and water vapour retrieval from MODIS data. *International Journal of Remote Sensing* 24 (24), 5161-5182.

Sobrino, J., Li, Z., Stoll, M., and Becker, F. (1996). Multi-channel and multi-angle algorithms for estimating sea and land surface temperature with ATSR data. *International Journal of Remote Sensing* 17 (11), 2089-2114.

Sobrino, J., Raissouni, N., and Li, Z.-L. (2001). A comparative study of land surface emissivity retrieval from NOAA data. *Remote Sensing of Environment* 75 (2), 256-266.

Sobrino, J. A., Jiménez-Muñoz, J. C., and Paolini, L. (2004). Land surface temperature retrieval from LANDSAT TM 5. *Remote Sensing of Environment* 90 (4), 434-440.

Sobrino, J. A., Jiménez-Muñoz, J. C., and Verhoef, W. (2005). Canopy directional emissivity: Comparison between models. *Remote Sensing of Environment* 99 (3), 304-314.

Sobrino, J. A., Oltra-Carrió, R., Jiménez-Muñoz, J. C., Julien, Y., Soria, G., Franch, B., and Mattar, C. (2012). Emissivity mapping over urban areas using a classification-based approach: Application to the Dual-use European Security IR Experiment (DESIREX). *International Journal of Applied Earth Observation and Geoinformation* 18, 141-147.

Song, C., Woodcock, C. E., Seto, K. C., Lenney, M. P., and Macomber, S. A. (2001). Classification and change detection using Landsat TM data: when and how to correct atmospheric effects? *Remote Sensing of Environment* 75 (2), 230-244.

Song, K., Wang, Z., Li, L., Tedesco, L., Li, F., Jin, C., and Du, J. (2012). Wetlands shrinkage, fragmentation and their links to agriculture in the Muleng–Xingkai Plain, China. *Journal of Environmental Management* 111, 120-132.

Song, Z. (2004). A numerical simulation of dust storms in China. *Environmental Modelling & Software* 19 (2), 141-151.

Soroush, A., and Rayati, M. (2004). Numerical Analysis of Karkheh Dam, Foundation, and Its Cutoff Wall Subjected to Earthquake Loading. *Proceedings of the 13th world conference on earthquake engineering, Vancouver, BC, Canada* 1-6.

Southworth, J. (2004). An assessment of Landsat TM band 6 thermal data for analysing land cover in tropical dry forest regions. *International Journal of Remote Sensing* 25 (4), 689-706.

Srinivasan, R., Ramanarayanan, T. S., Arnold, J. G., and Bednarz, S. T. (1998). Large area hydrologic modeling and assessment part II: Model application1. Wiley Online Library.

Srinivasan, R., Zhang, X., and Arnold, J. (2010). SWAT ungauged: hydrological budget and crop yield predictions in the Upper Mississippi River Basin. *Transactions of the ASABE* 53 (5), 1533-1546.

Srivastava, P., Majumdar, T., and Bhattacharya, A. K. (2009). Surface temperature estimation in Singhbhum Shear Zone of India using Landsat-7 ETM+ thermal infrared data. *Advances in Space Research* 43 (10), 1563-1574.

Srivastava, P., Majumdar, T., and Bhattacharya, A. K. (2010). Study of land surface temperature and spectral emissivity using multi-sensor satellite data. *Journal of Earth System Science* 119 (1), 67-74.

Steffen, W., Sanderson, R. A., Tyson, P. D., Jäger, J., Matson, P. A., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H. J., and Turner, B. L. (2006). *Global change and the earth system: a planet under pressure*. Springer.

Stehman, S. V. (1997). Selecting and interpreting measures of thematic classification accuracy. *Remote Sensing of Environment* 62 (1), 77-89.

Sun, J., Zhao, L., and Zhao, S. (2003). All integrated numerical modeling system of dust storm suitable to North China and its applications. *Climatic and Environmental Research* 8 (2), 125-142.

Symeonakis, E., Calvo-Cases, A., and Arnau-Rosalen, E. (2007). Land use change and land degradation in southeastern Mediterranean Spain. *Environmental Management* 40 (1), 80-94.

Syphard, A. D., and Garcia, M. W. (2001). Human-and beaver-induced wetland changes in the Chickahominy River watershed from 1953 to 1994. *Wetlands* 21 (3), 342-353.

Talebizadeh, M., Morid, S., Ayyoubzadeh, S. A., and Ghasemzadeh, M. (2010). Uncertainty analysis in sediment load modeling using ANN and SWAT model. *Water Resources Management* 24 (9), 1747-1761.

Tang, H., and Li, Z.-L. (2014). *Quantitative Remote Sensing in Thermal Infrared*. Springer, pp. 93-143.

Tarnavsky, E., Garrigues, S., and Brown, M. E. (2008). Multiscale geostatistical analysis of AVHRR, SPOT-VGT, and MODIS global NDVI products. *Remote Sensing of Environment* 112 (2), 535-549.

Thomson, A. M., Brown, R. A., Rosenberg, N. J., Izaurralde, R. C., Legler, D. M., and Srinivasan, R. (2003). Simulated impacts of el nino/southern oscillation on united states water resources1. Wiley Online Library.

Tilman, D. (1999). Global environmental impacts of agricultural expansion: the need for sustainable and efficient practices. *Proceedings of the National Academy of Sciences* 96 (11), 5995-6000.

Tiner, R. W. (2004). Remotely-sensed indicators for monitoring the general condition of "natural habitat" in watersheds: an application for Delaware's Nanticoke River watershed. *Ecological Indicators* 4 (4), 227-243.

Tuppad, P., Kannan, N., Srinivasan, R., Rossi, C. G., and Arnold, J. G. (2010). Simulation of agricultural management alternatives for watershed protection. *Water Resources Management* 24 (12), 3115-3144.

Turner, B. L., Lambin, E. F., and Reenberg, A. (2007). The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences* 104 (52), 20666-20671.

Urdal, H. (2005). People vs. Malthus: Population pressure, environmental degradation, and armed conflict revisited. *Journal of Peace Research* 42 (4), 417-434.

Valor, E., and Caselles, V. (1996). Mapping land surface emissivity from NDVI: Application to European, African, and South American areas. *Remote Sensing of Environment* 57 (3), 167-184.

Van de Griend, A., and Owe, M. (1993). On the relationship between thermal emissivity and the normalized difference vegetation index for natural surfaces. *International Journal of Remote Sensing* 14 (6), 1119-1131.

Van Griensven, A., Breuer, L., Di Luzio, M., Vandenberghe, V., Goethals, P., Meixner, T., Arnold, J., and Srinivasan, R. (2006). Environmental and ecological hydroinformatics to support the implementation of the European Water Framework Directive for river basin management. *Journal of Hydroinformatics* 8 (4), 239-252.

Van Griensven, A., and Meixner, T. (2007). A global and efficient multi-objective auto-calibration and uncertainty estimation method for water quality catchment models. *Journal of Hydroinformatics* 9 (4), 277-291.

Van Liew, M. W., Veith, T. L., Bosch, D. D., and Arnold, J. G. (2007). Suitability of SWAT for the conservation effects assessment project: Comparison on USDA agricultural research service watersheds. *Journal of Hydrologic Engineering* 12 (2), 173-189.

Vasconcelos, M., Mussá Biai, J., Araujo, A., and Diniz, M. (2002). Land cover change in two protected areas of Guinea-Bissau (1956-1998). *Applied Geography* 22 (2), 139-156.

Veldkamp, A., Kok, K., De Koning, G., Schoorl, J., Sonneveld, M., and Verburg, P. H. (2001). Multi-scale system approaches in agronomic research at the landscape level. *Soil and Tillage Research* 58 (3), 129-140.

Veldkamp, A., and Verburg, P. (2004). Modelling land use change and environmental impact. *Journal of Environmental Management* 72 (1), 1-3.

Vidal, A. (1991). Atmospheric and emissivity correction of land surface temperature measured from satellite using ground measurements or satellite data. *TitleRemote Sensing* 12 (12), 2449-2460.

Volk, M., Hirschfeld, J., Schmidt, G., Bohn, C., Dehnhardt, A., Liersch, S., and Lymburner, L. (2007). A SDSS-based ecological-economic modelling approach for integrated river basin management on different scale levels–The project FLUMAGIS. *Water Resources Management* 21 (12), 2049-2061.

Von Der Heyden, C. J., and New, M. G. (2003). The role of a dambo in the hydrology of a catchment and the river network downstream. *Hydrology and Earth System Sciences Discussions* 7 (3), 339-357.

Voogt, J. A., and Oke, T. R. (1997). Complete urban surface temperatures. *Journal of Applied Meteorology* 36 (9), 1117-1132.

Wang, M., Qin, D., Lu, C., and Li, Y. (2010). Modeling anthropogenic impacts and hydrological processes on a wetland in China. *Water Resources Management* 24 (11), 2743-2757.

Wang, W., and Fang, Z. (2006). Numerical simulation and synoptic analysis of dust emission and transport in East Asia. *Global and Planetary Change* 52 (1), 57-70.

Wang, X., and Melesse, A. (2005). Evaluation of the SWAT model's snowmelt hydrology in a northwestern Minnesota watershed. *Transactions of the ASAE* 48 (4), 1359-1376.

Wang, Z., Huang, N., Luo, L., Li, X., Ren, C., Song, K., and Chen, J. M. (2011a). Shrinkage and fragmentation of marshes in the West Songnen Plain, China, from 1954 to 2008 and its possible causes. *International Journal of Applied Earth Observation and Geoinformation* 13 (3), 477-486.

Wang, Z., Song, K., Ma, W., Ren, C., Zhang, B., Liu, D., Chen, J. M., and Song, C. (2011b). Loss and fragmentation of marshes in the Sanjiang Plain, Northeast China, 1954–2005. *Wetlands* 31 (5), 945-954.

Wang, Z., Song, K., Zhang, B., Liu, D., Ren, C., Luo, L., Yang, T., Huang, N., Hu, L., and Yang, H. (2009). Shrinkage and fragmentation of grasslands in the West Songnen Plain, China. *Agriculture, Ecosystems & Environment* 129 (1), 315-324.

Wang, Z., Zhang, B., Zhang, S., Li, X., Liu, D., Song, K., Li, J., Li, F., and Duan, H. (2006). Changes of land use and of ecosystem service values in Sanjiang Plain, Northeast China. *Environmental Monitoring and Assessment* 112 (1-3), 69-91.

Wasige, J. E., Groen, T. A., Smaling, E., and Jetten, V. (2013). Monitoring basin-scale land cover changes in Kagera Basin of Lake Victoria using ancillary data and remote sensing. *International Journal of Applied Earth Observation and Geoinformation* 21, 32-42.

Weber, T. (2004). Landscape ecological assessment of the Chesapeake Bay watershed. *Environmental Monitoring and Assessment* 94 (1-3), 39-53.

Weng, Q. (2003). Fractal analysis of satellite-detected urban heat island effect. *Photogrammetric engineering & remote sensing* 69 (5), 555-566.

Weng, Q. (2009). Thermal infrared remote sensing for urban climate and environmental studies: Methods, applications, and trends. *ISPRS Journal of Photogrammetry and Remote Sensing* 64 (4), 335-344.

Weng, Q. (2010). *Remote sensing and GIS integration: theories, methods, and applications*. McGraw-Hill New York.

Weng, Q., and Lu, D. (2008). A sub-pixel analysis of urbanization effect on land surface temperature and its interplay with impervious surface and vegetation coverage in Indianapolis, United States. *International Journal of Applied Earth Observation and Geoinformation* 10 (1), 68-83.

Weng, Q., Lu, D., and Schubring, J. (2004). Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies. *Remote sensing of Environment* 89 (4), 467-483.

Weng, Q., and Yang, S. (2006). Urban air pollution patterns, land use, and thermal landscape: an examination of the linkage using GIS. *Environmental Monitoring and Assessment* 117 (1-3), 463-489.

Wentz, E. A., Stefanov, W. L., Gries, C., and Hope, D. (2006). Land use and land cover mapping from diverse data sources for an arid urban environments. *Computers, Environment and Urban Systems* 30 (3), 320-346.

Williams, P., and Young, M. (1999). Costing dust. How much does wind erosion cost the people of South Australia? Final report. *Policy and Economic Research Unit. CSIRO Land and Water*.

Winchell, M., Srinivasan, R., Di Luzio, M., and Arnold, J. (2007). Arc-SWAT interface for SWAT2005-User's guide. *USDA Agricultural Research Service and Texas A&M Blackland Research Center, Temple, Texas*.

Winchell, M., Srinivasan, R., Di Luzio, M., and Arnold, J. (2010). ArcSWAT Interface for SWAT 2009. *USDA Agricultural Research Service and Texas A&M Blackland Research Center, Temple, Texas*.

Winter, T. C., Rosenberry, D. O., Buso, D. C., and Merk, D. A. (2001). Water source to four US wetlands: implications for wetland management. *Wetlands* 21 (4), 462-473.

Wondrade, N., 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. *Environmental Monitoring and Assessment* 186 (3), 1765-1780.

Wulder, M. A., White, J. C., Goward, S. N., Masek, J. G., Irons, J. R., Herold, M., Cohen, W. B., Loveland, T. R., and Woodcock, C. E. (2008). Landsat continuity: Issues and opportunities for land cover monitoring. *Remote Sensing of Environment* 112 (3), 955-969.

Xie, J., Yang, C., Zhou, B., and Huang, Q. (2010). High-performance computing for the simulation of dust storms. *Computers, Environment and Urban Systems* 34 (4), 278-290.

Xiuwan, C. (2002). Using remote sensing and GIS to analyse land cover change and its impacts on regional sustainable development. *International Journal of Remote Sensing* 23 (1), 107-124.

Xu, H., Taylor, R. G., Kingston, D. G., Jiang, T., Thompson, J. R., and Todd, M. C. (2010). Hydrological modeling of River Xiangxi using SWAT2005: A comparison of model parameterizations using station and gridded meteorological observations. *Quaternary International* 226 (1), 54-59.

Xu, X., Levy, J. K., Zhaohui, L., and Hong, C. (2006). An investigation of sand–dust storm events and land surface characteristics in China using NOAA NDVI data. *Global and Planetary Change* 52 (1), 182-196.

Yacouba, D., Guangdao, H., and Xingping, W. (2009). Assessment of land use cover changes using ndvi and dem in Puer and Simao counties, Yunnan Province, China. *World Rural Observations* 1 (2), 1-11.

Yang, G., Pu, R., Zhao, C., Huang, W., and Wang, J. (2011). Estimation of subpixel land surface temperature using an endmember index based technique: A case examination on ASTER and MODIS temperature products over a heterogeneous area. *Remote Sensing of Environment* 115 (5), 1202-1219.

Yang, J., Reichert, P., Abbaspour, K., Xia, J., and Yang, H. (2008). Comparing uncertainty analysis techniques for a SWAT application to the Chaohe Basin in China. *Journal of Hydrology* 358 (1), 1-23.

Ye, L., and Grimm, N. B. (2013). Modelling potential impacts of climate change on water and nitrate export from a mid-sized, semiarid watershed in the US Southwest. *Climatic Change* 120 (1-2), 419-431.

Young, R. A., Onstad, C., Bosch, D., and Anderson, W. (1989). AGNPS: A nonpoint-source pollution model for evaluating agricultural watersheds. *Journal of Soil and Water Conservation* 44 (2), 168-173.

Yuan, F., and Bauer, M. E. (2007). Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery. *Remote Sensing of Environment* 106 (3), 375-386.

Yue, W., Xu, J., Tan, W., and Xu, L. (2007). The relationship between land surface temperature and NDVI with remote sensing: application to Shanghai Landsat 7 ETM+ data. *International Journal of Remote Sensing* 28 (15), 3205-3226.

Zalidis, G. C., Mantzavelas, A. L., and Gourvelou, E. (1997). Environmental impacts on Greek wetlands. *Wetlands* 17 (3), 339-345.

Zarasvandi, A., Carranza, E., Moore, F., and Rastmanesh, F. (2011). Spatio-temporal occurrences and mineralogical–geochemical characteristics of airborne dusts in Khuzestan Province (southwestern Iran). *Journal of Geochemical Exploration* 111 (3), 138-151.

Zhang, J., Ma, K., and Fu, B. (2010). Wetland loss under the impact of agricultural development in the Sanjiang Plain, NE China. *Environmental Monitoring and Assessment* 166 (1-4), 139-148.

Zhang, Q., Wang*, J., Gong, P., and Shi, P. (2003). Study of urban spatial patterns from SPOT panchromatic imagery using textural analysis. *International Journal of Remote Sensing* 24 (21), 4137-4160.

Zhang, X., Srinivasan, R., and Hao, E. (2007). Predicting hydrologic response to climate change in the Luohe River basin using the SWAT model. *Transactions of the ASABE* 50 (3), 901-910.

Zhao, B., Kreuter, U., Li, B., Ma, Z., Chen, J., and Nakagoshi, N. (2004). An ecosystem service value assessment of land-use change on Chongming Island, China. *Land Use Policy* 21 (2), 139-148.

Zhao, H., Cui, B., Zhang, H., Fan, X., Zhang, Z., and Lei, X. (2010). A landscape approach for wetland change detection (1979-2009) in the Pearl River Estuary. *Procedia Environmental Sciences* 2, 1265-1278.

Zhou, W., Troy, A., and Grove, M. (2008). Object-based land cover classification and change analysis in the Baltimore metropolitan area using multitemporal high resolution remote sensing data. *Sensors* 8 (3), 1613-1636.

Zoljoodi, M., Didevarasl, A., and Saadatabadi, A. R. (2013). Dust events in the western parts of Iran and the relationship with drought expansion over the dust-source areas in Iraq and Syria. *Atmospheric and Climate Sciences* 3, 321.

Zubair, A. O. (2006). Change detection in land use and Land cover using remote sensing data and GIS: A case study of Ilorin and its environs in Kwara State. *Department of Geography, University of Ibadan* 176.