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World Meteorological Organization
Weather • Climate • Water

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Republic of Turkey
The Ministry of Forestry and Water Affairs

# INTERNATIONAL WORKSHOP ON
# “SAND AND DUST STORMS”

**4-7 October 2016, Istanbul, TURKEY**

# Dust Storm Network-based Integrated System of Forecast and Forewarning (DuSNIFF)

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# SDS Projects from 2005

1. **SDS Economic Impacts Assessment in Khuzestan**, Sponsored by DoE, 2016
2. **Satellite Image Receive and Analysis (SIRA),** Sponsored by Atmospheric Science and Meteorological Research Center (ASMERC), 2016
3. **Dust phenomena study and finding the best combating solutions**, Sponsored by (ASMERC), 2015
4. **Dust sources hotspots identification in Iran**, Sponsored by DoE, 2014
5. **Investigate the effects of Dust Particles on Vegetation and Health Systems**, Sponsored by Vice-president for science and technology of presidency of Iran, 2015
6. **Regional (West Asia) Dust Storms Baseline Situational Analysis,** Sponsored by UNEP-ROWA, 2013
7. **Identification of Regional and trans-boundary dust storm sources,** Sponsored by Vice-president for science and technology of presidency of Iran, 2010
8. **PhD and Master thesis, etc**

# Regional (West Asia) Dust Storms Baseline Situational Analysis, Sponsored by UNEP-ROWA, 2013

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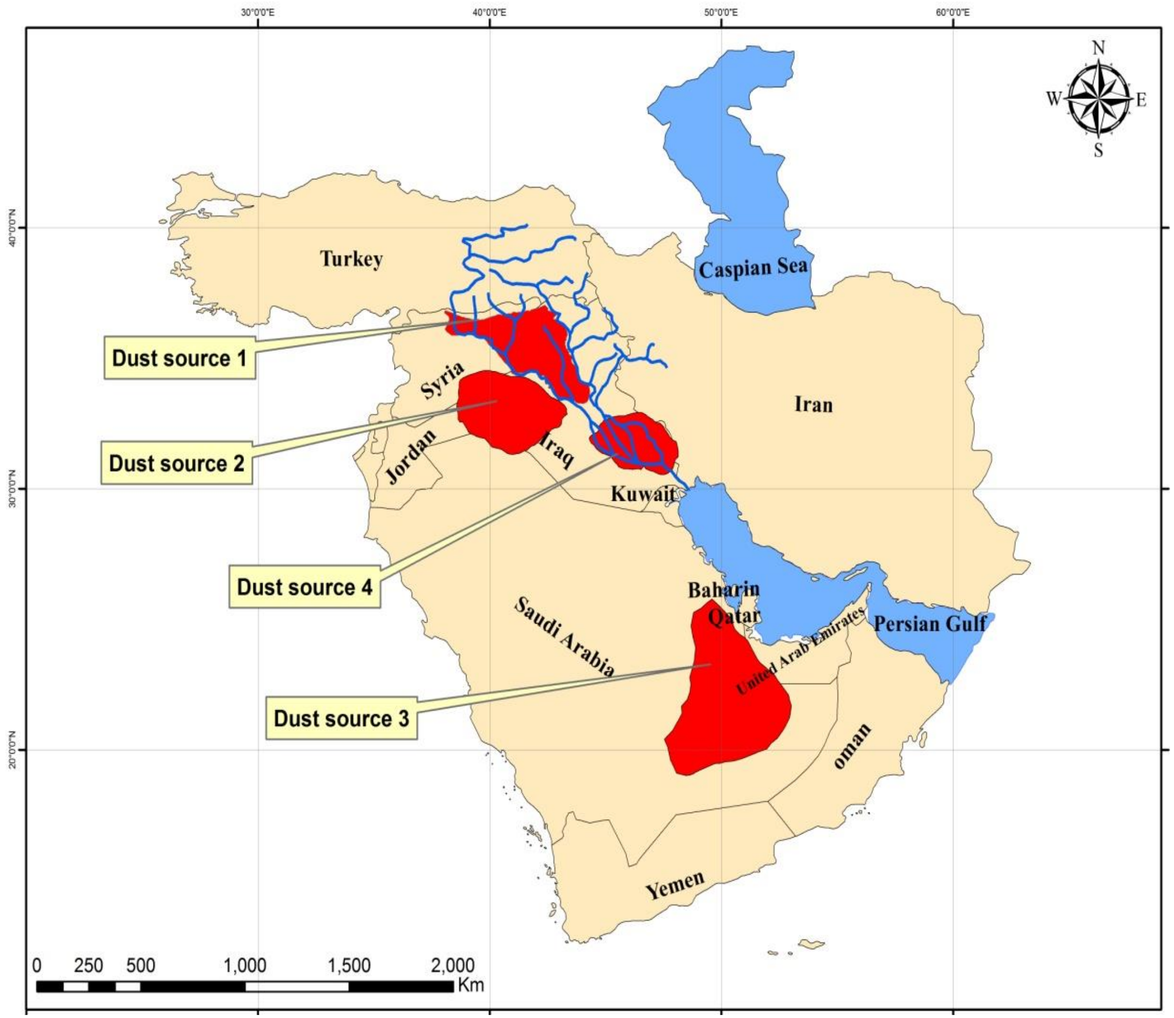
Digital Earth for All

## Dust Sources Clustering

## Dust Sources Hotspots



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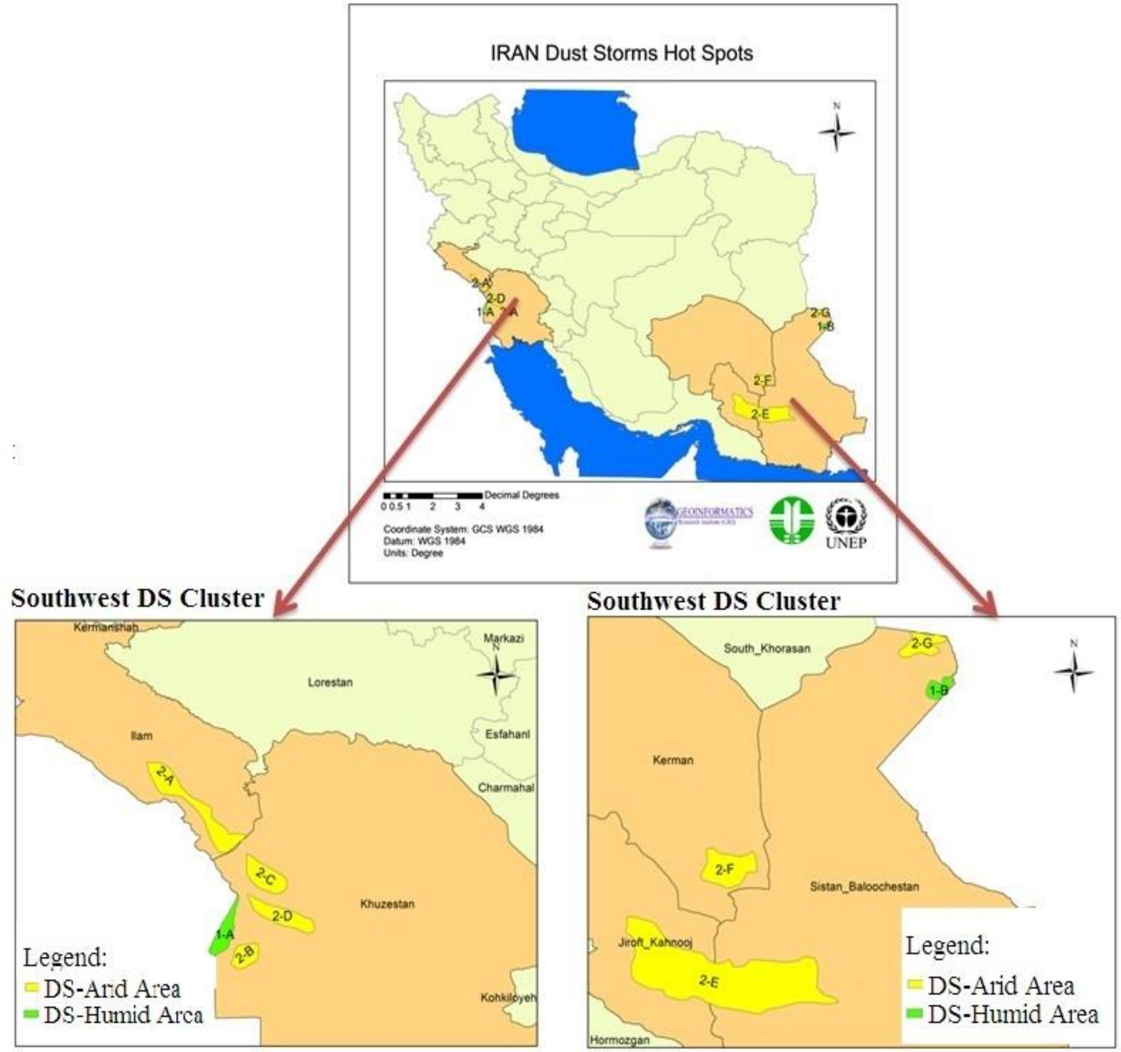
# Dust sources hotspots identification in Iran, Sponsored by DoE, 2014

## Dust Sources Clustering

## Dust Sources Hotspots



# Dust Hot Spots Characterization

Int. J. Environ. Eng. Nat. Resour.
Volume 1, Number 4, 2014, pp. 203-219
Received: July 3, 2014; Published: October 30, 2014

International Journal of
Environmental Engineering
and Natural Resources

## Sand & Dust Storm "Hot Spots" in Iran

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*2. Department of the Environment, Center of Researches, Tehran, Iran*

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**Abstract:** Dust storms as a challenging issue in environment have brought several harmful effects to WAR. This phenomenon has influenced many countries such as Iran, Jordan, Iraq, Syria, Persian Gulf countries tremendously. For controlling and combating with this event, provision of a comprehensive plan was on the agenda by United Nation Environmental Program- Regional Office of WAR (UNEP-ROWA). During the first meeting in Nairobi and technical meeting in Abu Dhabi, the following report is provided in Islamic Republic of Iran. Regarding the span of the issue, a concise introduction of Iran is presented. Then the selected areas for implementation of pilot projects of UNEP- ROWA in dust source (DS) areas are identified. Based on this, two major clusters in south west and south east of Iran are determined as follows: DS cluster 1: This cluster consists of 4 sources with arid and semi-arid ecosystems and one other source with humid ecosystem (i.e. Hour- Al-Azim) in south west of Iran. DS Cluster 2: This cluster consists of 3 active sources with arid and semi-arid ecosystems in Sistan and Baluchistan and Kerman and one source in humid zone of Hamun (south east of Iran). It should be noted that, in this report, dust sources are primarily introduced. Also, based on a plenty of related information, if complementary and detailed information are required, the GRI of University of Tehran can provide them. Department of Environment (DoE) with cooperation of Geo-Informatics Research Institute (GRI) of the University of Tehran has accomplished this work.

**Key words:** Dust storm, West Asia, cluster.

### 1. Introduction

During the last decade, Dust storms have affected WAR Region (WAR) destructively. For controlling and combating with such a phenomenon, it is essential that a comprehensive plan be provided. In order to do this plan, UNEP-ROWA has been preparing a Master Plan for Combating Sand and Dust Storms in WAR Region (MPC-SDS-WAR). Therefore, a meeting was held in Nairobi with the hosting and presence of Iran, Iraq, Jordan, Turkey, and United Arab Emirate. The constitution of a technical meeting about the program agreed to increase the understanding and cooperation of countries. According to this, technical meeting for management of dust storms in WAR was held on 6 and 7 May 2013, in Abu Dhobi. More than 50 representatives from 11 countries from WAR attended as well as UN agencies and regional organizations. In Summary the approvals of that meeting are as follows:

Verification of UNEP proposal regarding the cooperation of UN and regional organizations;

Determination of Dust Storm Corridor in West Asia Region (DSC-WAR) based on climatologically evaluation of WMO;

Additional understanding about SDS-WAR status based on oral reports of countries and WMO reports of present condition;

Agreement on a road map consisting of verification of steps by leading committee and meetings of ministries;

Agreement on taking action along with documenting of program. So that, it be possible to call it MPC-SDS-WAR;

Establishment of a trust fund for the execution of dust storm control and combat projects;

## Developing protocols for using Geoinformation data for SDS studies and investigation

- **Remote Sensing,**
- **Meteorology Data,**
- **Ground Stations, etc**

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# 1. Dust Detection Procedure

Samadi et al. Journal of Environmental Health Science & Engineering 2014, 12:20
http://www.ijehse.com/content/12/1/20

JOURNAL OF ENVIRONMENTAL HEALTH SCIENCE & ENGINEERING

RESEARCH ARTICLE Open Access

## Global dust Detection Index (GDDI); a new remotely sensed methodology for dust storms detection

Mehdi Samadi[1,2*], Ali Darvishi Boloorani[1,2], Seyed Kazem Alavipanah[1], Hossein Mohamadi[3] and Mohamad Saeed Najafi[4]

**Abstract**

Dust storm occurs frequently in arid and semi-arid areas of the world. This natural phenomenon, which is the result of stormy winds, raises a lot of dust from desert surfaces and decreases visibility to less than 1 km. In recent years the temporal frequency of occurrences and their spatial extents has been dramatically increased. West of Iran, especially in spring and summer, suffers from significant increases of these events which cause several social and economic problems. Detecting and recognizing the extent of dust storms is very important issue in designing warning systems, management and decreasing the risk of this phenomenon. As the process of monitoring and prediction are related to detection of this phenomenon and it's separation from other atmospheric phenomena such as cloud, so the main aim of this research is establishing an automated process for detection of dust masses. In this study 20 events of dust happened in western part of Iran during 2000–2011 have been recognized and studied. To the aim of detecting dust events we used satellite images of MODIS sensor. Finally a model based on reflectance and thermal infrared bands has been developed. The efficiency of this method has been checked using dust events. Results show that the model has a good performance in all cases. It also has the ability and robustness to be used in any dust storm forecasting and warning system.

**Keywords:** Remote sensing, Dust detection index, MODIS

**Introduction**

Every year in Iran, several natural hazards occur which cause social, economic and environmental damages. Western dust storms, i.e. the dust coming from western neighbors of Iran, are one of these hazards which have been increased in both spatial and temporal aspects during last decade.

Dust storms are, in most cases, the result of turbulent winds which raise large quantities of dust from land surfaces and reduce visibility to less than 1 km [1]. They reach concentrations in excess of 6000 μg/m$^3$ in severe events [2]. Dust storms are generated from regions that are mainly deserts, dry lakebeds and semi-arid desert regions [3]. They can carry large quantity of dust and move forward to destroy crop plants, ruin the mining and communication facilities, reduce visibility and disturb human's daily activities. They also impact the air and ground transportation. They pollute the atmosphere and reduce air quality, influence cloud formation [4], obscure the sunlight, and reduce the temperature [5]. They also can accelerate the desertification procedure [6]. Their direct effects on human health are mainly depicted in breathing difficulties [7].

Over the past decades, Middle East dust storms have caused many problems for the residents of South and Southwest regions of Iran. During the recent years, there has been an increase in the trend of dust storm activities in this region, especially in spring and summer [8]. Now, this trend is changing into the main persistent environmental problem in Iran and the Middle East region. Middle East dust storms have great impacts on the quality of the inhabitant's lives, visibility and transportation, microclimate, ecosystem, communication systems, and

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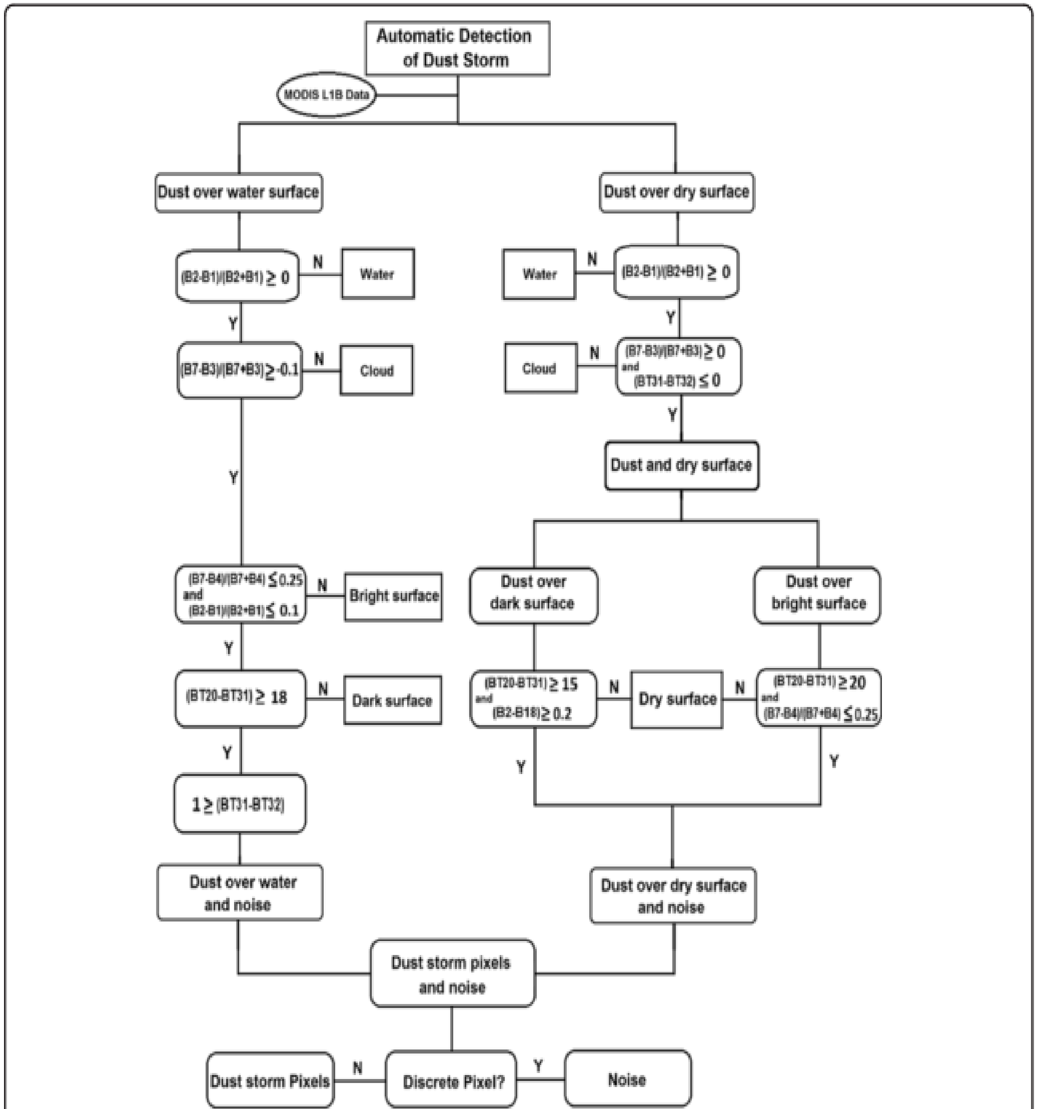


Figure 9 Flowchart of Global Dust Detection Index (GDDI).

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# 1. Dust Detection Procedure

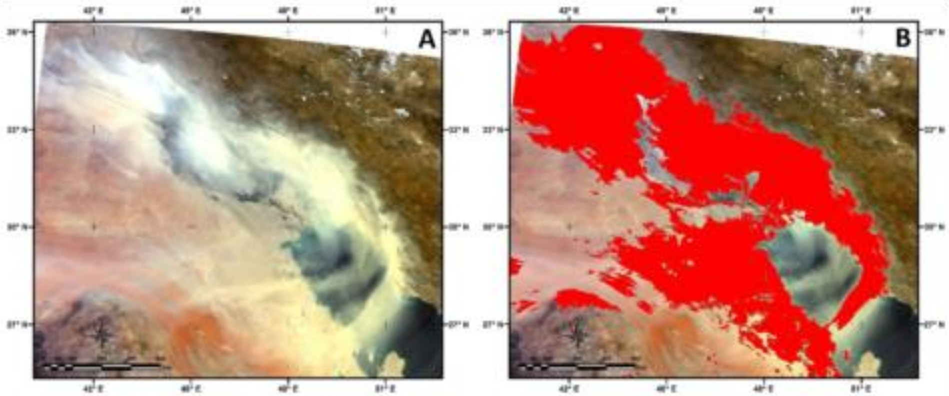

**Figure 13 Evaluation of the developed dust detection method. (A)** MODIS true color image on 1 July 2008 and **(B)** Detected dust event using developed method.



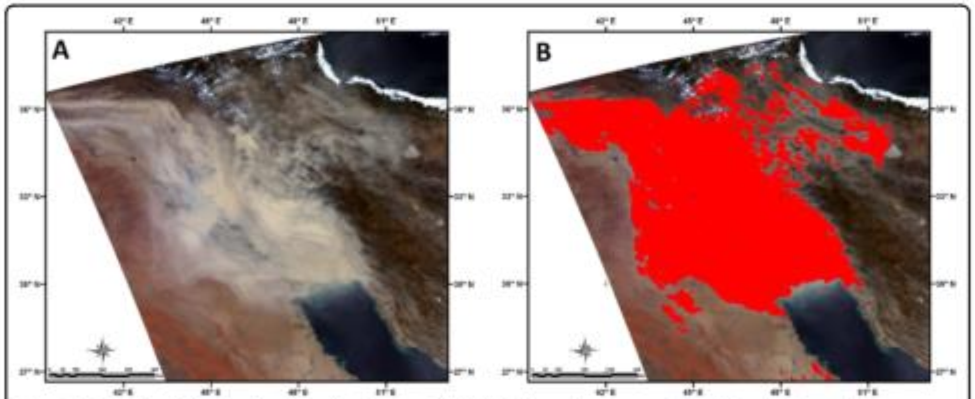

**Figure 14 Evaluation of the developed dust detection method. (A)** MODIS true color image on 5 July 2009 and **(B)** Detected dust event using developed method.

UNEP

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# 1. Dust Detection Procedure

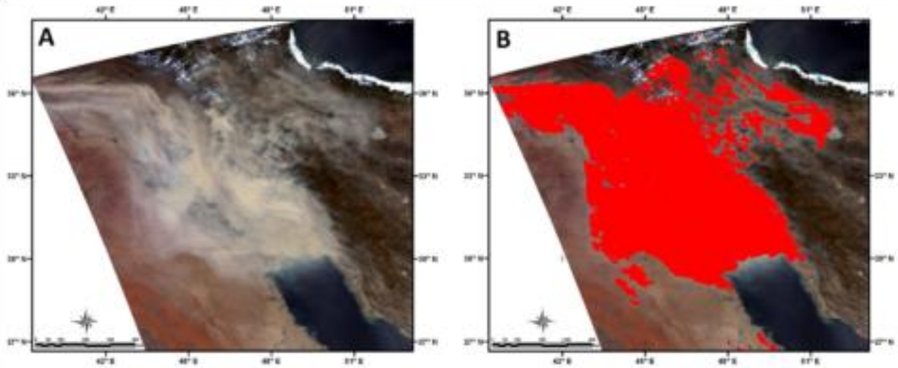


**Figure 14 Evaluation of the developed dust detection method. (A)** MODIS true color image on 5 July 2009 and **(B)** Detected dust event using developed method.

Experiments show that the bright surfaces have amounts higher than 0.25 in the adapted (B7-B4)/(B7 + B4) index. In the defined B2-B18 index, the dark surfaces have a threshold less than 0.2. These two thresholds were adapted for separate bright and dark surfaces from other classes, respectively (Figure 6).

The results of BTD (31–32) show that the best threshold to separate clouds is the amounts higher than zero (Figure 7). Results also show that for the BTD (20–31) the amounts higher than 20 and 15 Kelvin, are dust over bright and dark surfaces, respectively (Figure 8).

Due to the different nature of dust detection over water bodies, the amount of threshold for some indices like NDDI could be changeable. The existence of icy clouds is also a problem. Experimentally a threshold more than one in the BTD (31–32) was adapted for icy clouds separation from the dust in the image.

As shown in the flowchart (Figure 9), MODIS L1B data defined as model input. The whole procedure is divided into two parts: dust over land and dust over water. In dust detection over land, after removing water and clouds, the land is divided into dark and bright surfaces. By using the defined indices, these two parts separate from image and what remains is dust and noise. In the same procedure dusts over water are also discriminated. So, all features separate from image step by step. At the end, the results of both will be combined for making a dust storm map. We also face some single pixels that

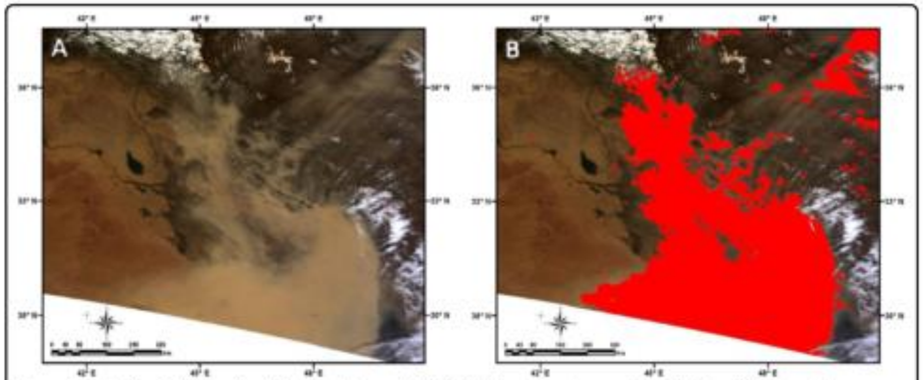


**Figure 15 Evaluation of the developed dust detection method. (A)** MODIS true color image on 13 April 2011 and **(B)** Detected dust event using developed method.

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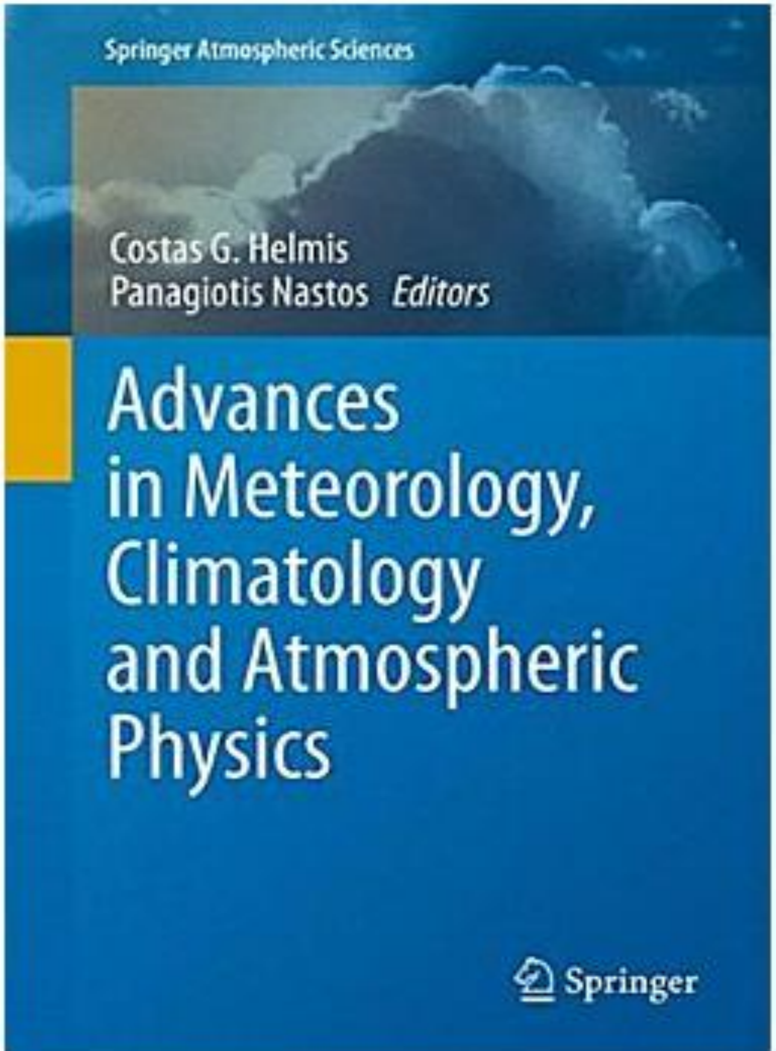
# 2. Dust Characterization with Synoptic Analysis, 2012



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## Characterization of Dust Storm Sources in Western Iran Using a Synthetic Approach

A. Darvishi Boloorani, S.O. Nabavi, R. Azizi, and H.A. Bahrami

**Abstract** Encountering numerous problems, many areas of the world experience dust storms every year. The west of Iran is considered as an area with numerous dust events because of vast deserts in Syria, Iraq, and the Arabian Peninsula. In recent years, the number of dust storms and the affected areas has remarkably increased. The present study is an attempt to identify west of Iran's dust sources using a synthetic approach including remote sensing technique of dust detection, physical–meteorological model called HYSPLIT, and analysis of the studied area's soil texture, land covering, and wind velocity data. Results show that there are two main dust storm sources affecting western Iran: The first region is the area between the west bank of Euphrates and east bank of Tigris, and the second one is the east and south eastern Arabian Peninsula a region called Rub' Al Khali.

### 1 Introduction

Concerning the definition of World Meteorological Organization, dust storms are resultant of weather turbulences which introduce a high mass of dust in the atmosphere, and consequently decrease the horizontal visibility to less than 1,000 m (Goudie and Middleton 2006). In a general perspective, primary sources

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C.G. Helmis and P.T. Nastos (eds.), *Advances in Meteorology, Climatology and Atmospheric Physics*, Springer Atmospheric Sciences,
DOI 10.1007/978-3-642-29172-2_59, © Springer-Verlag Berlin Heidelberg 2012

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# 2. Dust Characterization with Synoptic Analysis, 2012



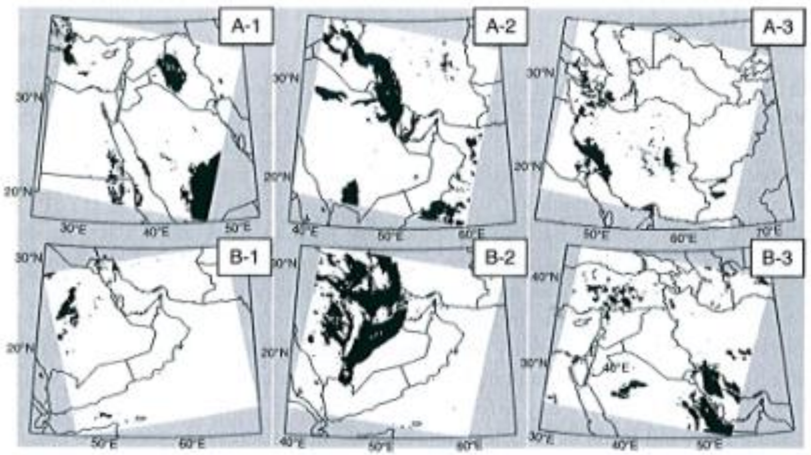


**Fig. 1** Formation of dust storm from the area between the eastern bank of Euphrates and the western bank of Tigris on Jun 30, 2008; its expansion on Iran through Jul 2–3, 2008 (**a-1**, **a-2**, **a-3**) and from the eastern and southeastern deserts of Arabia Saudi Arabia on Mar 1, 2007 to Mar 3, 2007 (**b-1**, **b-2**, **b-3**)

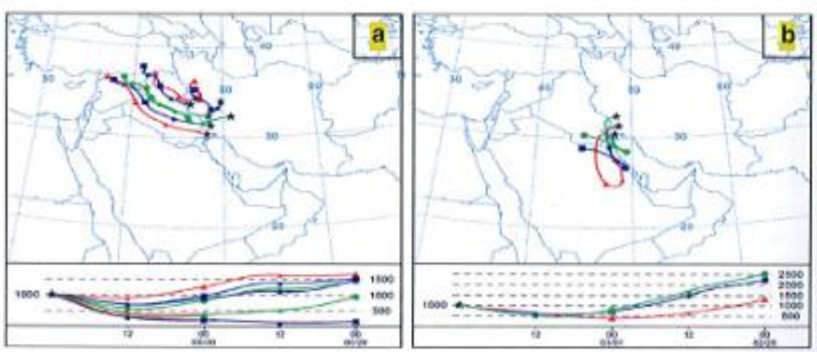


**Fig. 2** Two examples of wind trajectory maps on Jun 30, 2008 (**a**) and Mar 1, 2007 (**b**) using HYSPLIT model. The *symbol (*)* shows the locations of synoptic stations affected by dust storm



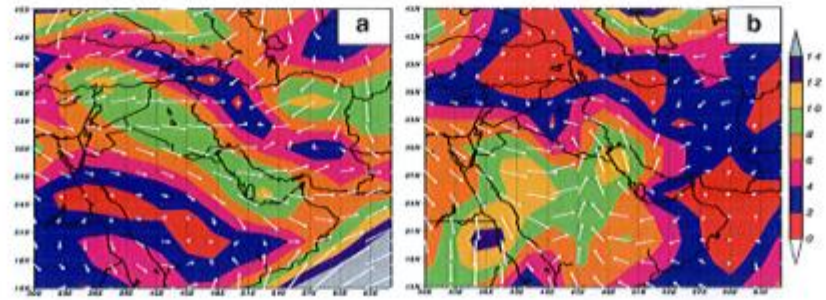


**Fig. 3** Two examples of wind velocity maps on Jun 30, 2008 (**a**) and Mar 1, 2007 (**b**). *Vectors* show wind directions and *colored background* represents wind speed ($ms^{-1}$)

of Iraq and the east of Syria called Gypsisols that is mostly developed in arid regions with sporadic vegetation. Presence of having such soil type prepares conditions for wind erosion, whereas southernmost area of the trajectory, i.e. the southeast of Iraq, consists of Solonchaks soil which is also found in arid and semi-arid regions; But one of its significant features is that the water table is high and the soil is moist; A condition that sometimes leads to water stillness on the soil surface Thus, such regions are less liable to develop extensive dust sources. About 20–23% of soil texture in the western bank of Euphrates and the eastern bank of Tigris consists of clay. In addition, the region has got a 50 unit of soil moisture, which is sometimes lowered to 15 units in some areas. These types of soil texture, with low moisture and sporadic vegetation, provide necessary conditions for wind erosion. Although this type of soil texture is also found in the southeast of Iraq (southern area of the trajectory), due to high soil moisture (almost 150 units), grasslands, and brushes, the surface soil is less likely to be removed from this region. The second trajectory includes Persian Gulf and its southern coast. Therefore, the only dust-prone areas along this trajectory are located in its southern parts, i.e. eastern and southeastern areas of Arabia (the desert region of Rub-Al-Khali). This part of Arabia consists of Regosol soil, the most texture of which is composed of gravel and sand coverings. In some parts of this region, more than 30% of soil texture is clay and could be considered as one of the most arid regions (the soil moisture is calculated as negligible, relatively zero) without vegetation (FAO/IIASA/ISRIC/

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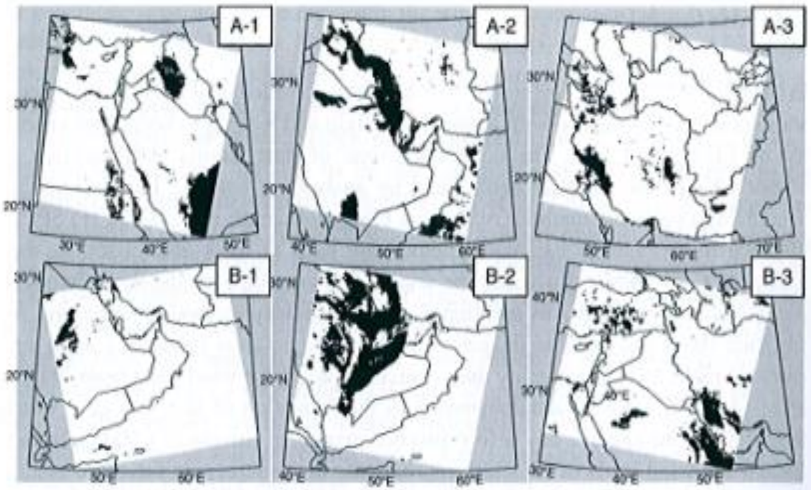
# 2. Dust Characterization with Synoptic Analysis, 2012



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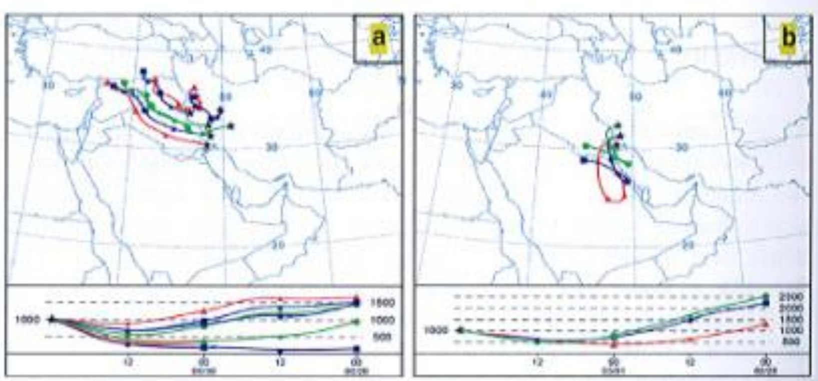


**Fig. 2** Two examples of wind trajectory maps on Jun 30, 2008 (**a**) and Mar 1, 2007 (**b**) using HYSPLIT model. The *symbol (*)* shows the locations of synoptic stations affected by dust storm



## 4 Conclusions

Using the data from synoptic stations in the region, satellite images, and also tracking wind flows during dust events in the western stations in Iran, two main trajectories of dust transfer were recognized: The northwest-southeast trajectory which starts from the northwest of Iraq and the east of Syria, ends in the west of Iran, and the south–north trajectory that starts from the southern banks of Persian Gulf leads to the west of Iran through a south–north path. Utilizing the results of previous section, the simultaneous study of soil maps, land cover, and wind velocity along determined paths, led us to identify two main sources of dust storms in the west of Iran: The area between the eastern bank of Euphrates and the western bank of Tigris as the main dust sources; out of 12 dust storms, 10 cases were formed in this region and the eastern and southeastern deserts of Arabia. Considering more coarse soil texture of the eastern and southeastern deserts of Arabia rather than the first source, higher-velocity winds are required to form dust in this region.

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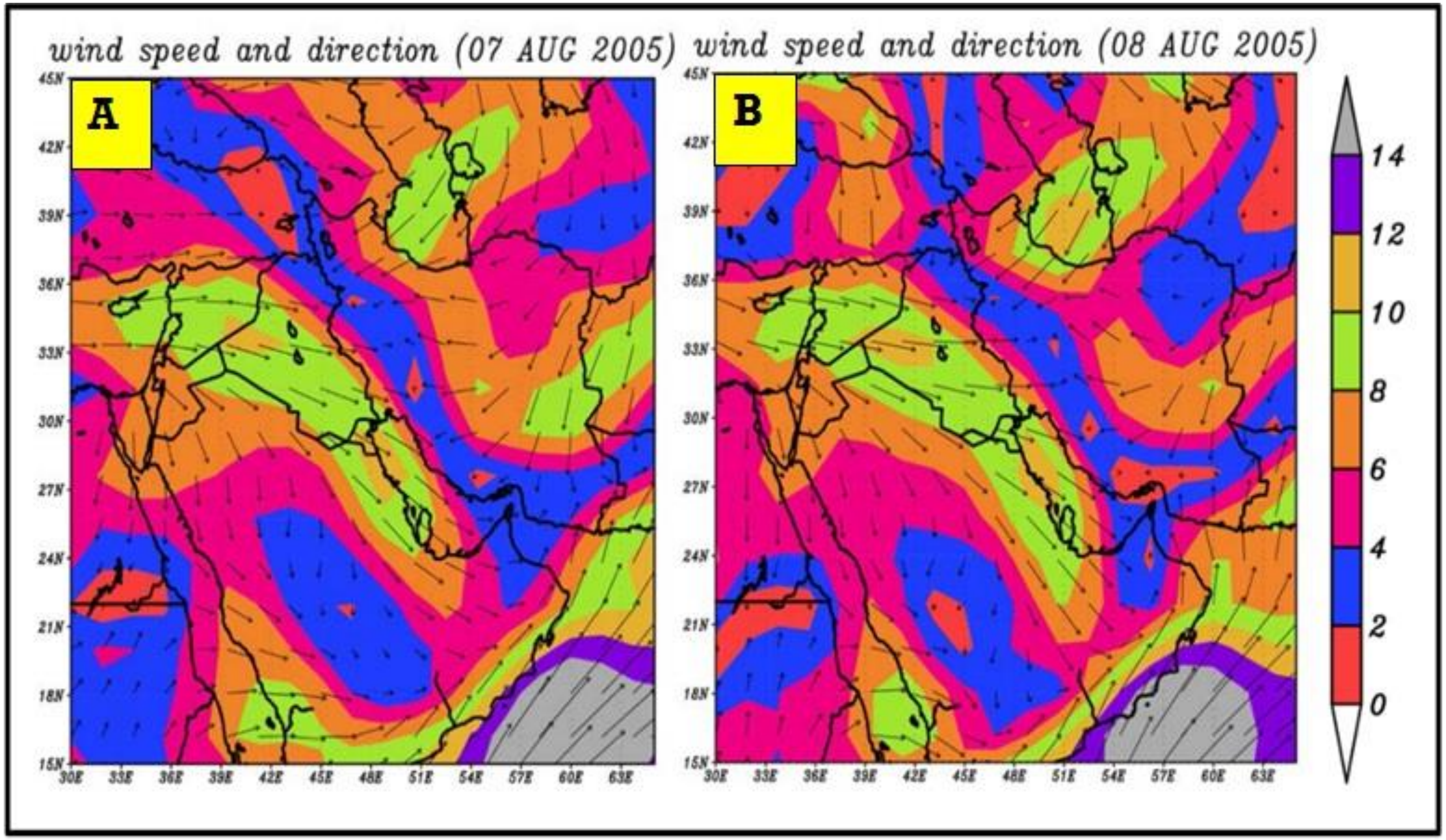
# 3. Wind Modeling, Speed and Direction



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# 4. Weather information

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| 04-Jul-05 | 05-Jul-05 | 5 |
| 24-Jul-05 | 25-Jul-05 | 6 |
| 07-Aug-05 | 08-Aug-05 | 7 |
| 08-Aug-05 | 09-Aug-05 | 8 |
| 17-Apr-06 | 18-Apr-06 | 9 |
| 17-Jul-07 | 18-Jul-07 | 10 |
| 18-Jul-07 | 19-Jul-07 | 11 |
| 15-Feb-08 | 15-Feb-08 | 12 |
| 04-Apr-08 | 05-Apr-08 | 13 |
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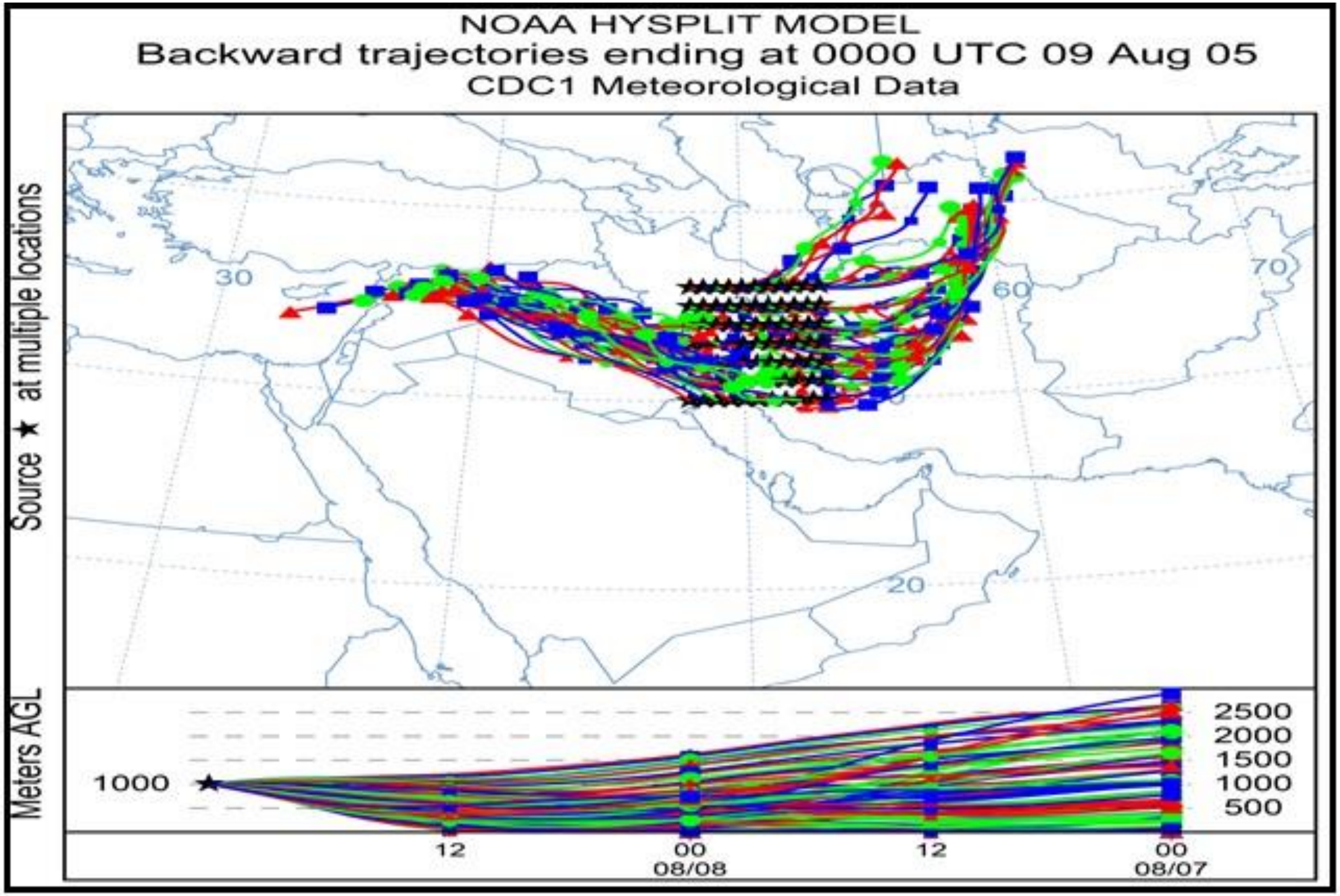
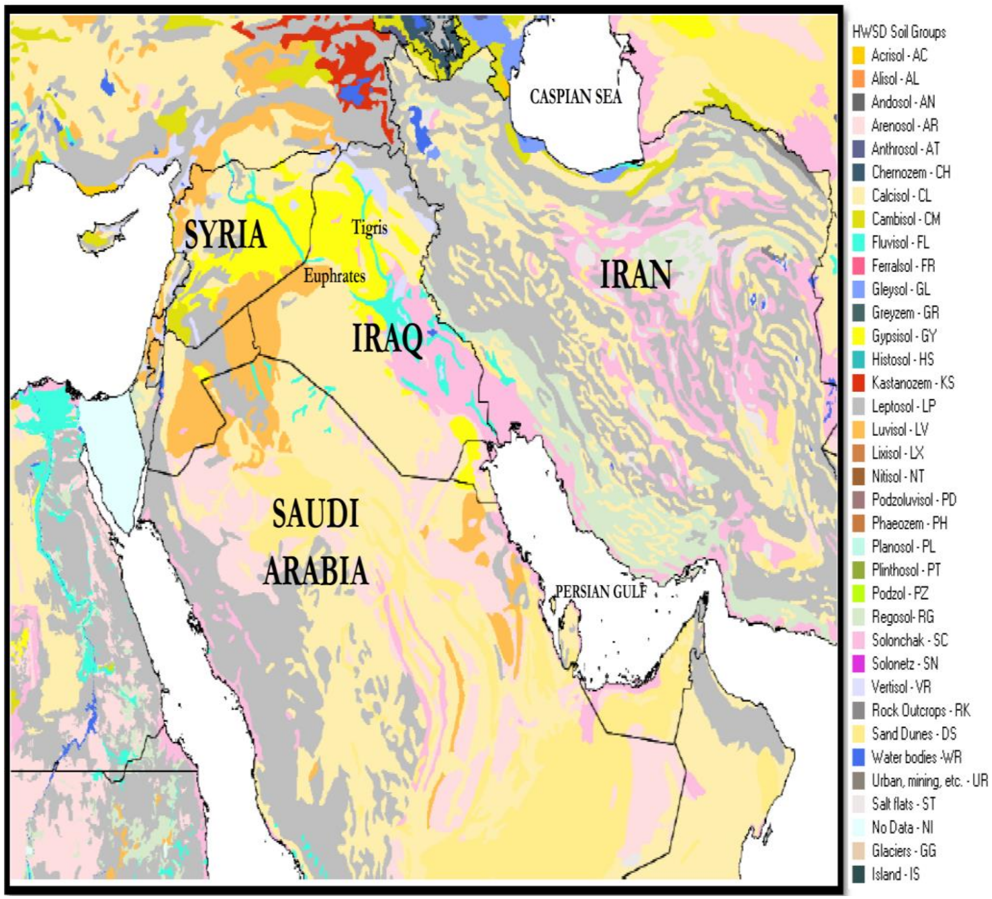
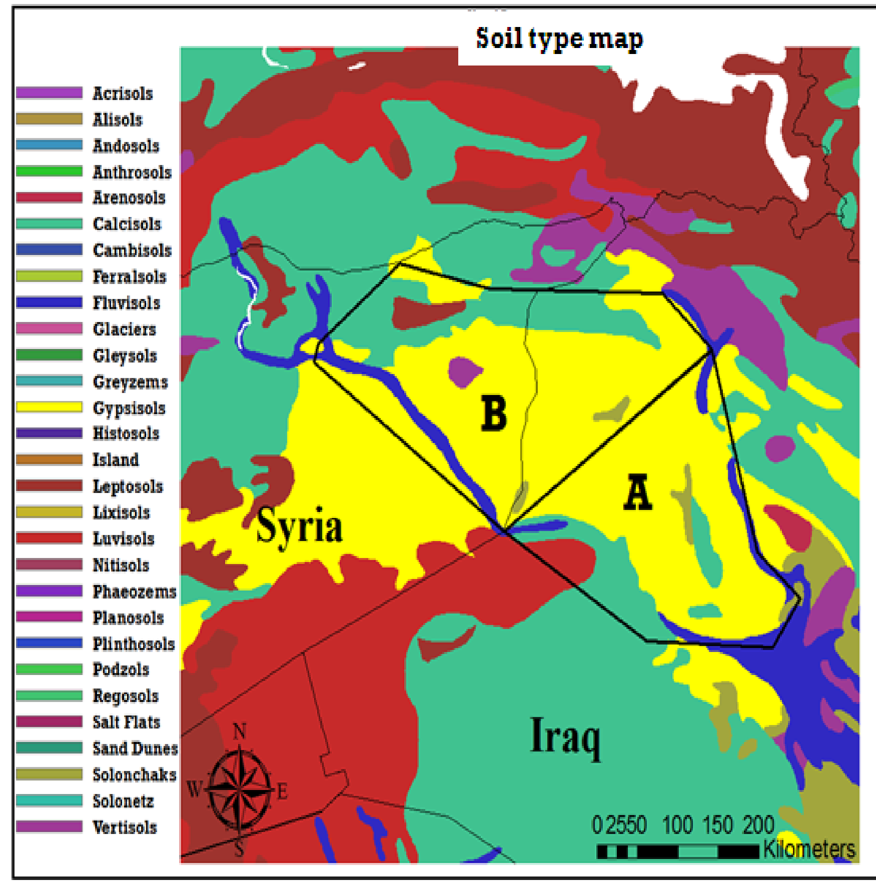
# 4. Wind Trajectory



# 5. Soil Properties (Soil Type)



# 5. Soil Properties

| | | | |
|---|---|---|---|
| Topsoil Texture | Medium | Medium | Medium |
| Avalible Water Capacity (mm) | 50 | 150 | 15 |
| Topsoil Sand Fraction (%) | 35 | 39 | 43 |
| Topsoil Silt Fraction (%) | 45 | 37 | 34 |
| Topsoil Clay Fraction (%) | 20 | 24 | 23 |
| Topsoil USDA Texture Classification | Loam | loam | loam |

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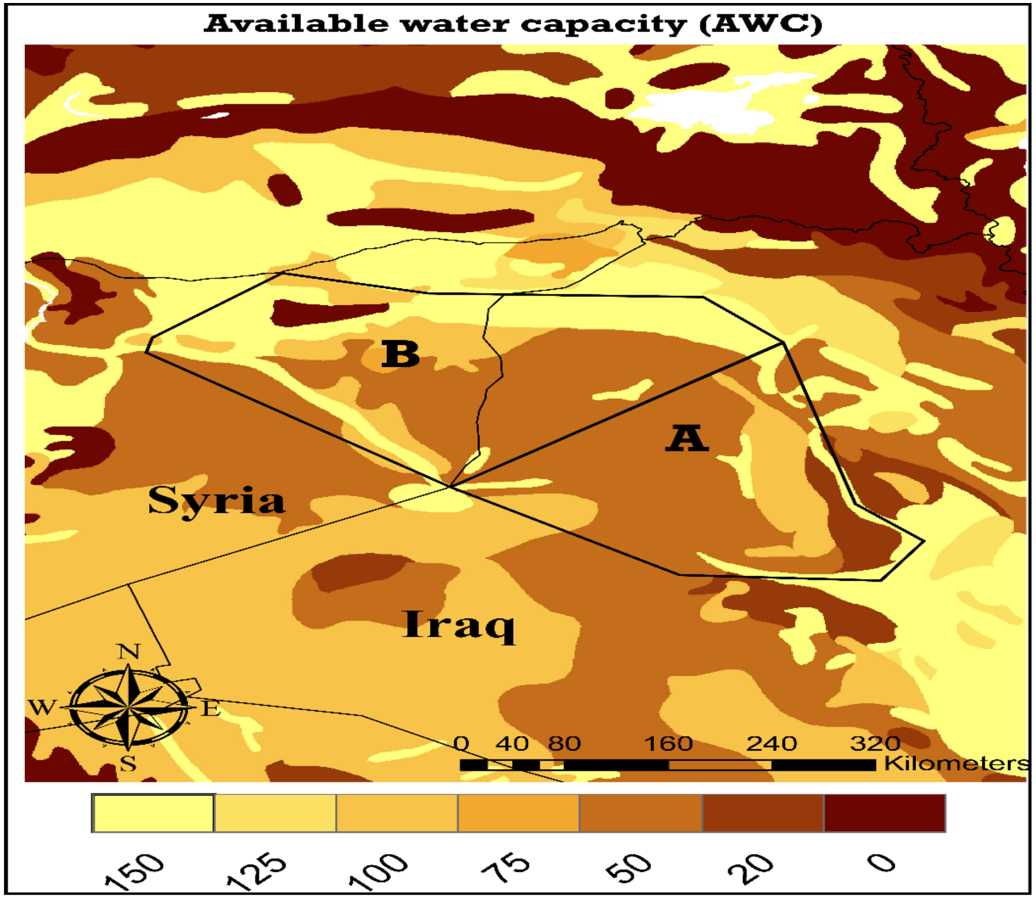
# 6. Available Water Capacity



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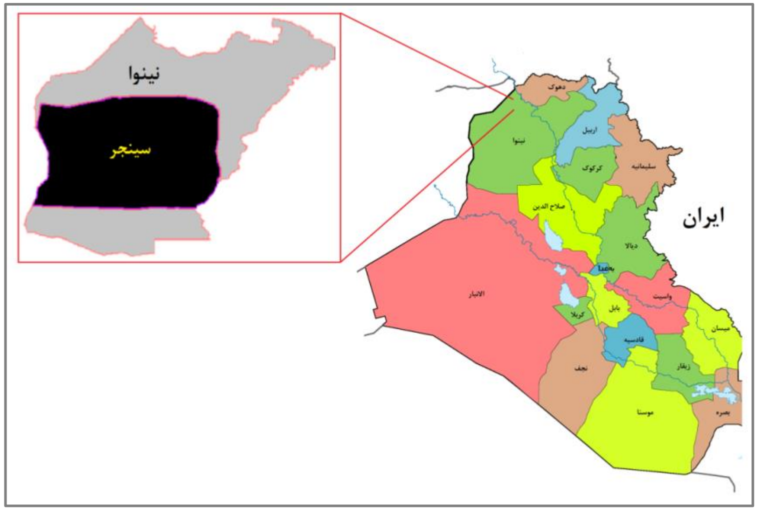
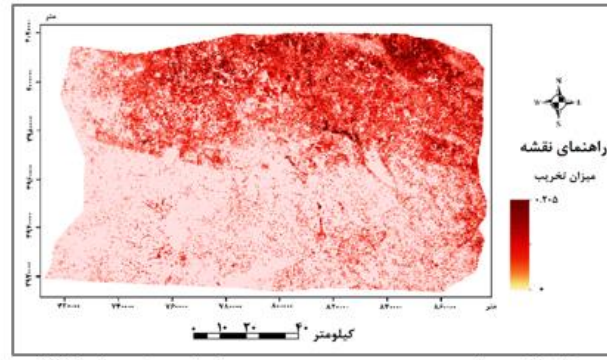
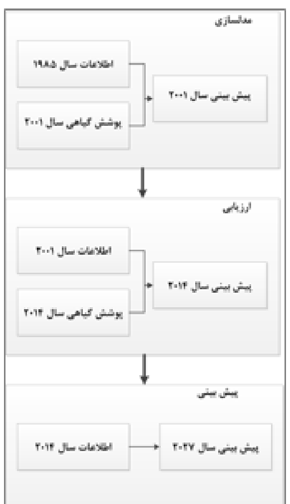
# 6. Land degradation trend analysis



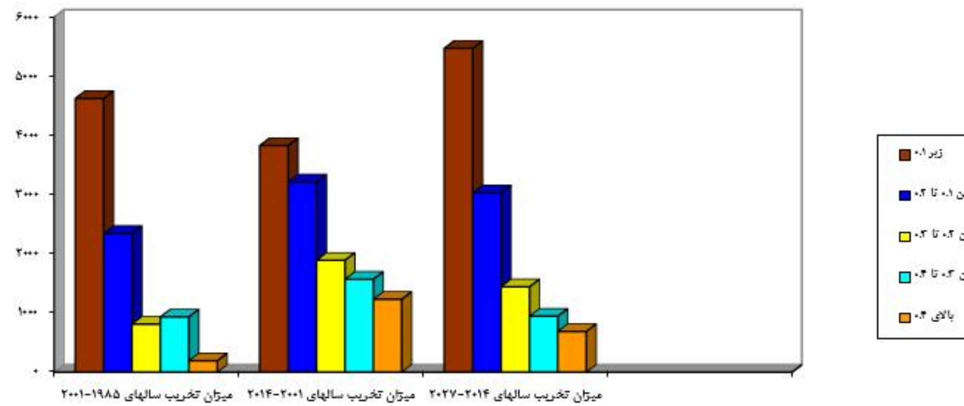




شکل 41- میزان تخریب پیش‌بینی‌شده پوشش گیاهی برای سال 2027




شکل 2- ساختار کلی حل مسئله تخریب پوشش گیاهی


شکل 1- مؤلفه‌های روش پیشنهادی برای مدلسازی تخریب پوشش گیاهی



# 6. Soil Erosion Modeling

GEOINFORMATICS Research Institute (GRI)

Advances in Environmental Biology, 6(1): 109-124, 2012
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed **ORIGINAL ARTICLE**

**Mapping Soil Erosion and Sediment Yield Susceptibility using RUSLE, Remote Sensing and GIS (Case study: Cham Gardalan Watershed, Iran)**

**[1]Saleh Arekhi, [2]Ali Darvishi Bolourani, [3]Afshin Shabani, [4]Hassan Fathizad, [5]Salman Ahamdy-asbchin**

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*[2]Department of Cartography, Geography College, University of Tehran, Tehran, Iran.*
*[3]MSc of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran,*
*[4]MSc Student of Combating desertification,*
*[5]Department of biology, Faculty of science, Ilam university, Ilam, Iran*

Saleh Arekhi, Ali Darvishi Bolourani, Afshin Shabani, Hassan Fathizad, Salman Ahamdy-asbchin: Mapping Soil Erosion and Sediment Yield Susceptibility using RUSLE, Remote Sensing and GIS (Case study: Cham Gardalan Watershed, Iran)

**ABSTRACT**

The soil erosion is the most serious environmental problem in watershed areas in Iran. The main factors affecting the amount of soil erosion and sediment yield include vegetation cover, topography, soil, and climate. In order to describe the areas with high soil erosion and sediment yield risks and to develop adequate erosion prevention measures in watersheds of dams, erosion and sediment yield maps should be generated considering these factors. The purpose of this study was to investigate the spatial distribution of annual soil loss and sediment yield in Cham Gardalan watershed, Ilam Province, Iran, using Revised Universal Soil Loss Equation (RUSLE) model. Remote Sensing (RS) and Geographic Information System(GIS) technologies were used for erosion and sediment yield risk mapping, based on the this model. The R-, K-, LS-, C- and P- factors were obtained from monthly and annual rainfall data, soil map of the region, 50-meter Digital Elevation Model (DEM), Remote Sensing (RS) techniques (with use of NDVI), and GIS, respectively. The mean values of the R-, k-, LS-, C- and P- factors were 265.96 MJ mm $ha^{-1}$ $h^{-1}$ $year^{-1}$, 0.29 t h $MJ^{-1}$ $mm^{-1}$, 14.31, 0.48 and 1 , respectively. The study indicated that the slope length (L) and slope steepness (S) of the RUSLE model ($R^2$ = 0.84) were the most effective factors controlling soil erosion in the region. The average annual soil loss and sediment yield is predicted up to 38.81 and 19.01 (t $h^{-1}$ $year^{-1}$), respectively. The measured average annual sediment yield 16.58 (t $h^{-1}$ $year^{-1}$) was very close to estimated value (19.01 t $h^{-1}$ $year^{-1}$). Moreover, the results indicated that 47.46%, 11.22%, 9.69%, 11.29%, 20.34% of the study area was under minimal, low, moderate, high and extreme actual erosion risks, respectively. Since 31.63% of the region is under high and extreme erosion risk, adoption of suitable conservation measures seems to be inevitable. The RUSLE model integrated with RS and GIS technologies has great potential for producing accurate and inexpensive erosion and sediment yield risk maps in Iran.

*Key words:* GIS, RS, RUSLE, Sediment yield, Soil erosion, Cham Gardalan watershed

**Introduction**

Soil erosion in watershed areas and the subsequent deposition in rivers, lakes and reservoirs are of great concern for two reasons. Firstly, rich fertile soil is eroded from the watershed areas. Secondly, there is a reduction in reservoir capacity as well as degradation of downstream water quality [17]. Although sedimentation occurs naturally, it is exacerbated by poor land use and land management practices adopted in the upland areas of watersheds. Uncontrolled deforestation due to forest fires, grazing, incorrect methods of tillage and unscientific agriculture practices are some of the poor land management practices that accelerate soil erosion, resulting in large increases in sediment inflow into streams [41]. Therefore, prevention of soil erosion is of paramount importance in the management and conservation of natural resources [35,48].

Land degradation by soil erosion is a serious problem in Iran with an estimated soil loss of 2500 $\times 10^6$ t $year^{-1}$ and about 94% of arable lands and permanent rangelands are in the process of degradation [18,42,30]. In terms of erosion, Iranian soils are under a serious risk due to hilly topography, soil conditions facilitating water erosion (i.e. low

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Mediterranean climate) with mean annual rainfall of about 592.78 mm, and average temperature is 21.7 °C in summer and 4.7 °C in winter [37]. According to land use classification, the most common land use and Table 1). The Cham Gardalan Dam is one of the most important dams in the western Iran that supplies drinking water to the Ilam City.

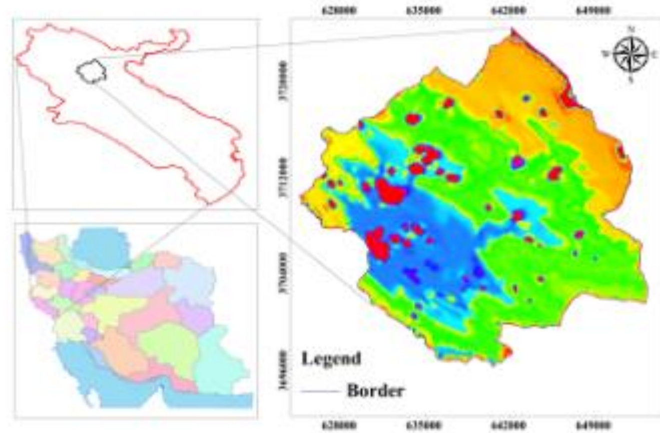


Fig. 1: Location of the study area

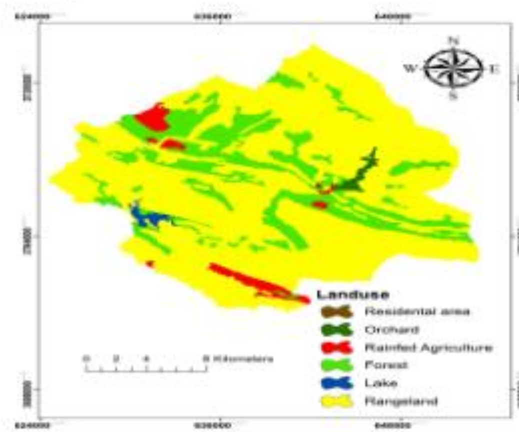


Fig. 2: Land use/land cover of the study area

Table 1: Landuse/land cover statistics of the study area

| Landuse/land cover type | Area(hectare) | Area (%) |
|---|---|---|
| Forest | 9228 | 19.3 |
| Lake | 307 | 0.6 |
| Rainfed Agriculture | 1299 | 2.7 |
| Orchard | 357 | 0.7 |
| Residential area | 333 | 0.7 |
| Rangeland | 36452 | 76 |

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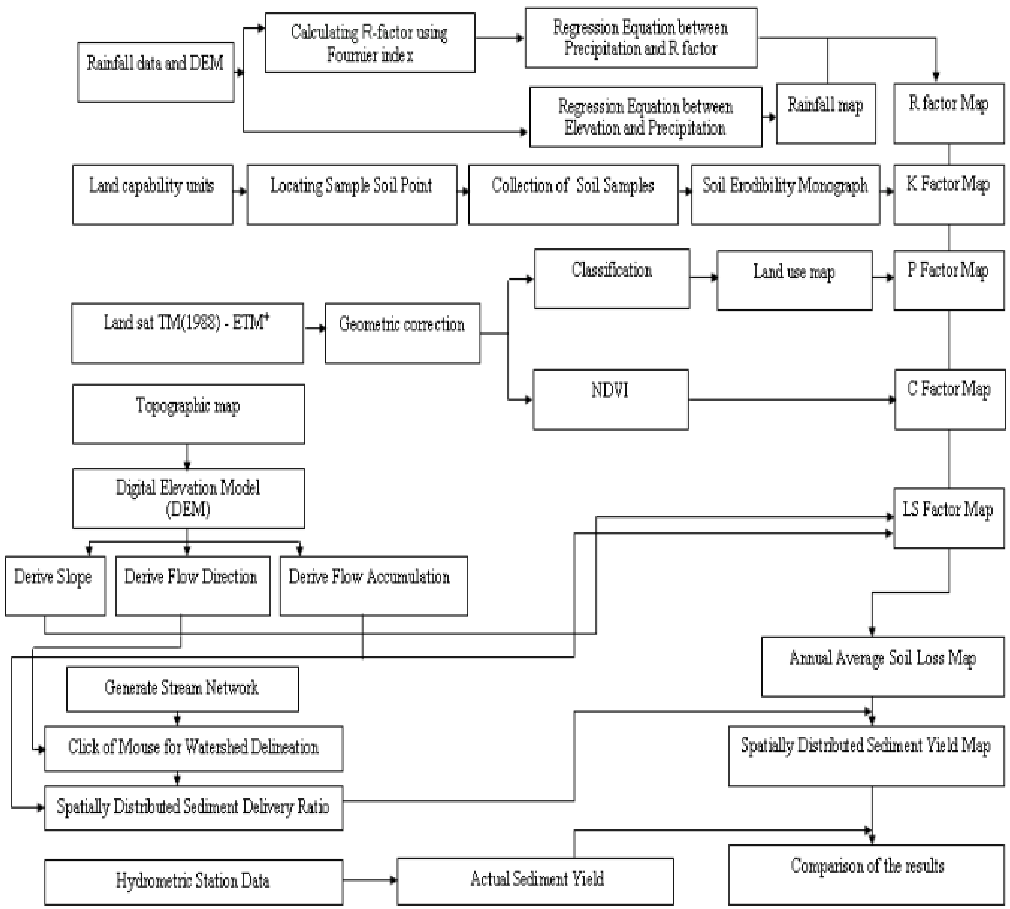
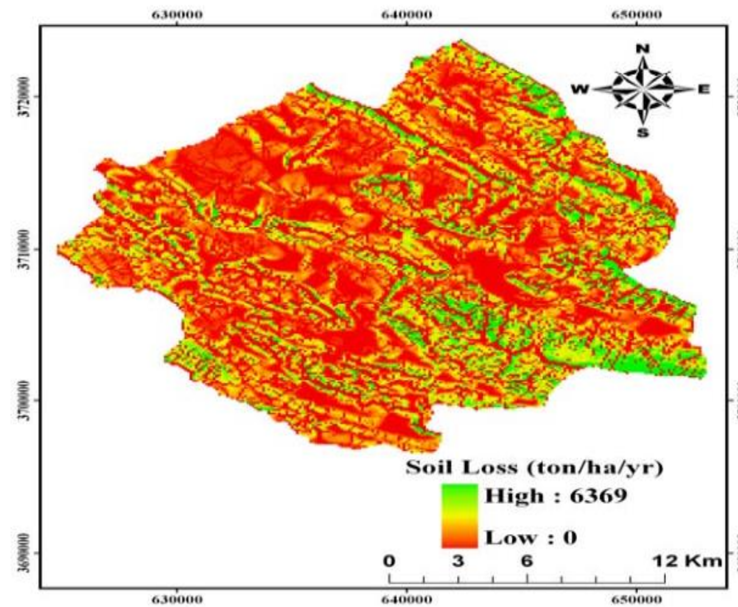
# 6. Soil Erosion




istribution of soil loss (gradual)

**Fig. 3:** Methodology for estimation of soil loss and sediment yield of the study area

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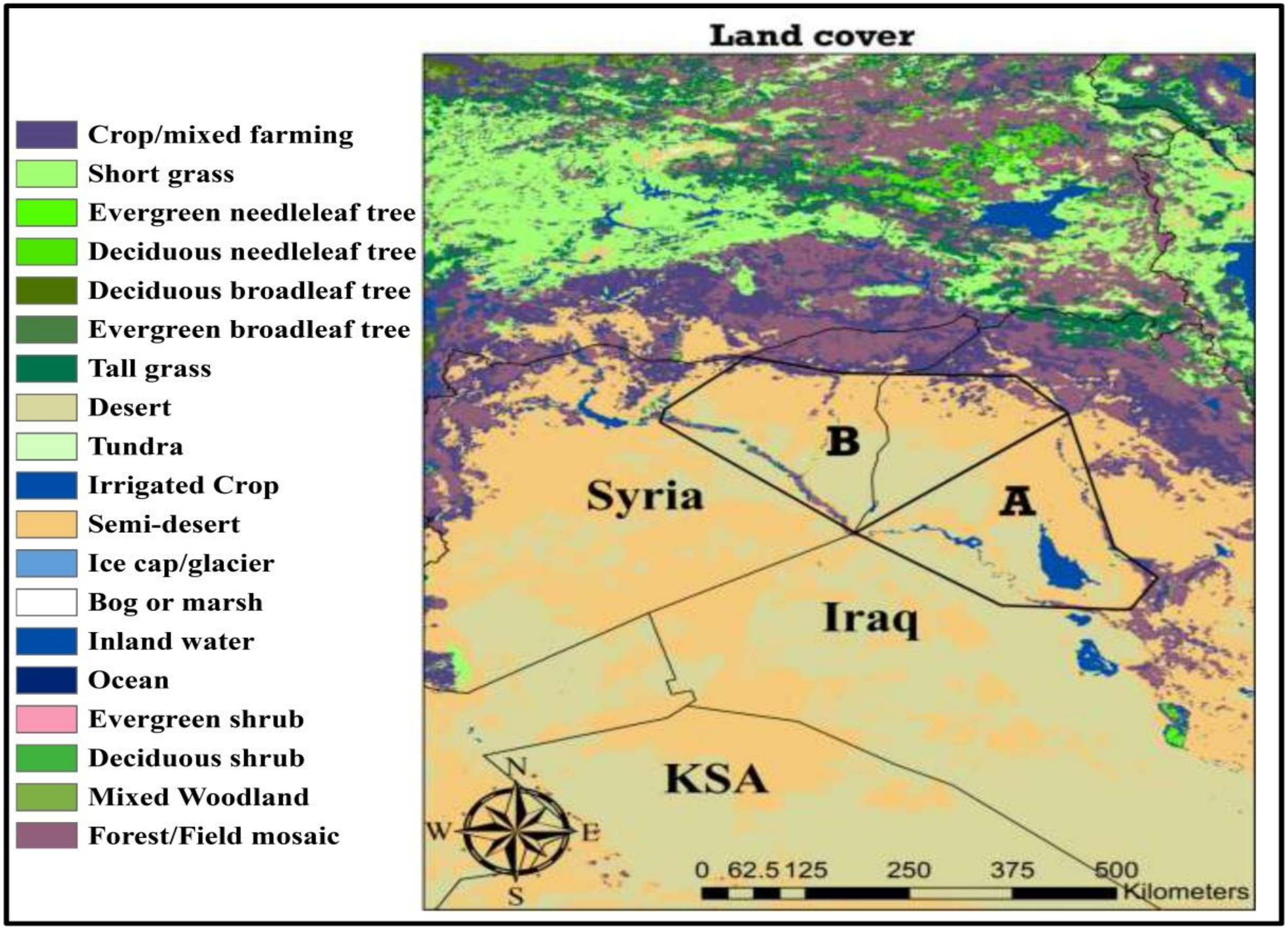
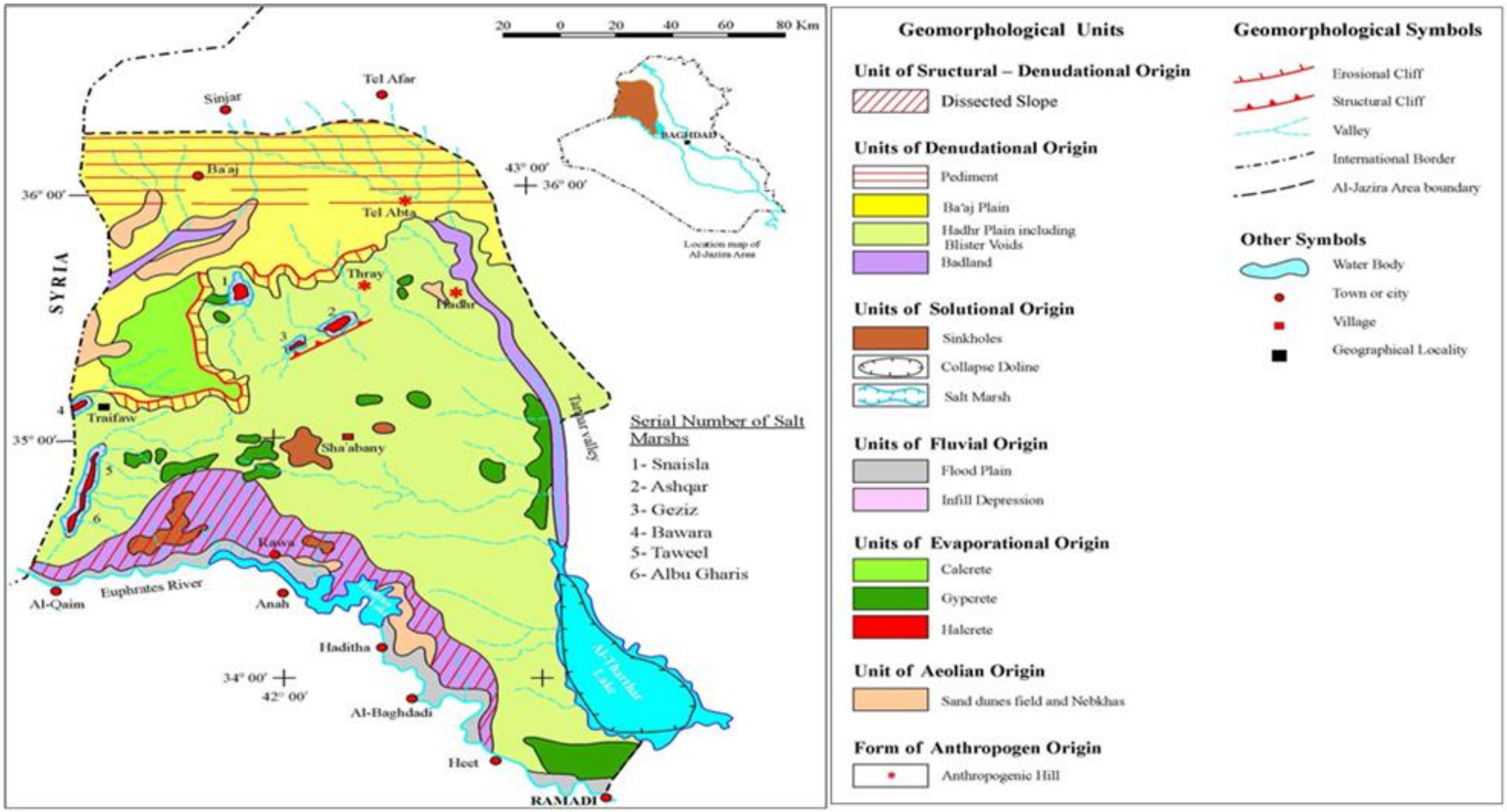
# 7. Land Cover and Veg.



# 8. Geology and Geomorphology



# 9. Morphogenetic Processes

| Periods of the continental evolution | Climate | Morphogenetic processes | |
|---|---|---|---|
| | | Type | Agent |
| Late Oligocene | Semiarid | Mechanical weathering | Temperature changes and wind action |
| | | Chemical weathering | Groundwater |
| Late Miocene | Wet | Depositional | River |
| Pliocene | Wet | Erosional | Rainwater |
| | | Depositional | River |
| Pleistocene | Wet | Depositional | River |
| | | Chemical weathering | Rainwater |
| | Semiarid | Deposition | Evaporation |
| early Holocene | Wet | Depositional | River |
| | | Chemical weathering | Rainwater |
| late Holocene | Semiarid | Depositional | River, wind action, evaporation |
| | | Erosional | Wind action |

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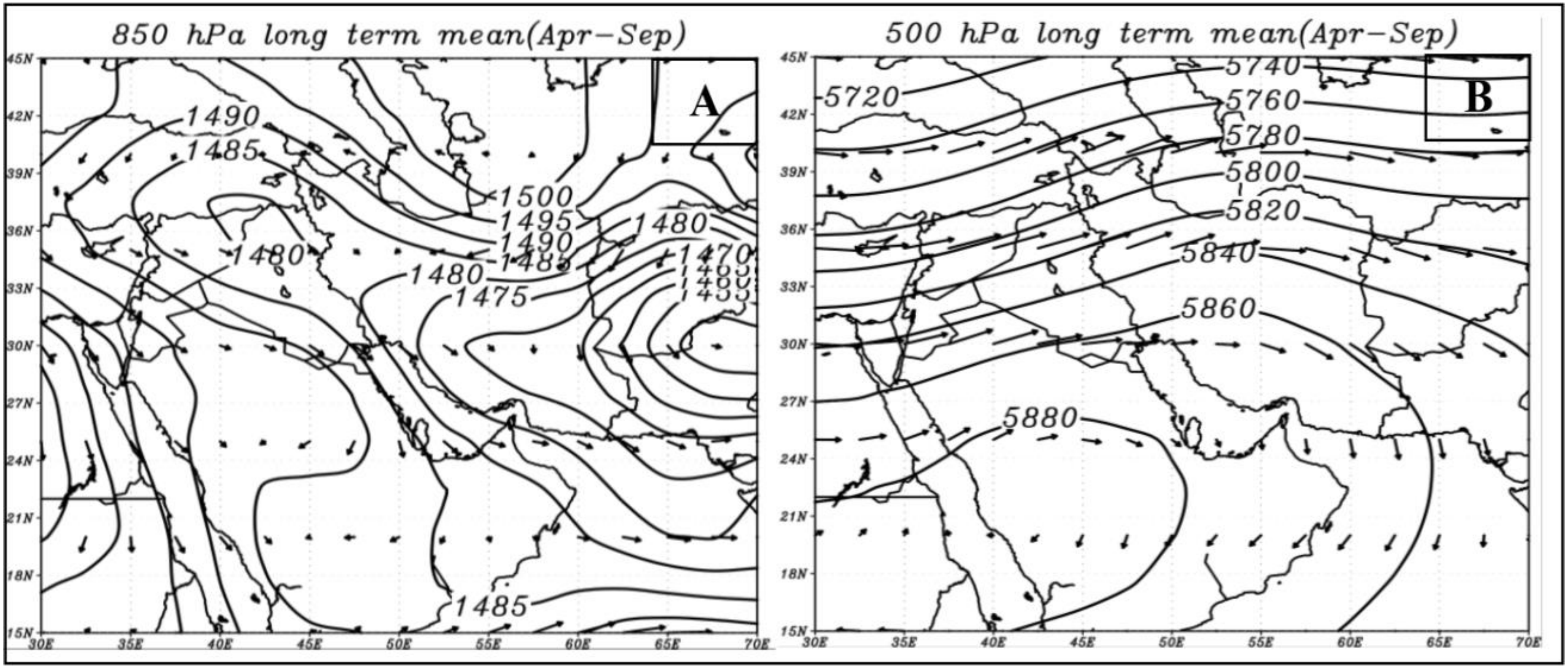
# 10. Wind and Geopotential Height Anomaly Detection



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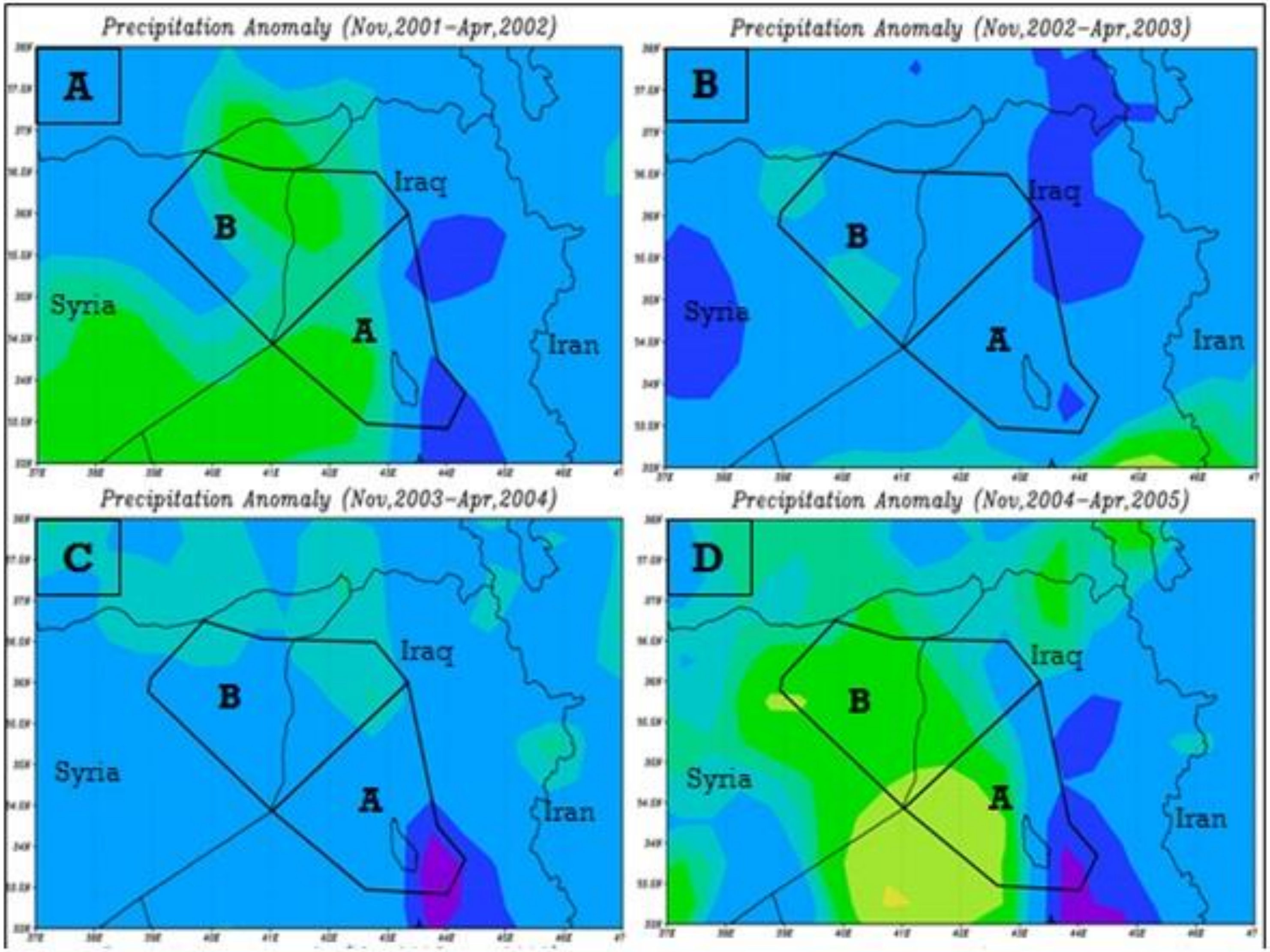
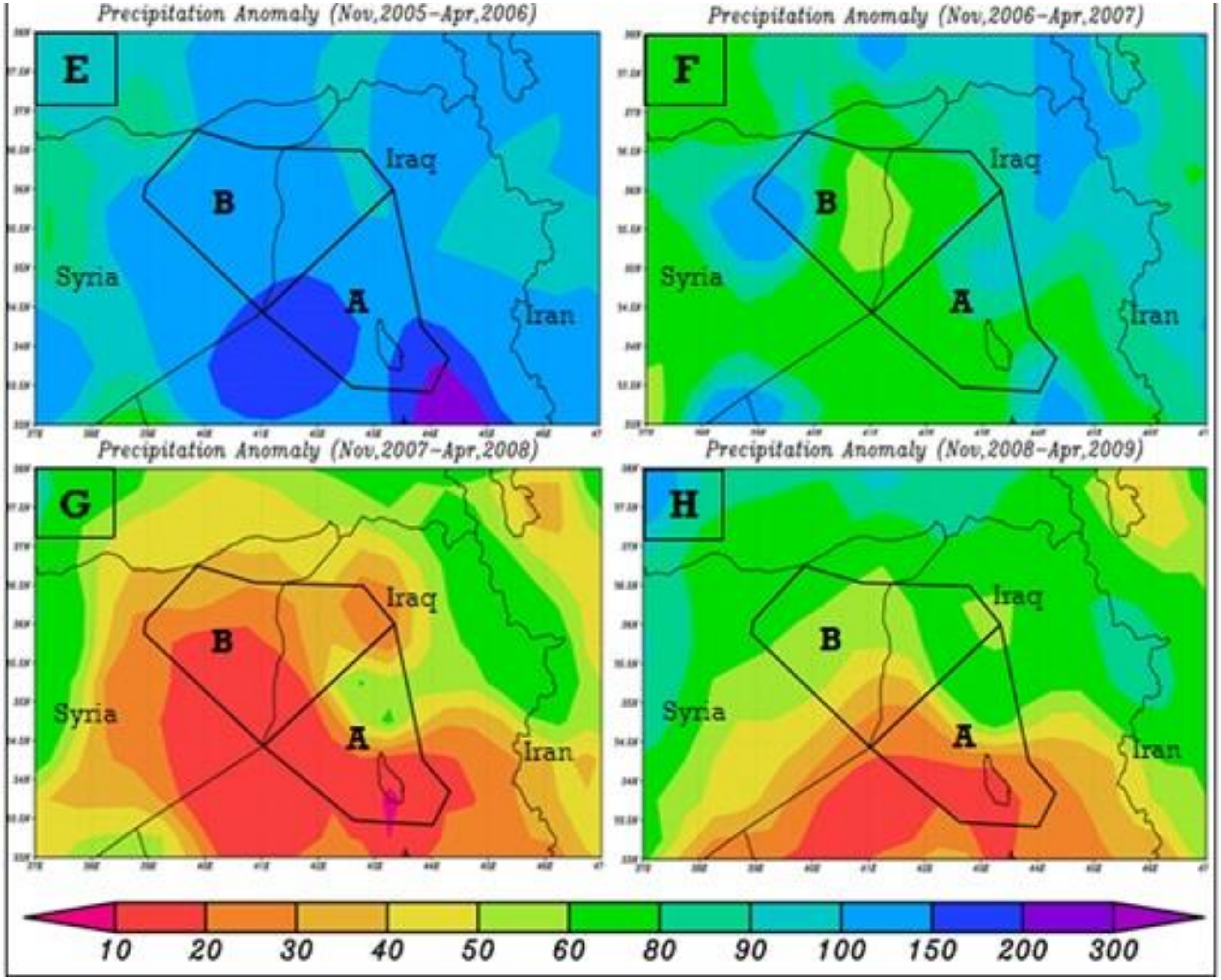
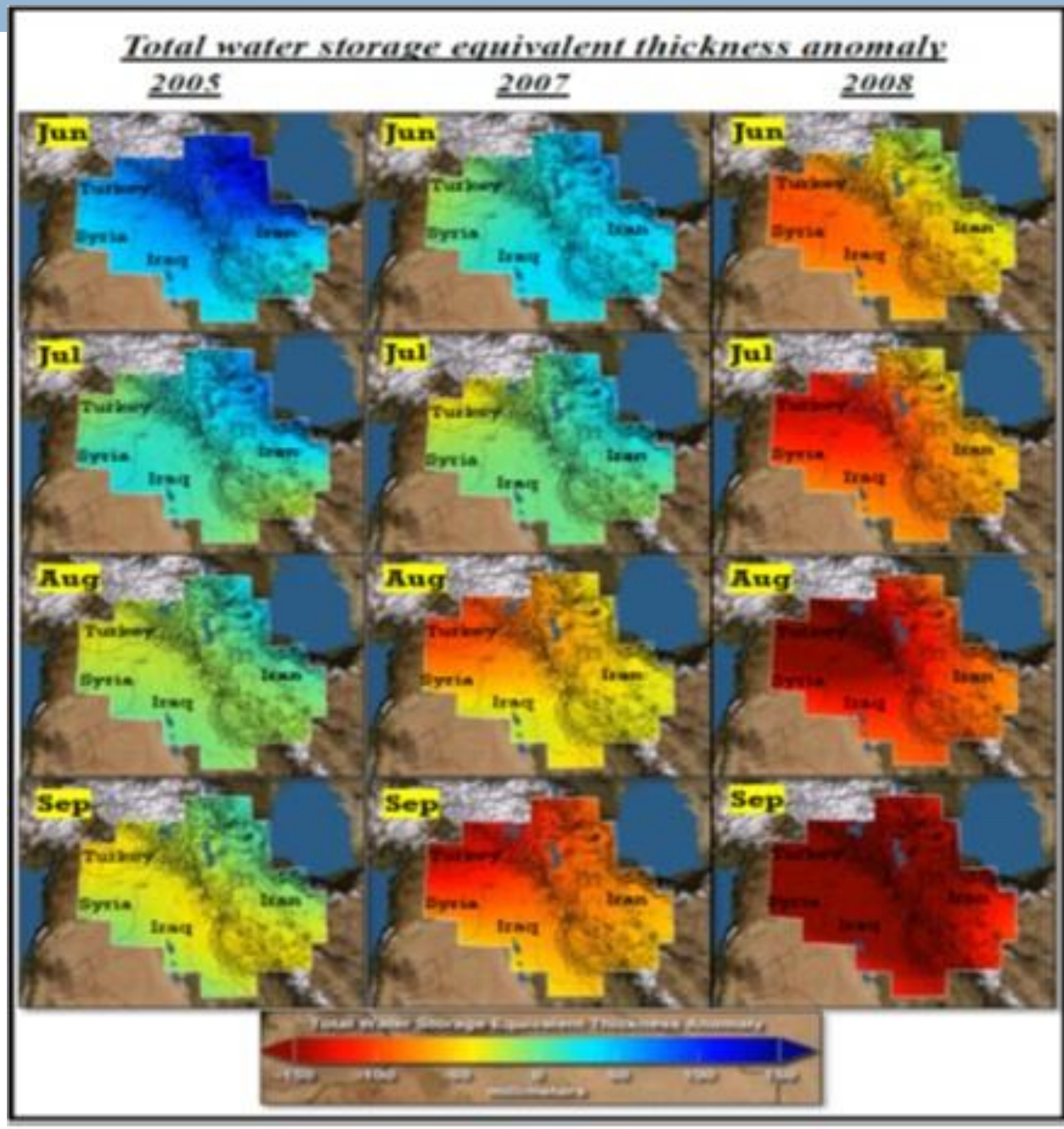
# 11. Precipitation Anomaly Detection



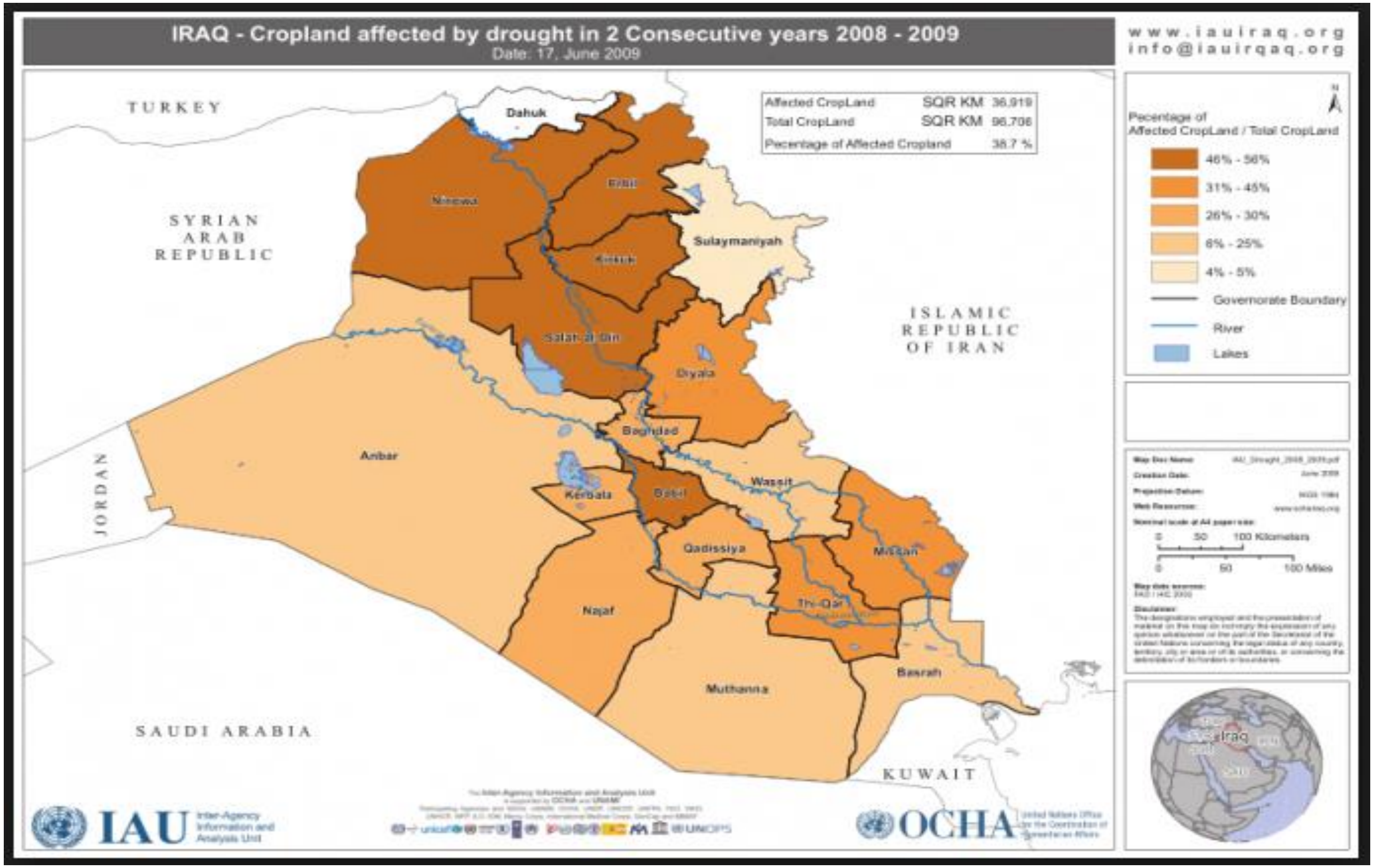
# 11. Precipitation Anomaly Detection



# 12. Total water storage anomaly



# 13. Agricultural Activities Monitoring




Source: Iraq: Cropland affected by drought in 2 Consecutive years 2008-2009, Inter-Agency Information and Analysis Unit, UN Office for the Coordination of Humanitarian Affairs

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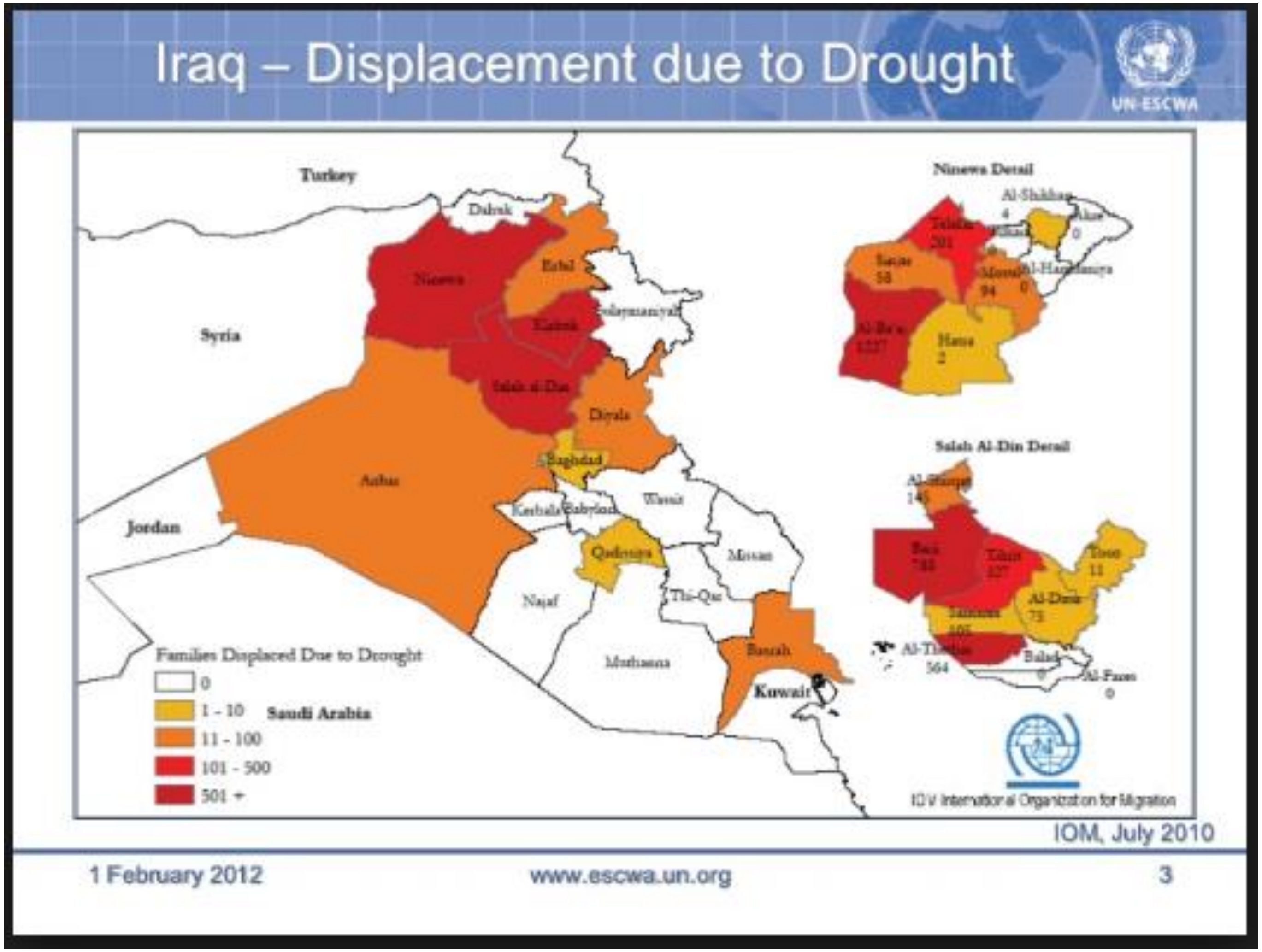
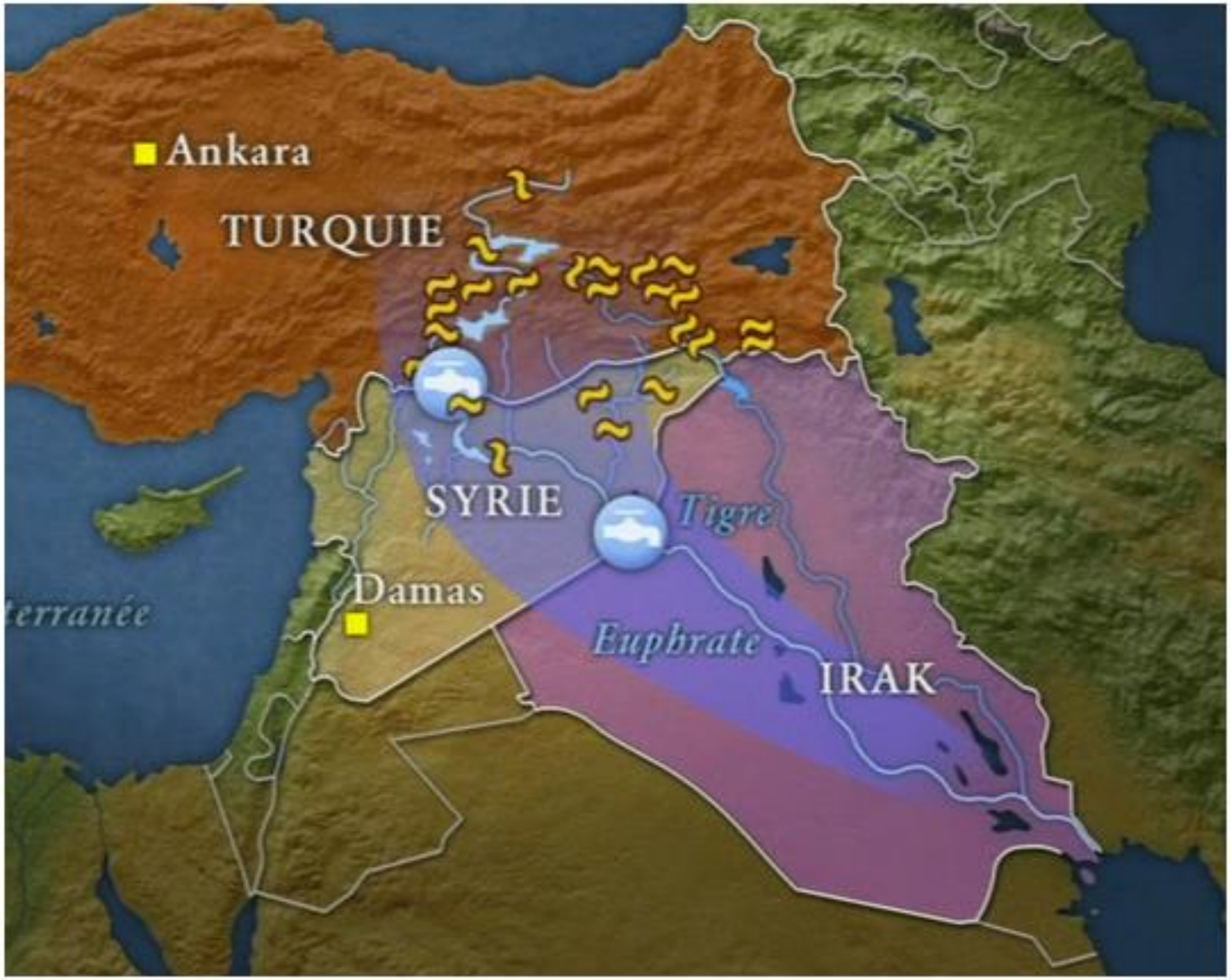
# 15. Socioeconomic Analysis



# 16. Hydraulic Structures



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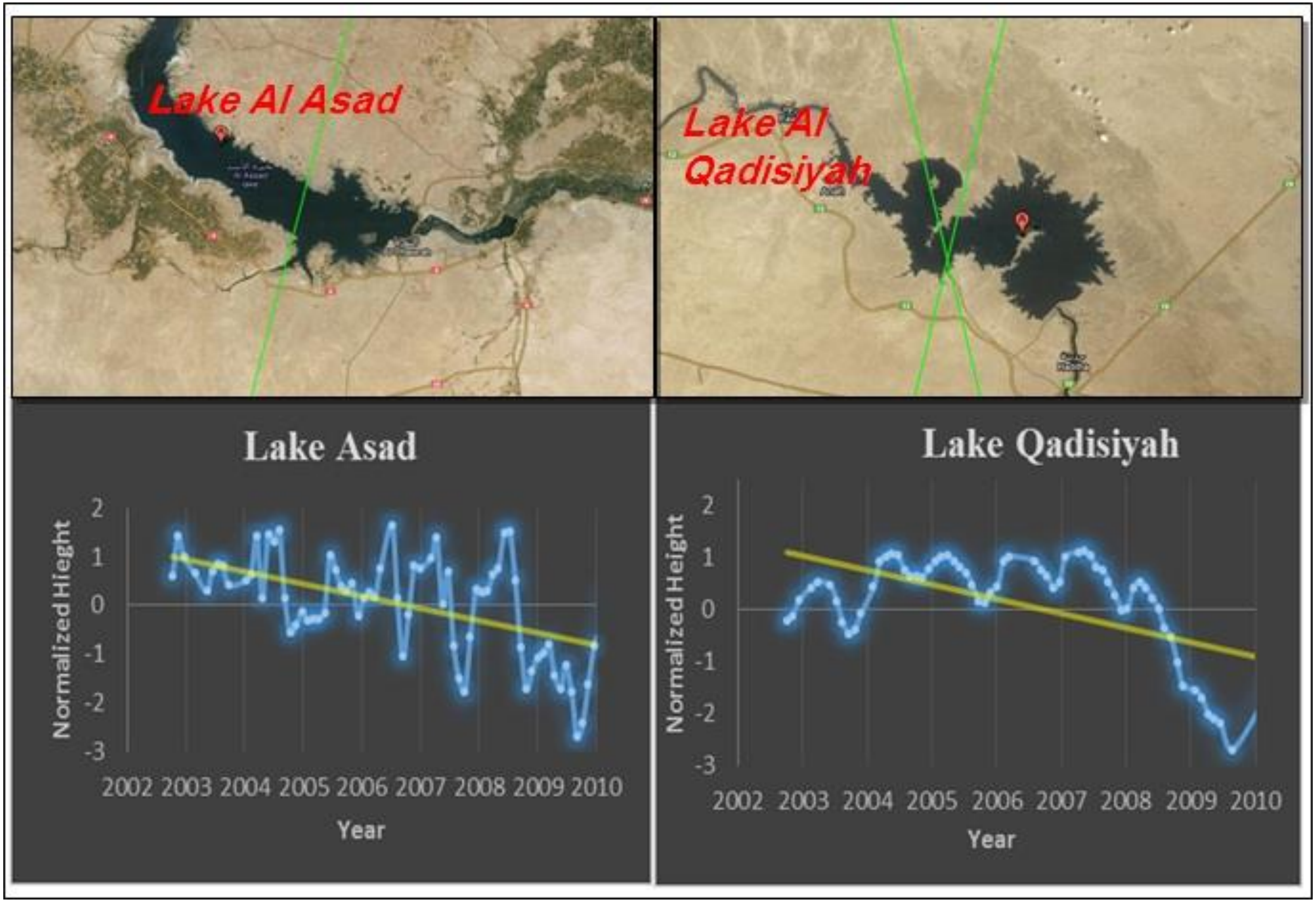
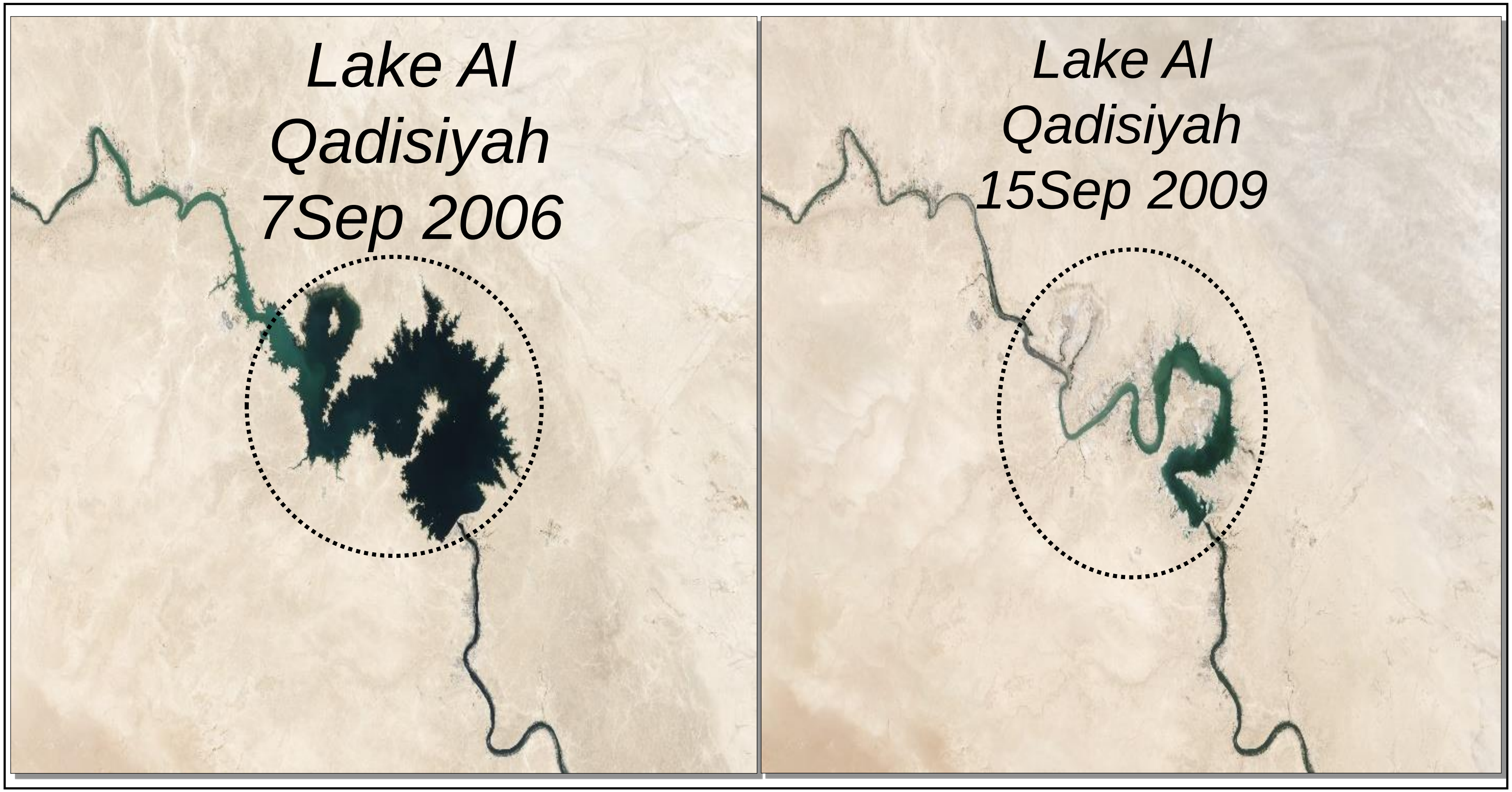
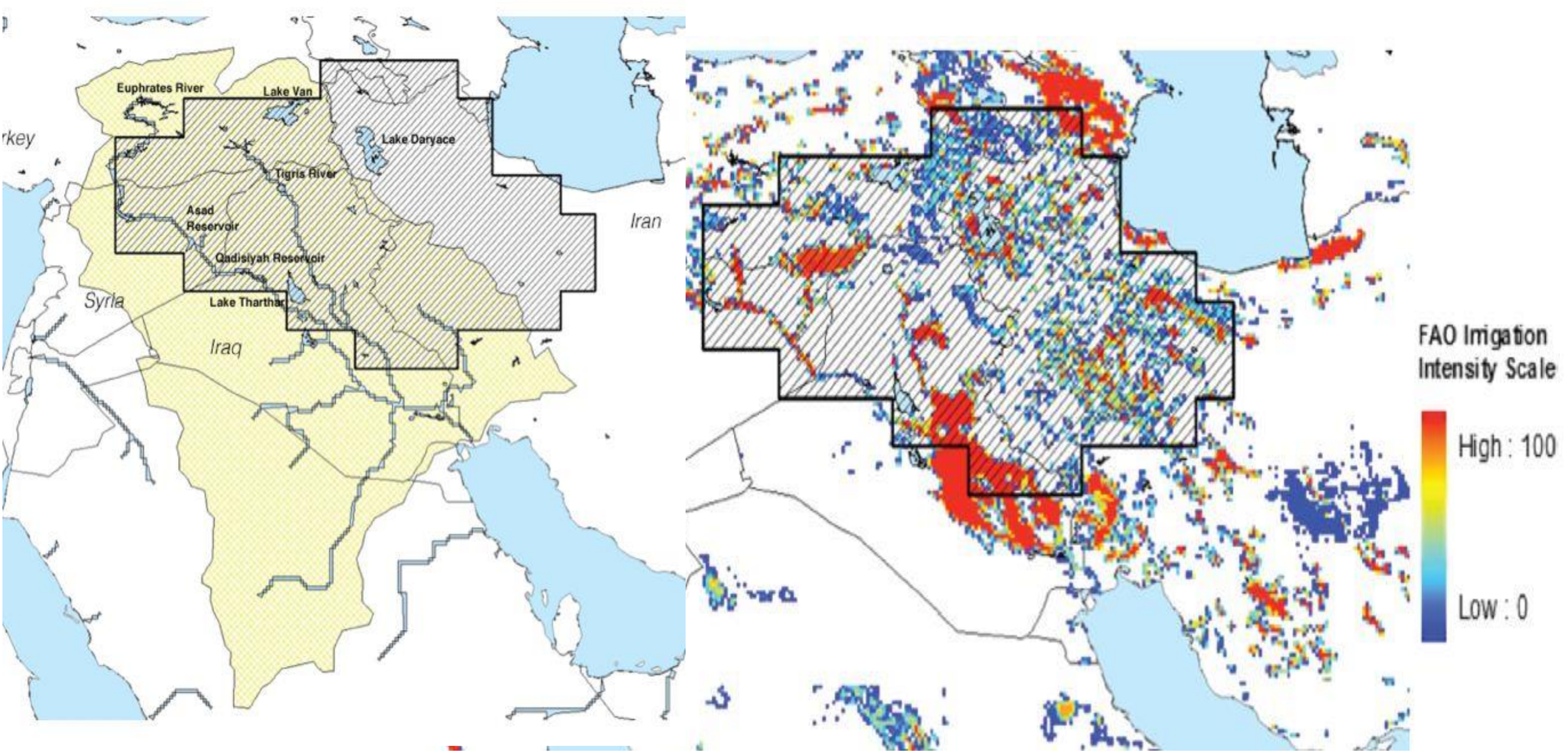
# 18. Hydraulic Monitoring



# 18. Hydraulic Monitoring



# 19. Groundwater Estimation Using Satellite Data




**Source: Groundwater depletion in the Middle East from GRACE with implications for transboundary water management in the Tigris-Euphrates-Western Iran region, 2013**

# SDS Current Projects

- SDS Vulnerability Mapping
- SDS Networking and Geoportal
- DusNIFF

# SDS Vulnerability Mapping

# SDS Effects Parameters

Human

Biome

Agriculture

Livestock

Industrial

Tourism

Infrastructure

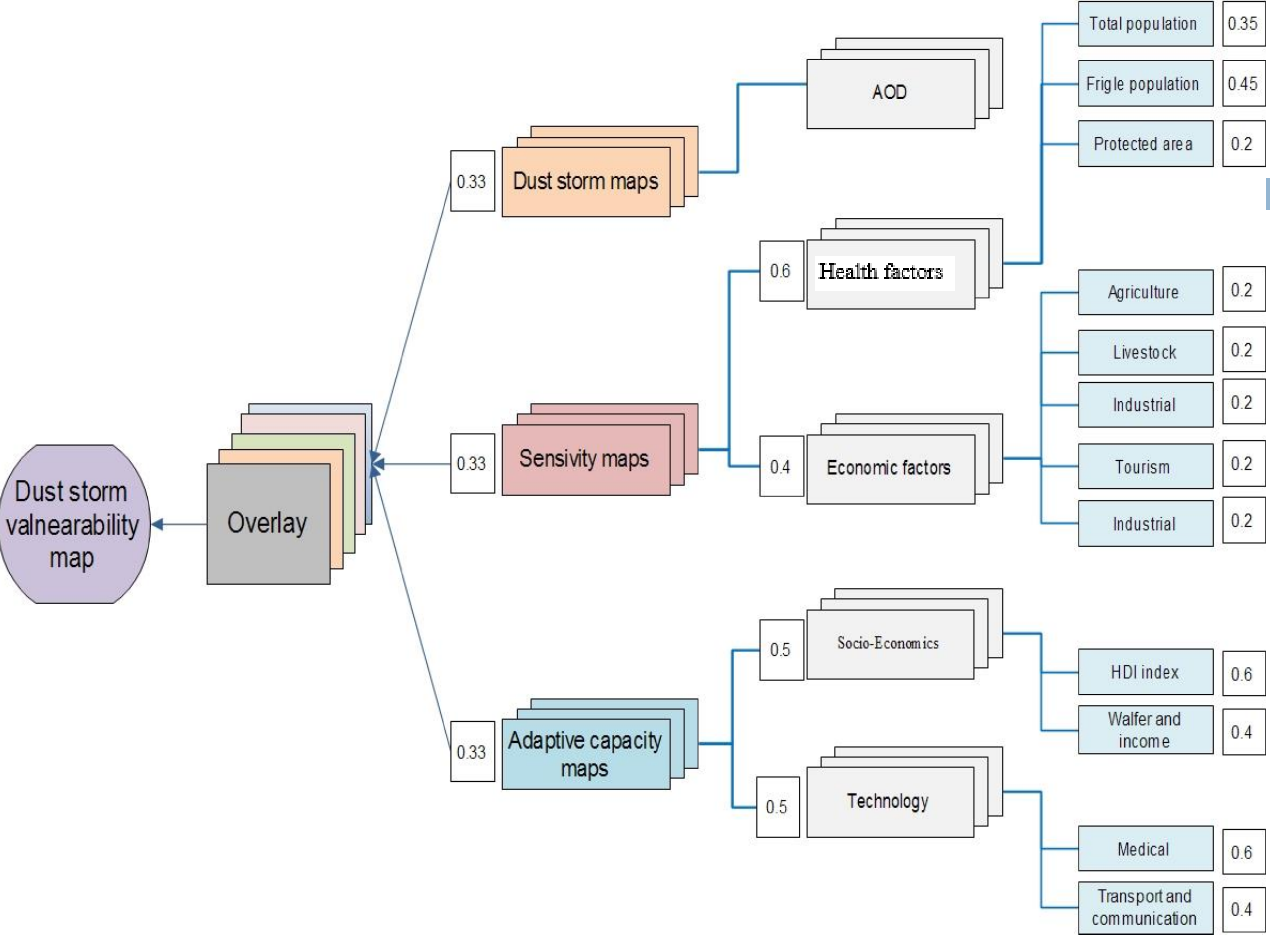
# SDS Vulnerability Parameterization

## Adapted from IPCC

- **Exposure:** “the nature and degree to which a system is exposed to SDS”;

- **Sensitivity:** “the degree to which a system is affected, either adversely or beneficially by SDS”; and

- **Adaptive Capacity:** “the ability of a system to adjust to SDS, to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences”.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Overlay
0.33
Dust storm maps
0.33
Sensivity maps
0.33
Adaptive capacity maps
AOD
0.6
Health factors
0.4
Economic factors
0.5
Socio-Economics
0.5
Technology
Total population
0.35
Frigle population
0.45
Protected area
0.2
Agriculture
0.2
Livestock
0.2
Industrial
0.2
Tourism
0.2
Industrial
0.2
HDI index
0.6
Walfer and income
0.4
Medical
0.6
Transport and communication
0.4

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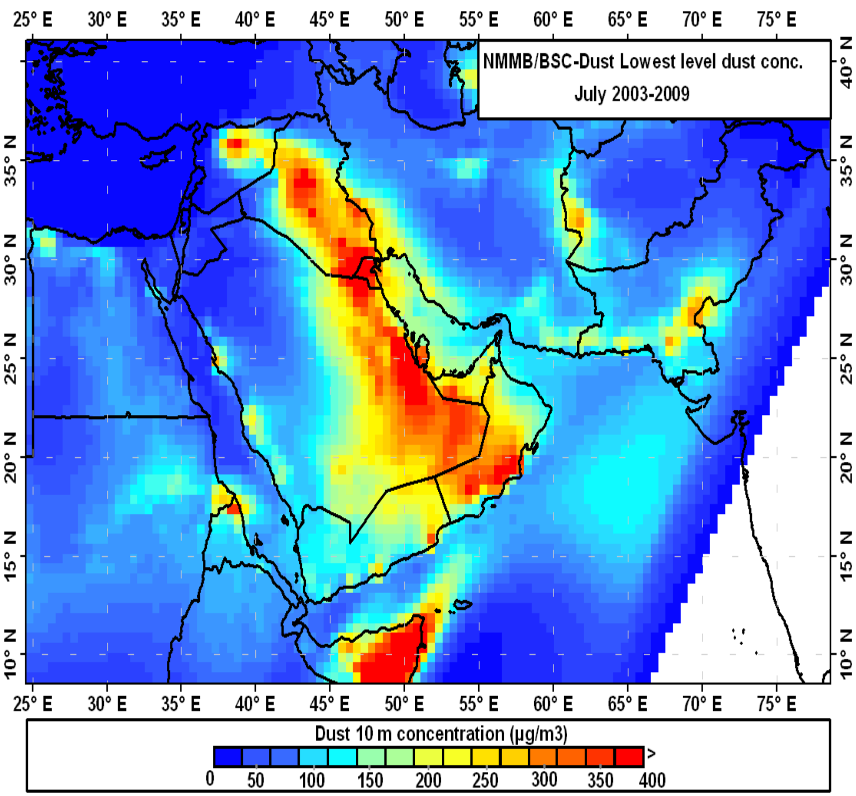
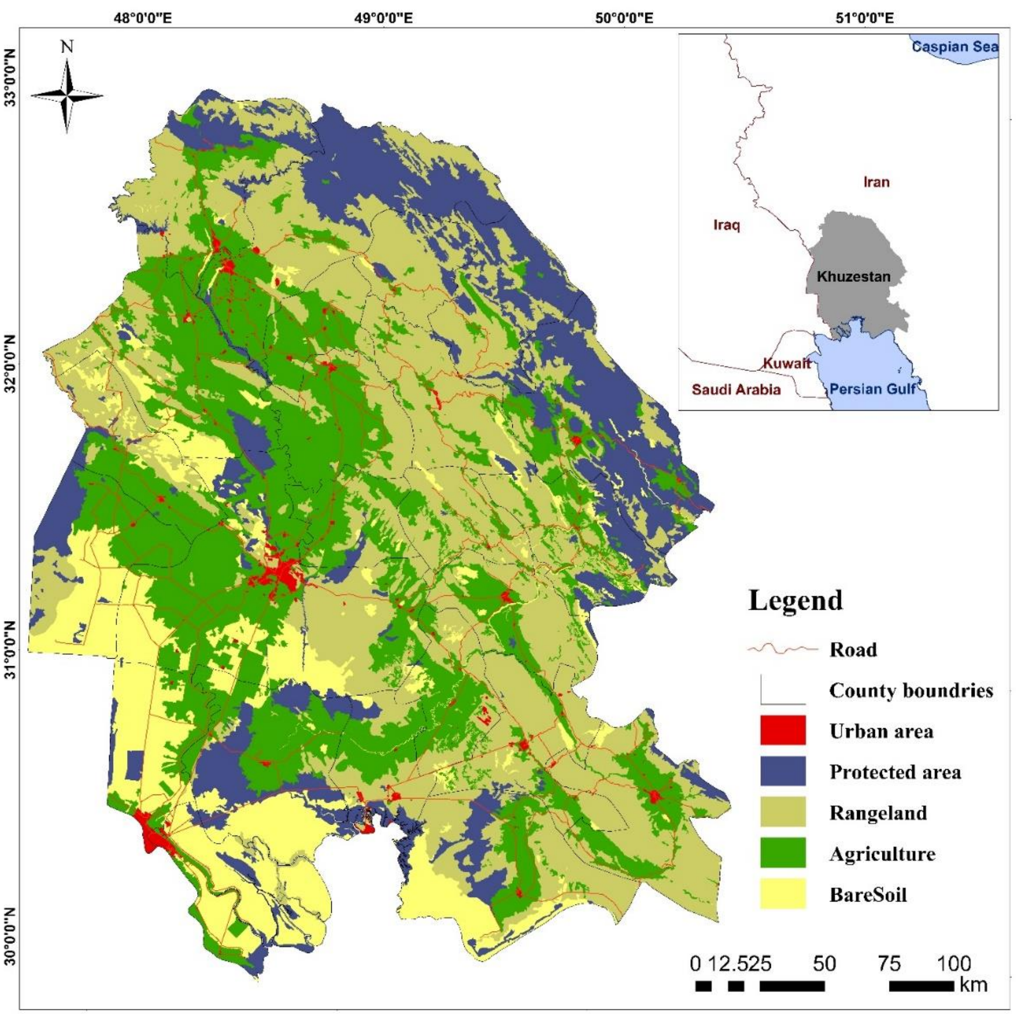
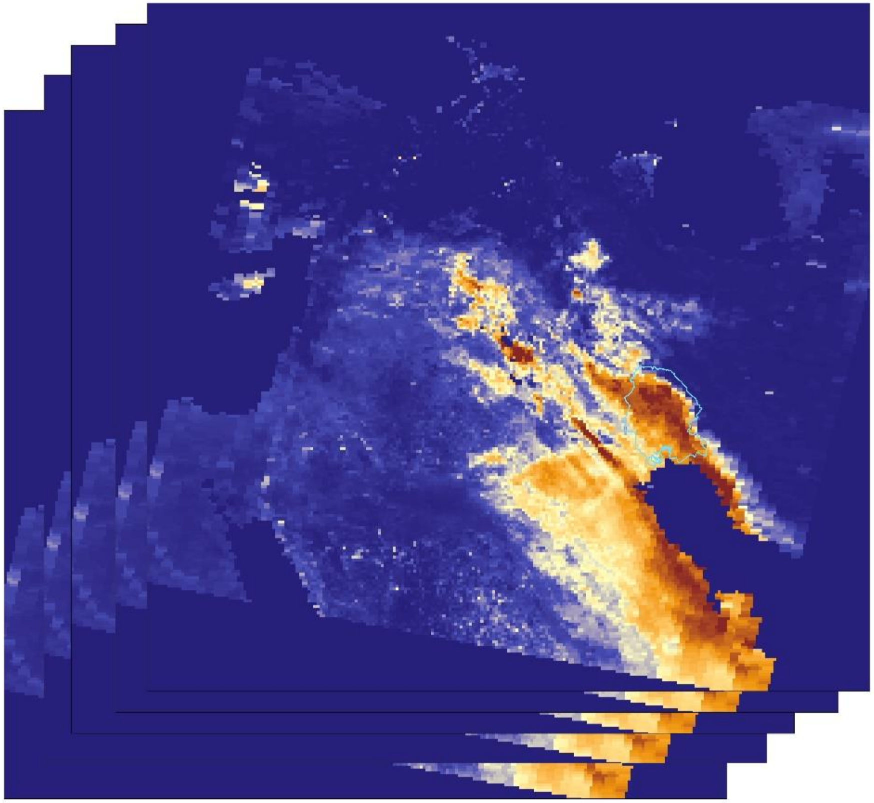
# Khuzestan Province



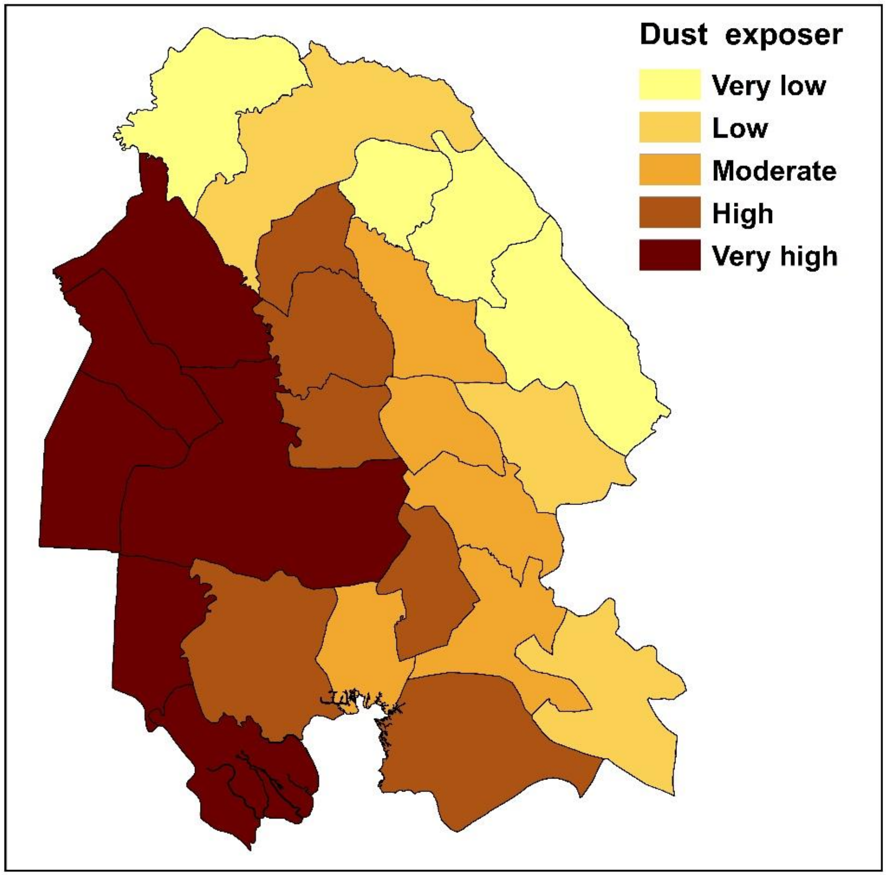



# SDS Vulnerability Mapping

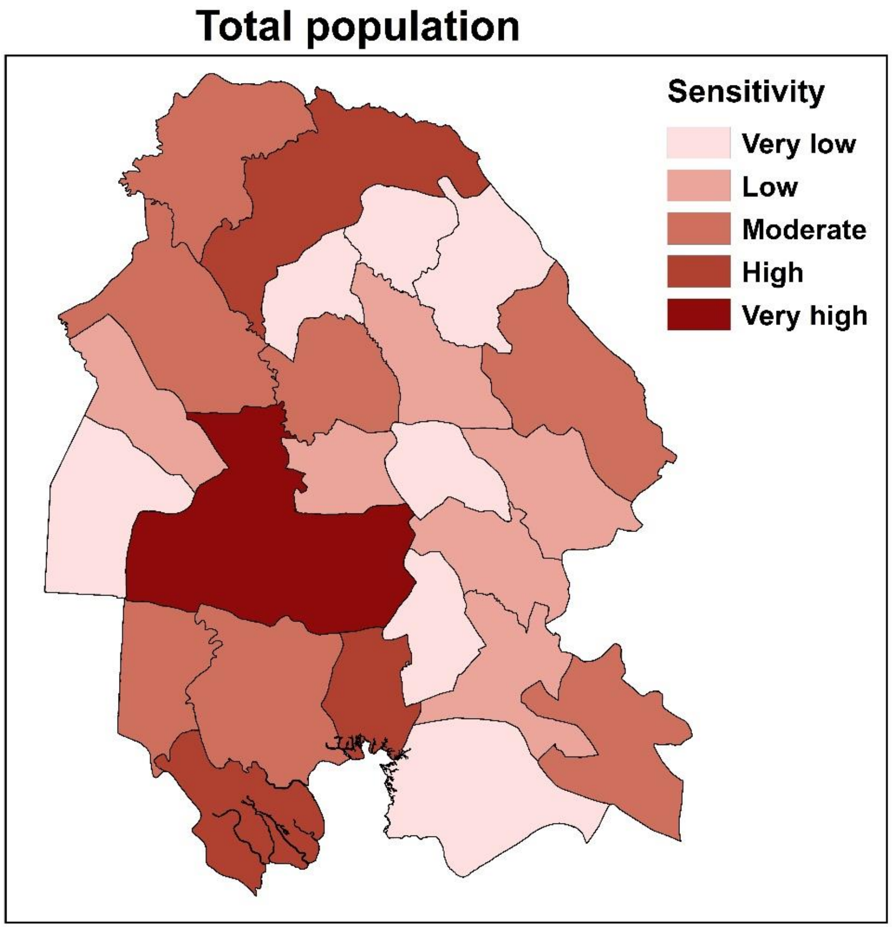
AOD

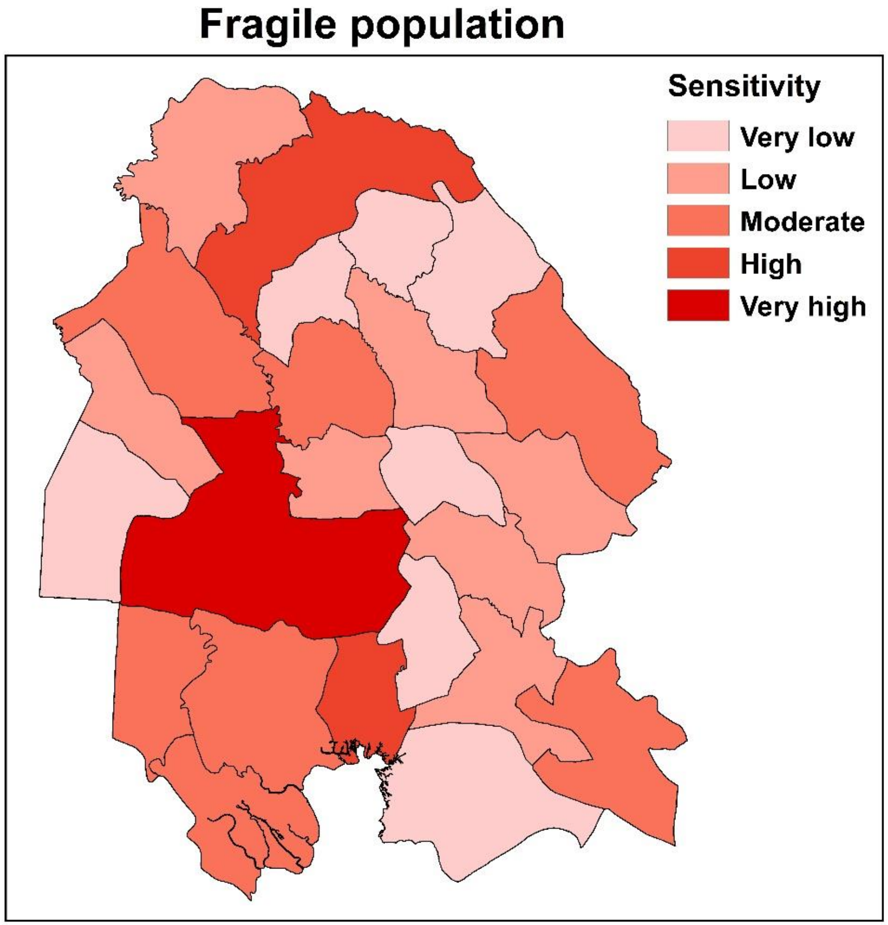


Dust storm exposer



# SDS Vulnerability Mapping



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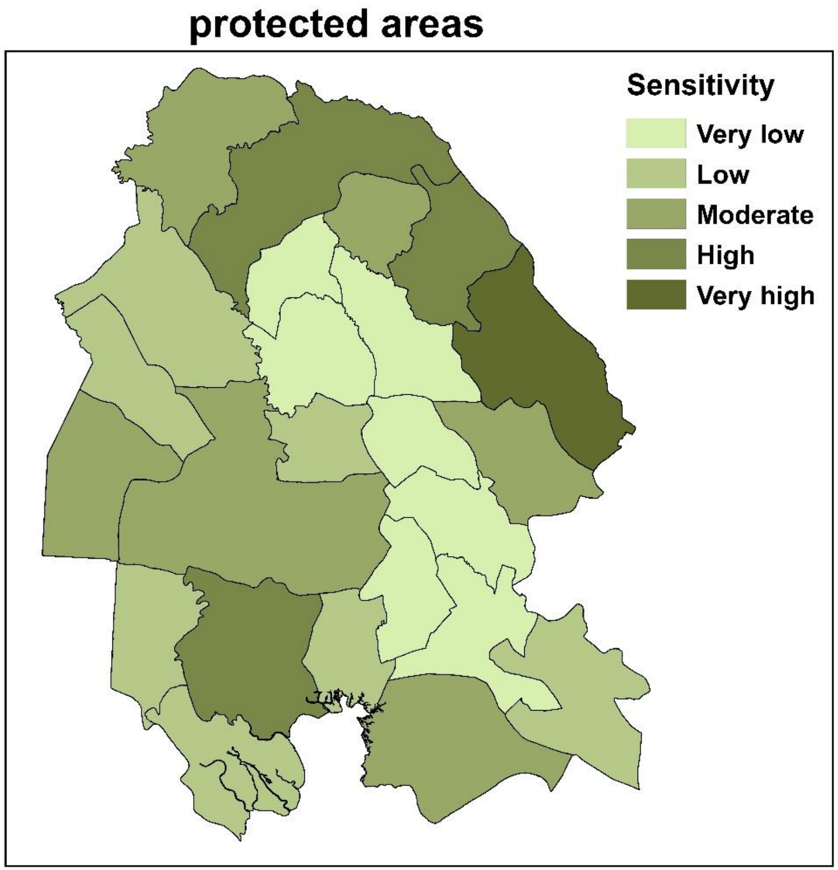


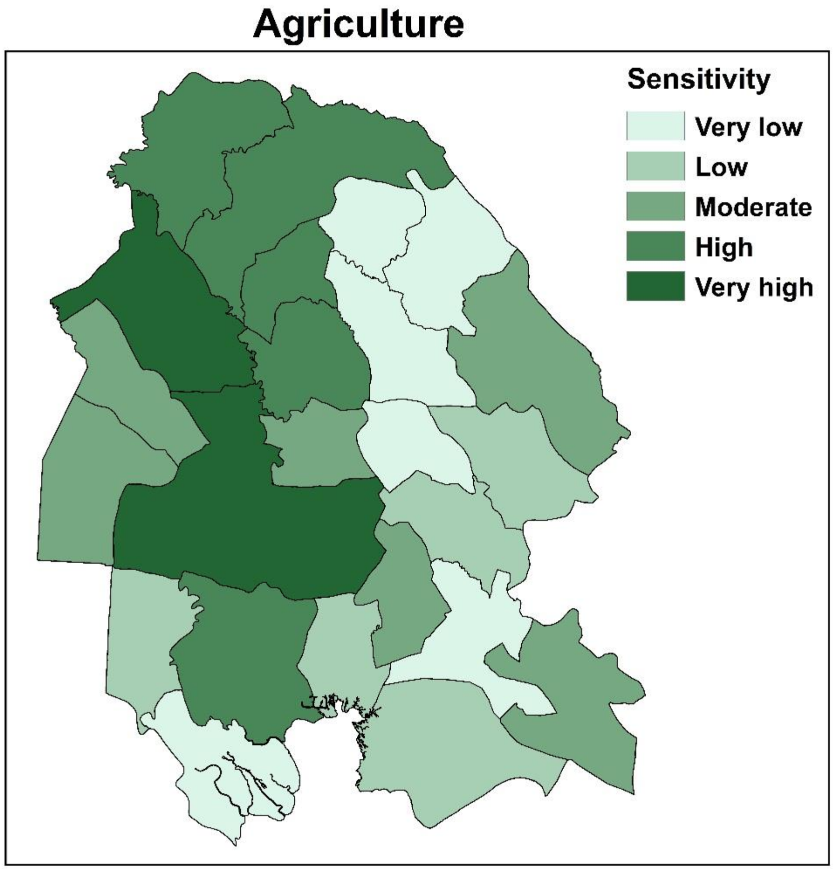

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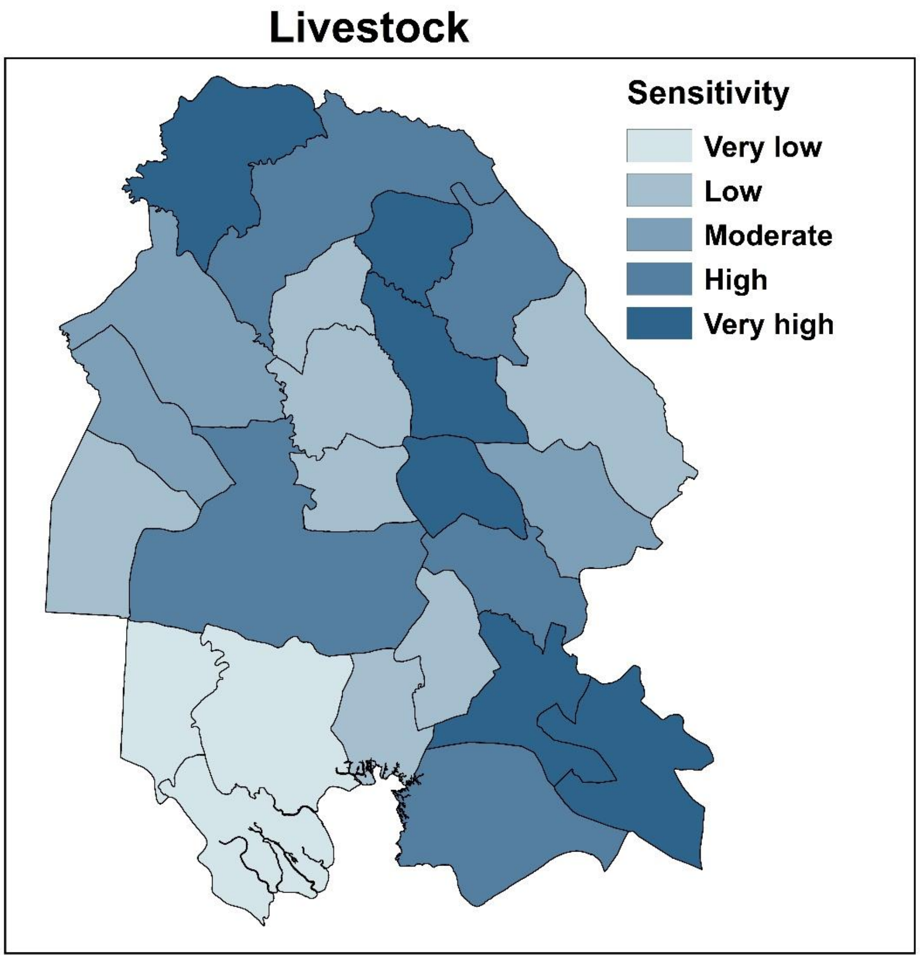
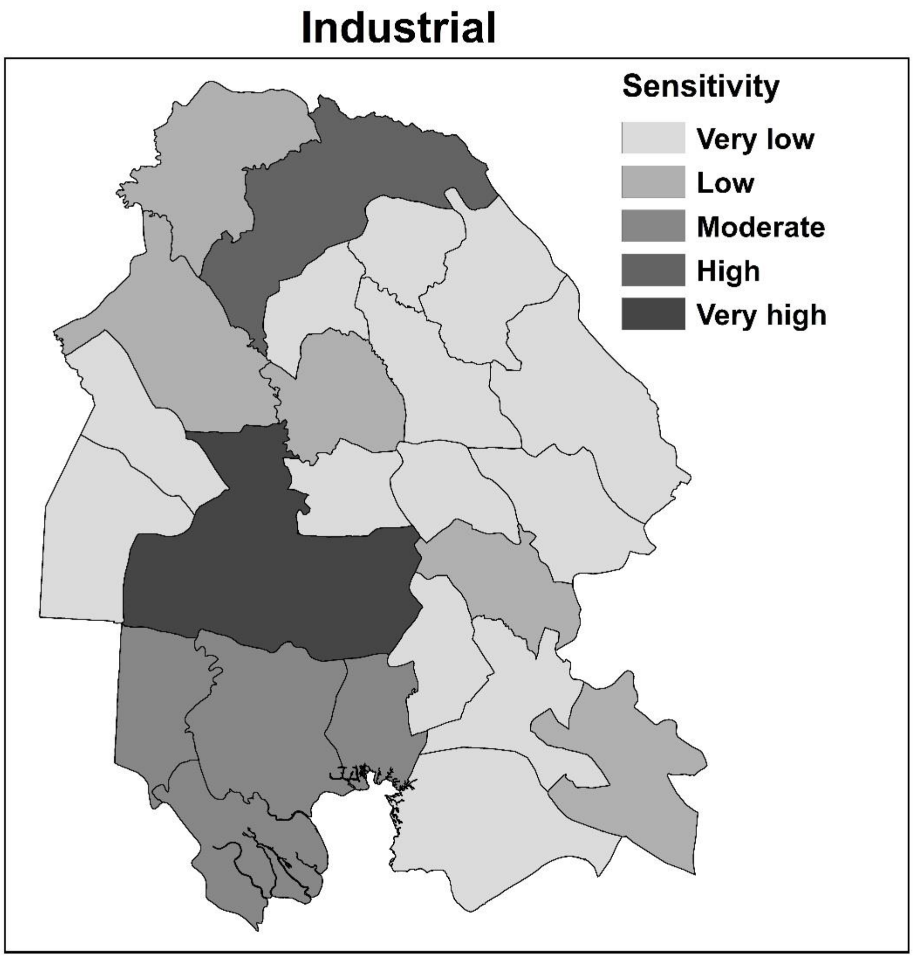
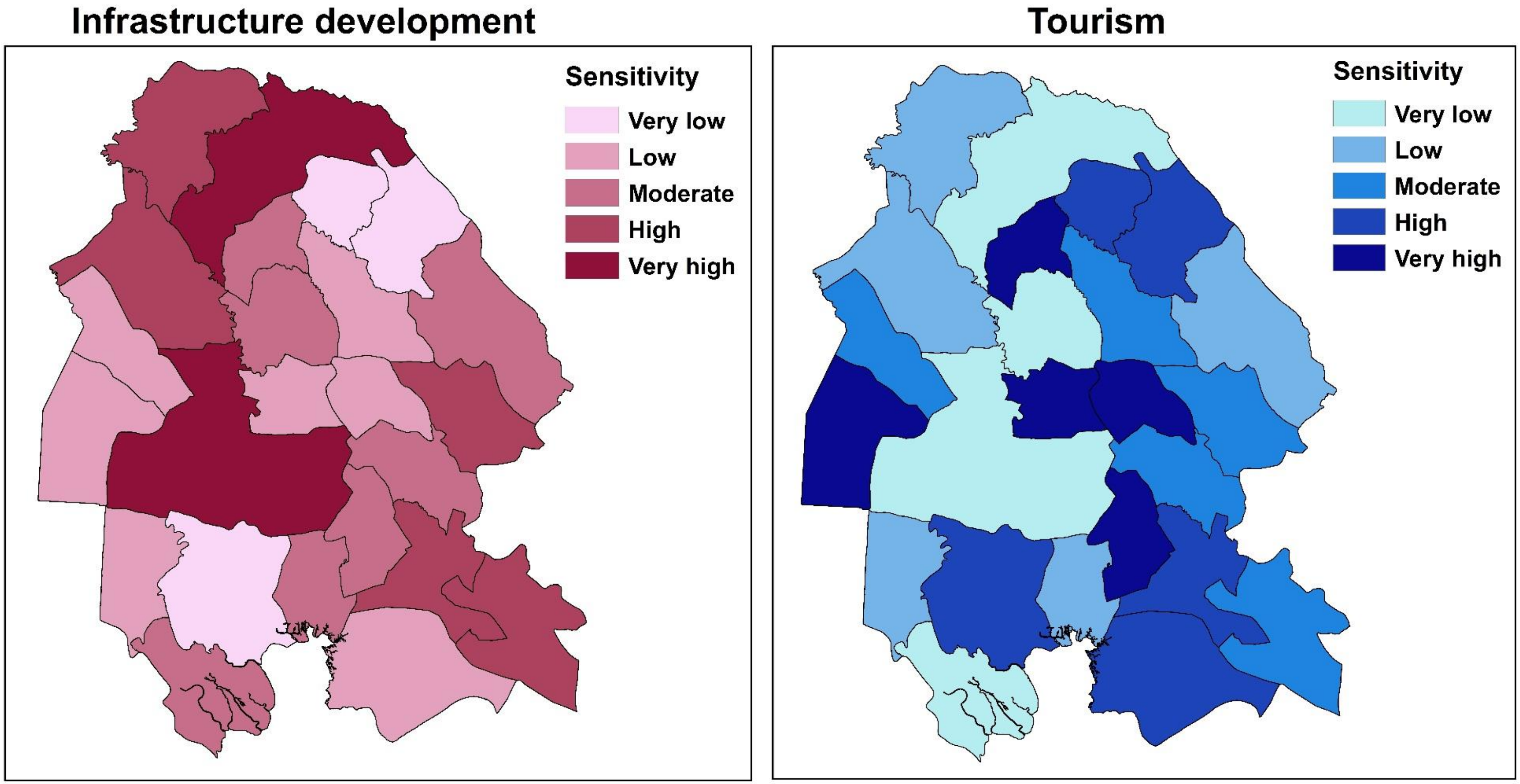


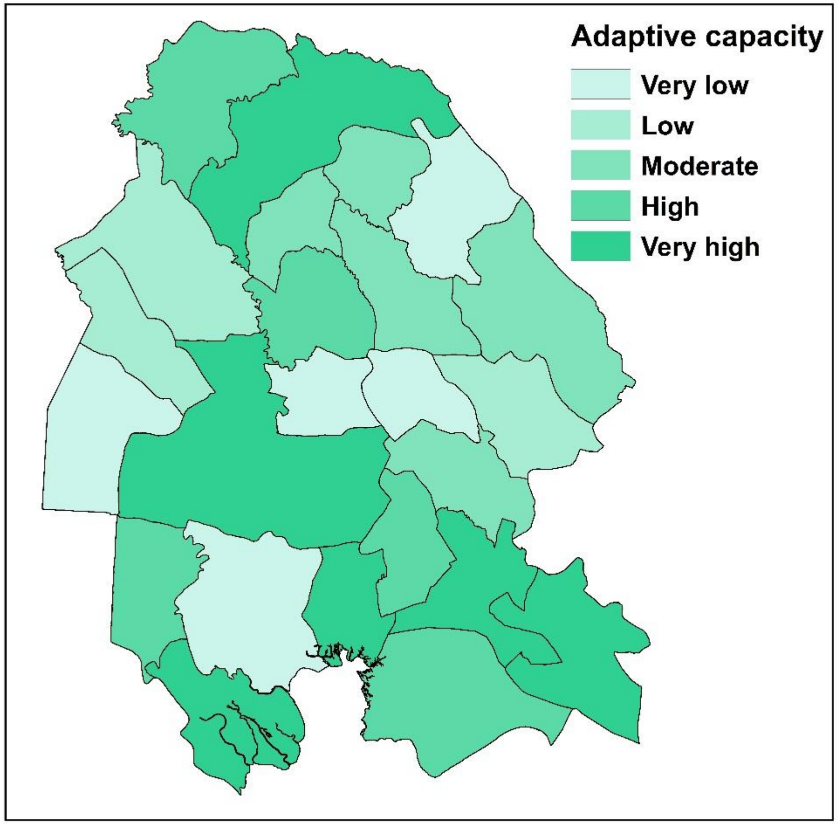



# SDS Vulnerability Mapping

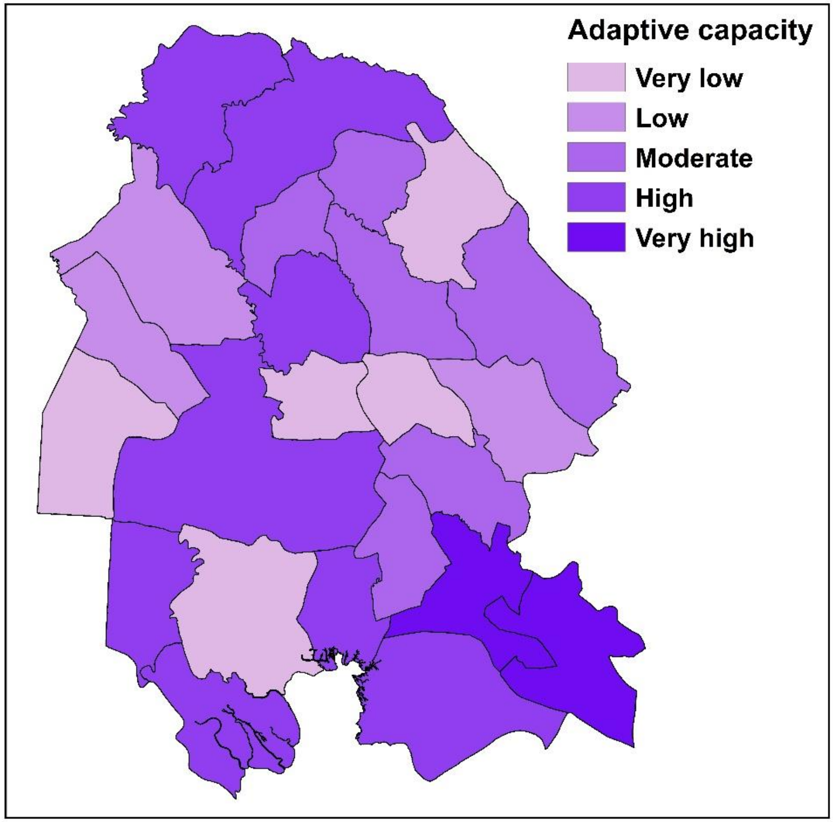


# SDS Vulnerability Mapping

Human Development Index




Welfare and income



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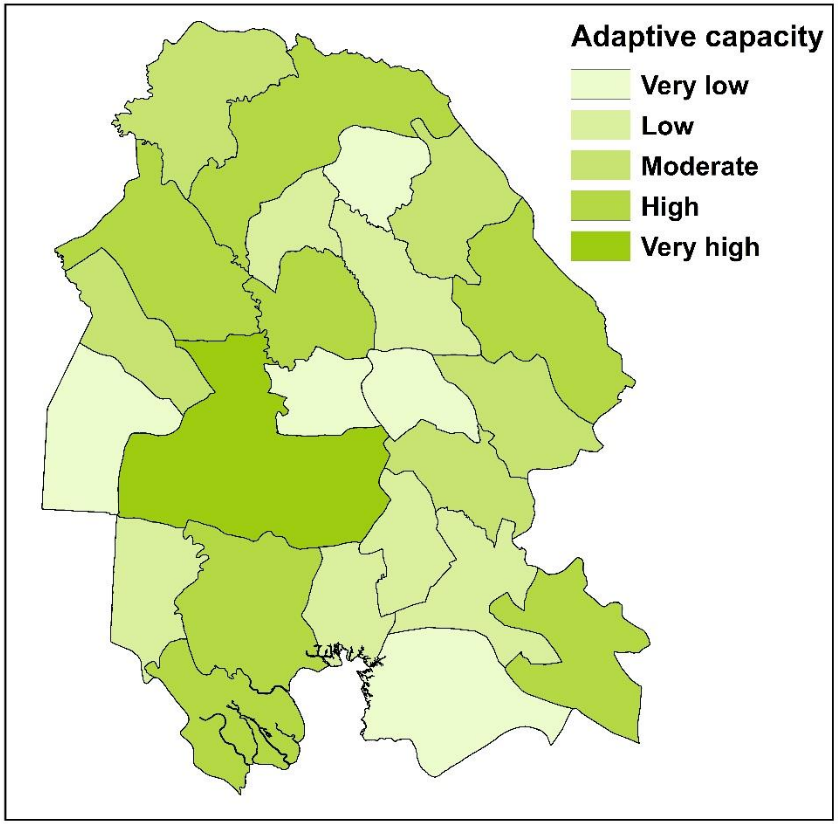
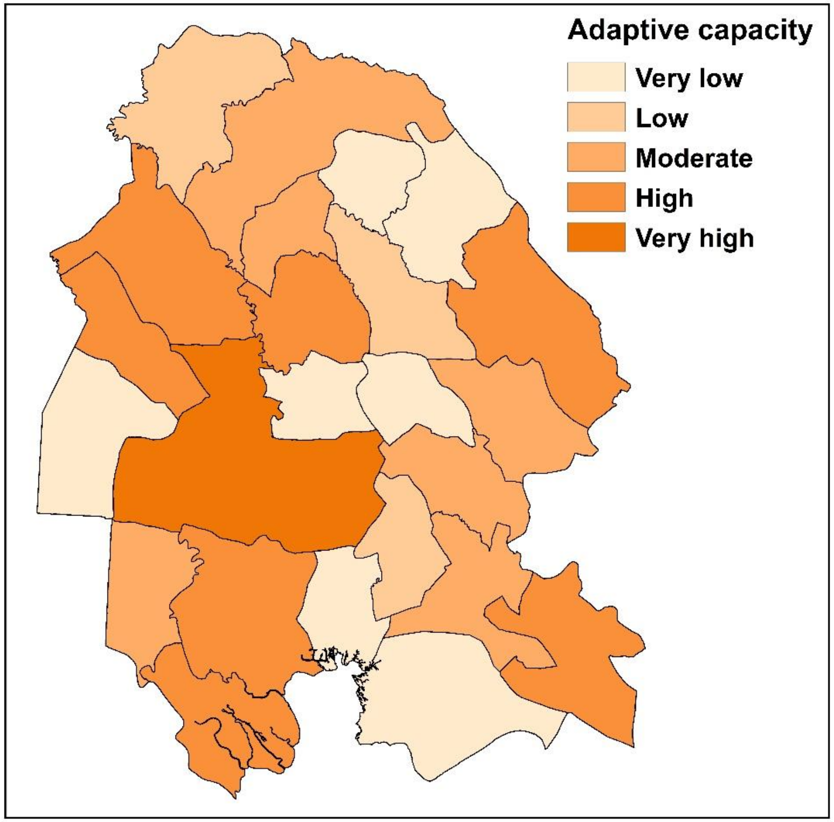
# SDS Vulnerability Mapping

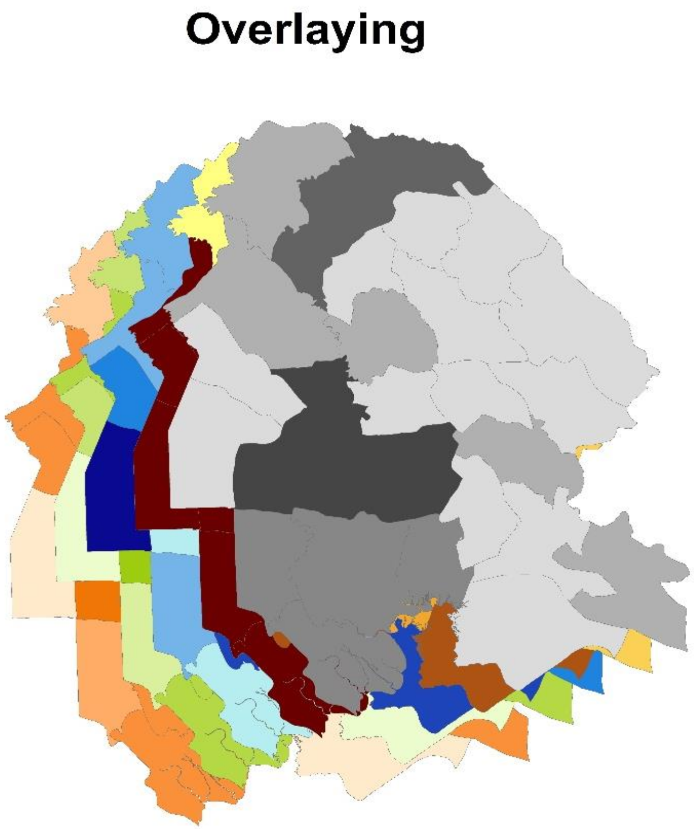
Medical

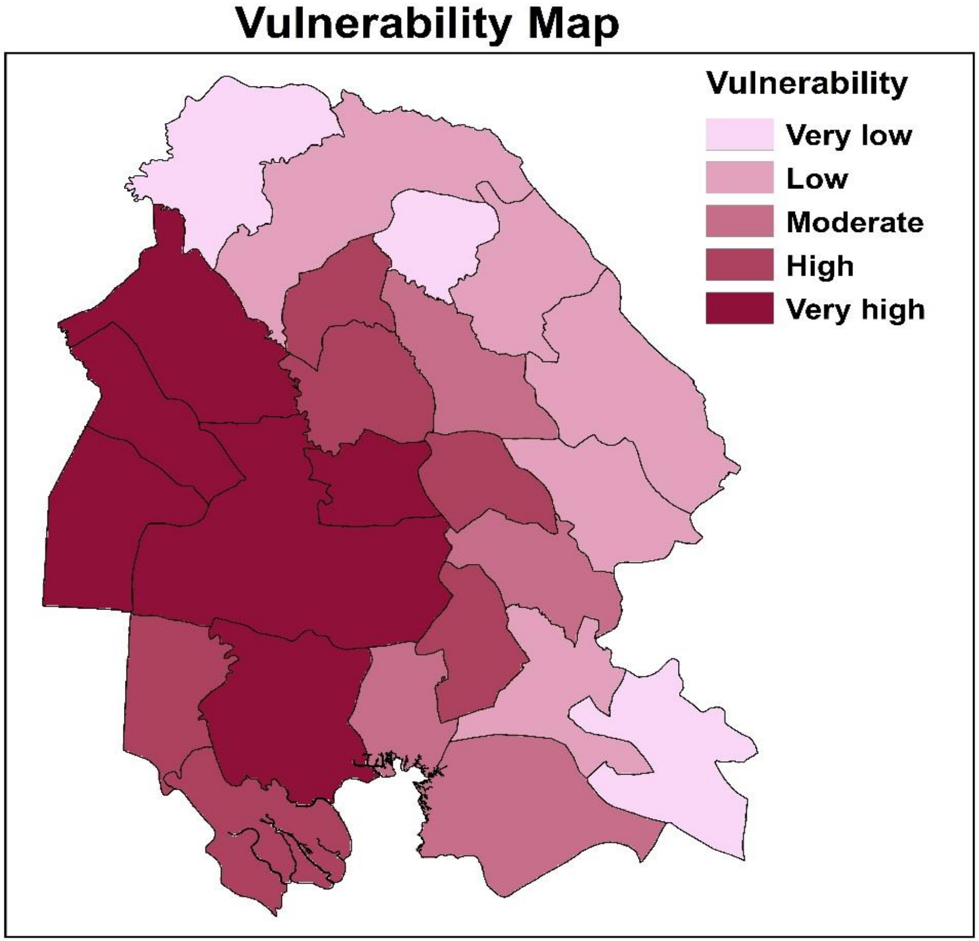



Transport and communications



# SDS Vulnerability Mapping



# SDS Current Projects

## SDS Networking and Geoportal

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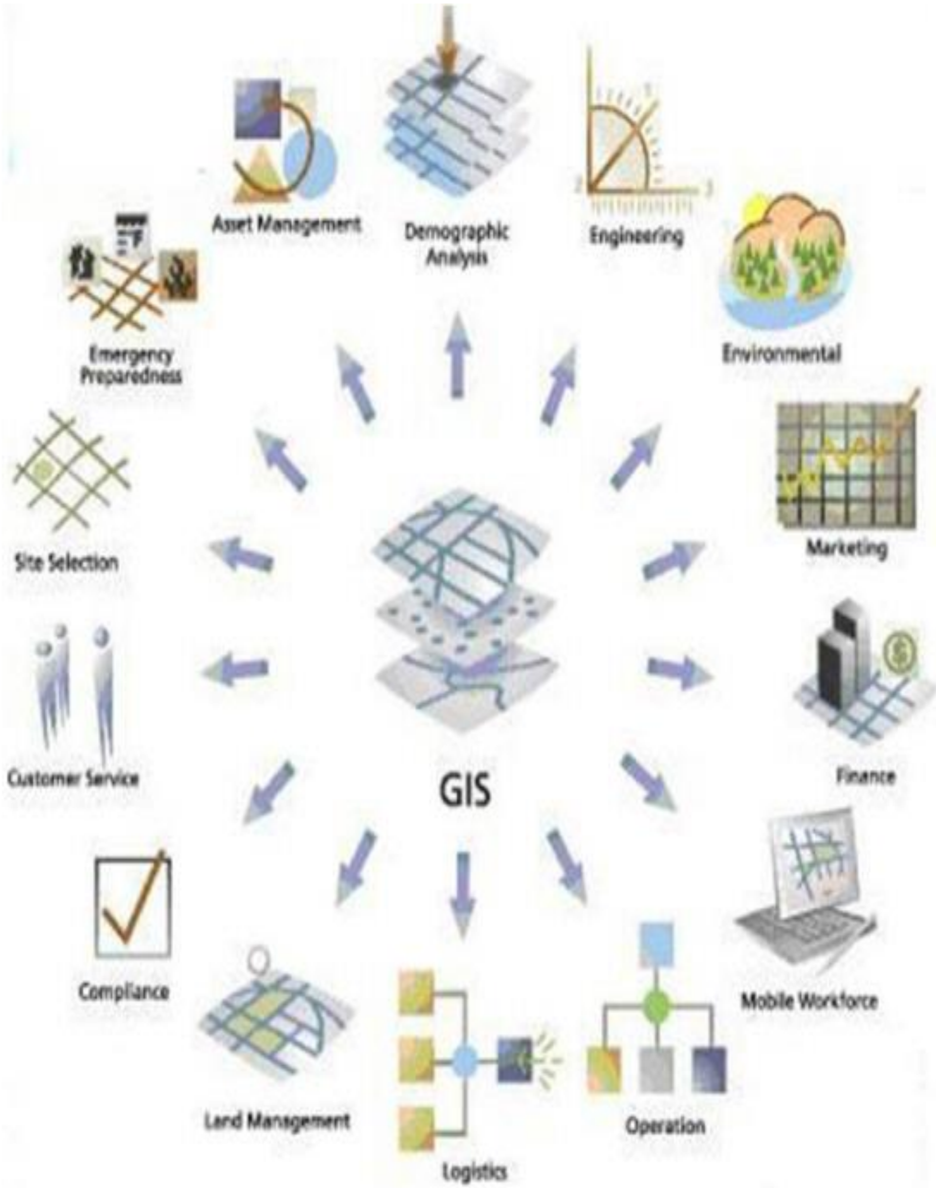
# SDS Networking and Geoportal



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# DusNIFF:

# Dust Storm Network-based Integrated system of Forecast and Forewarning

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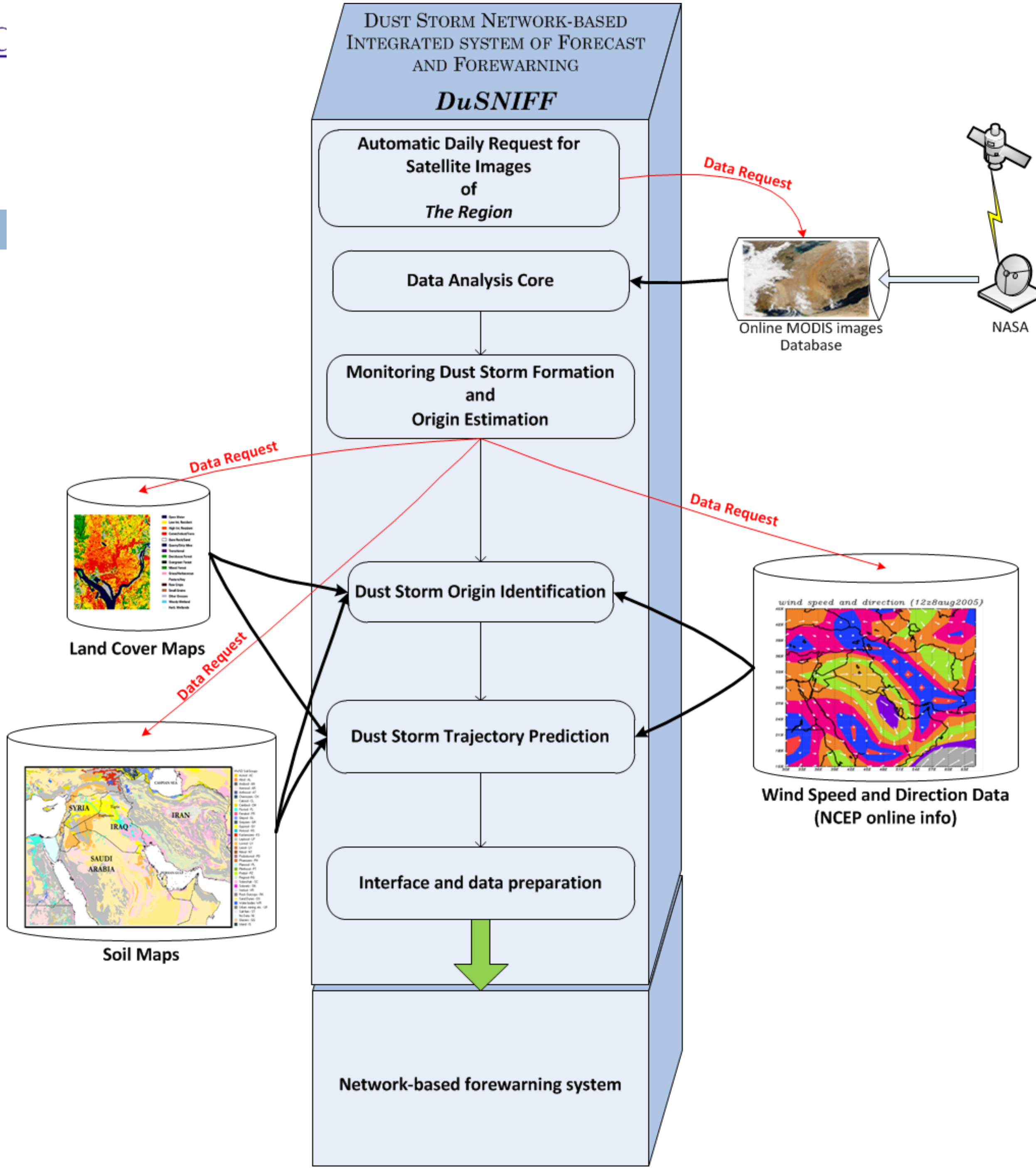

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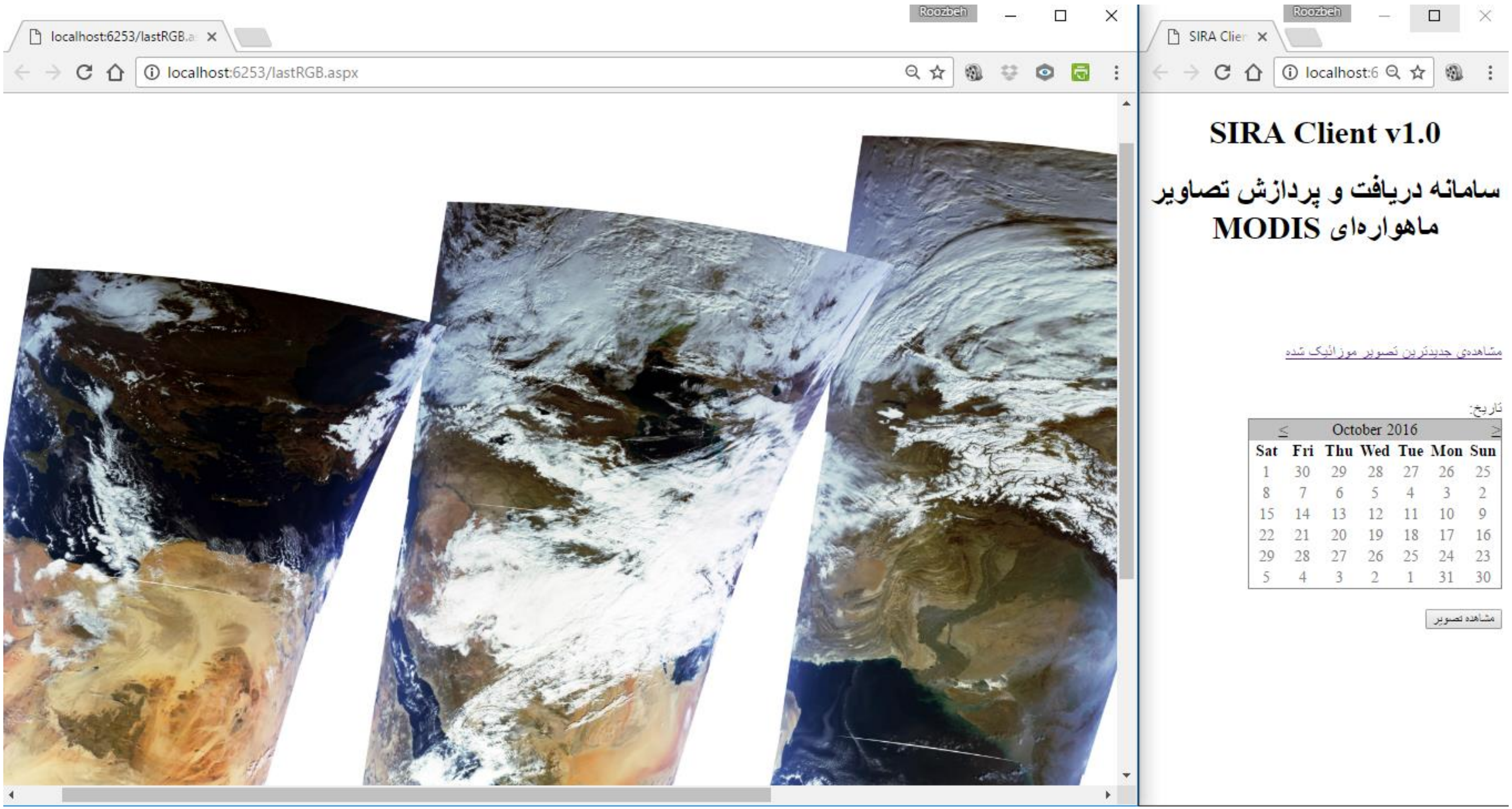
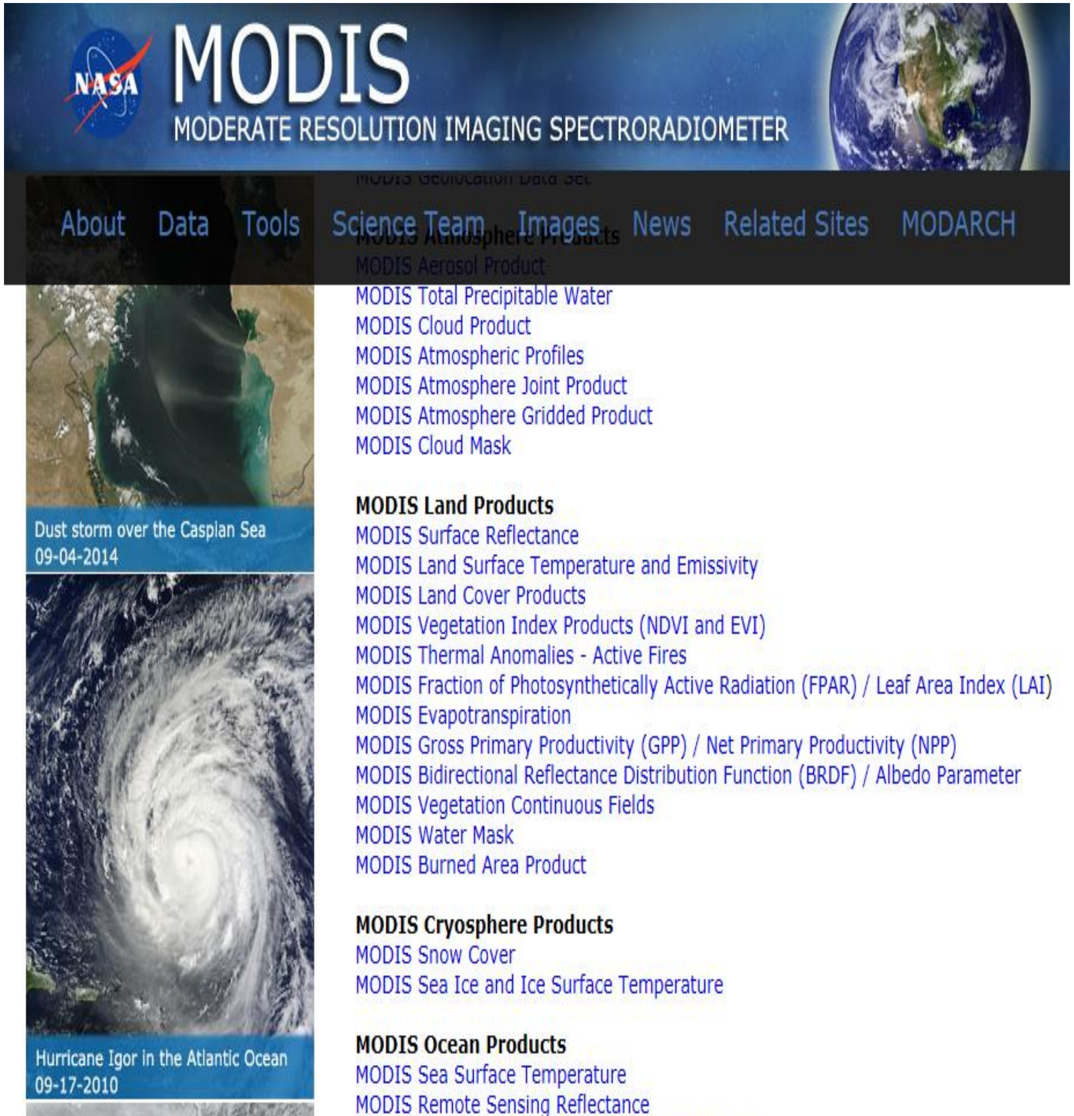
# Satellite Image Receive and Analysis (SIRA)



# Satellite Image Receive and Analysis (SIRA)



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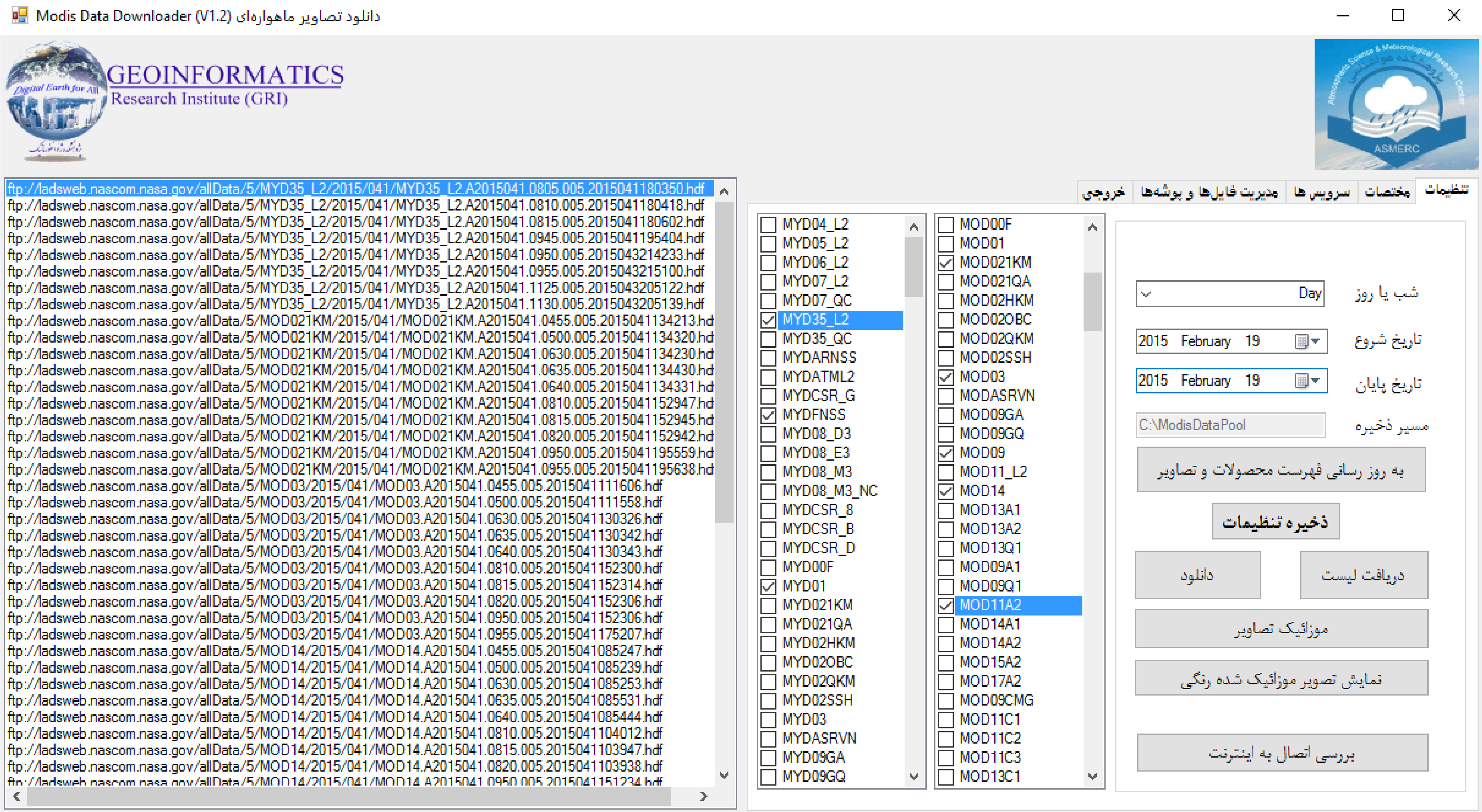
# Satellite Image Receive and Analysis (SIRA)



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# فاعتبروا یا اولی الابصار

# Action or No Action