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Contingency Planning for the Reduction and Management of Dust Disaster Risks

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مرکز پژوهش های توسعه و آینده نگری

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Outline:

I. **Dust Disasters**

II. **Dust Sources Modeling and Mapping**

III. **Dust Impacts Analysis**

IV. **Dust Disaster Risk Reduction and Contingency Planning**

Dust Disasters

Dust Storm / Sand and Dust Storm

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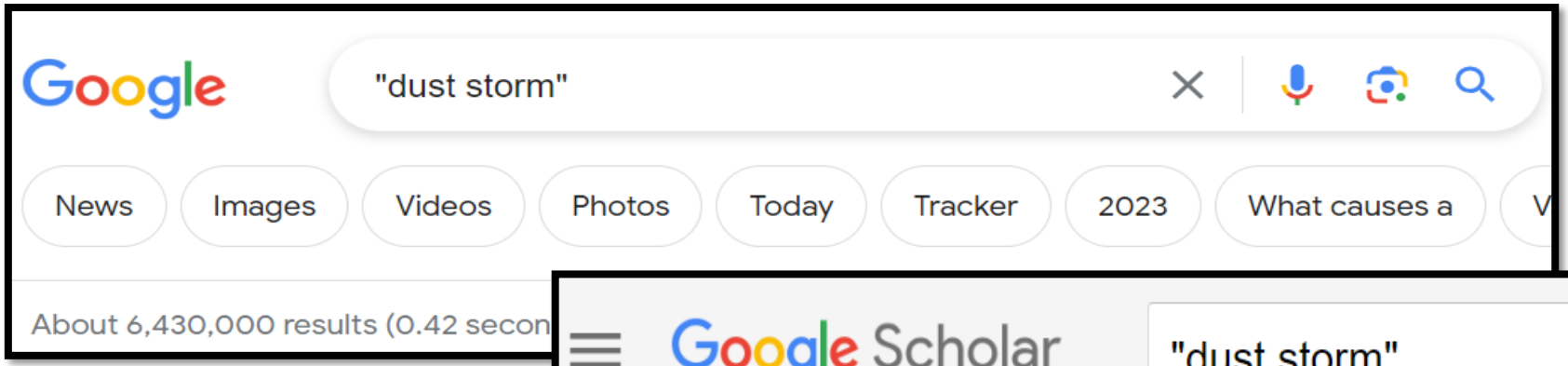

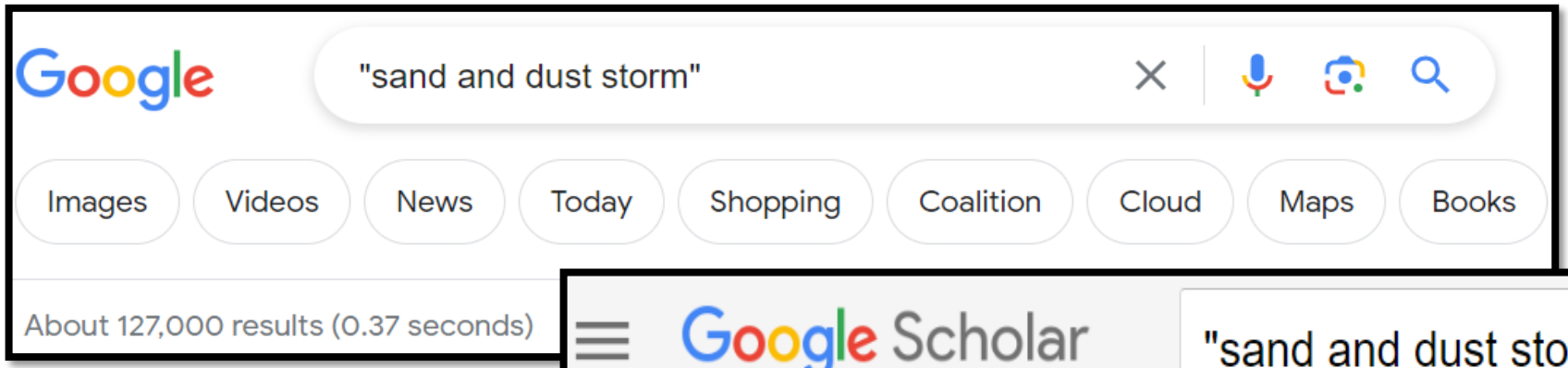

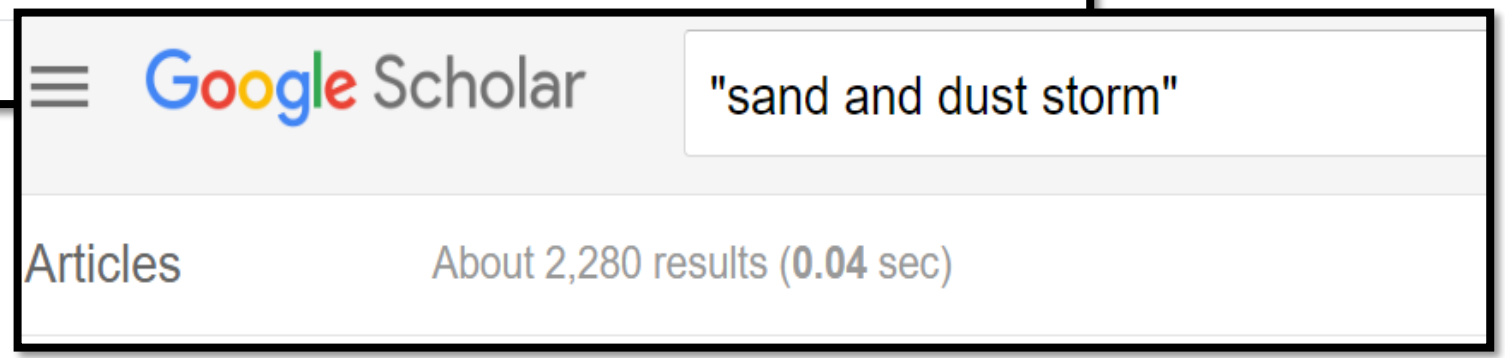

Top 10 Global Challenges in 21 Century

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1. ***Climate change and environmental degradation***
2. Economic inequality and ***poverty***
3. Global terrorism and political instability
4. Nuclear weapons proliferation and disarmament
5. Cybersecurity threats and information privacy
6. Pandemics and ***global health crises***
7. ***Mass migration and refugee crises***
8. ***Geopolitical tensions and regional conflicts***
9. Energy security and resource depletion
10. Access to education, technology, and infrastructure

Dust Storms are Global Disasters?

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Incredible Photos of Massive Dust Storm Taken From Fleeing News Helicopter

By Jessica Stewart on August 20, 2018

AZERNEWS

Tuesday November 12 2019

LATEST | NATION | WORLD | BUSINESS | OIL & GAS | ARMENIAN AGGRESSION | NAGORNO-KARABAKH

LIFESTYLE | EVENTS | HEALTHCARE | CULTURE | SPORTS | TRAVEL

Tehran unable to tackle dust storms

1 June 2015 15:20 (UTC+04:00) 2 388

NAWAIWAQT GROUP | News Paper & TV Channel | Magazines

THE NATION

E-PAPER | TODAY'S PAPER | EDITOR'S PICKS | OPINION | NEWS | MULTIMEDIA | BLOGS

LATEST pitals in Sindh 9:19 PM | November 11, 2019 11 million tree saplings simultaneously planted in

Dust storm shrouds Tokyo in haze

Share:

The Journey of Dust is Transcontinental

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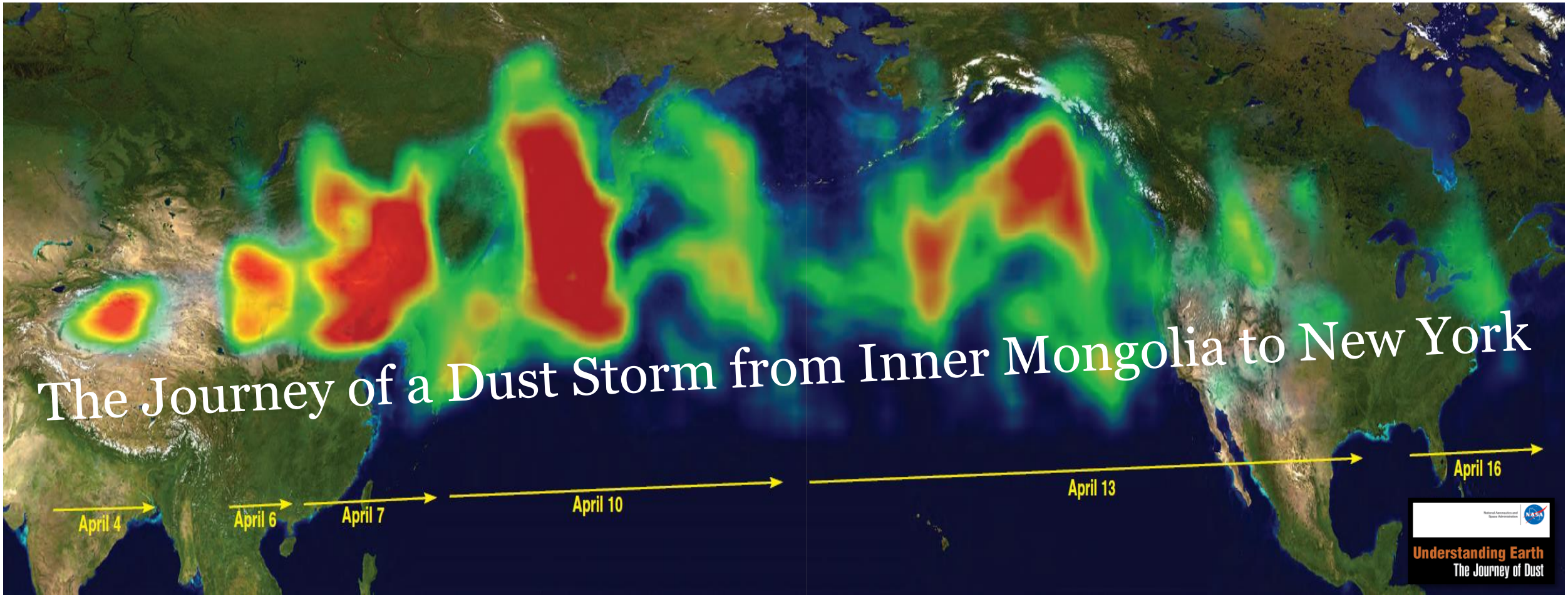

Land Degradation and Dust Disasters in 21 Century

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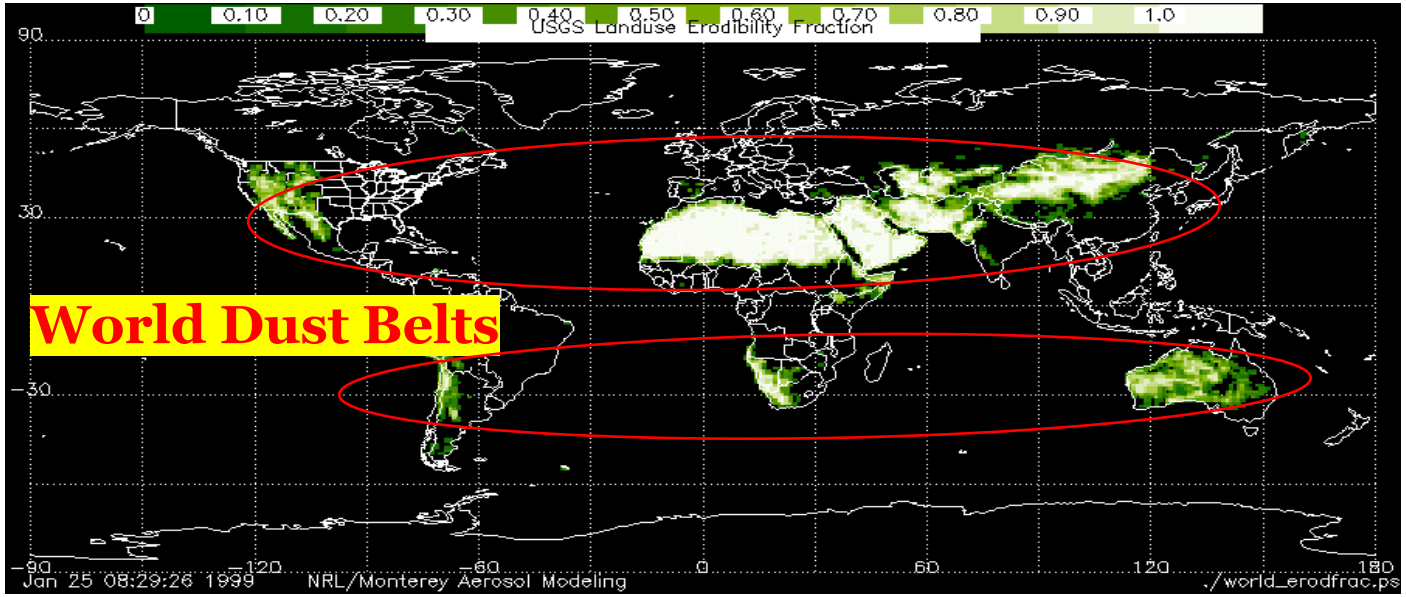
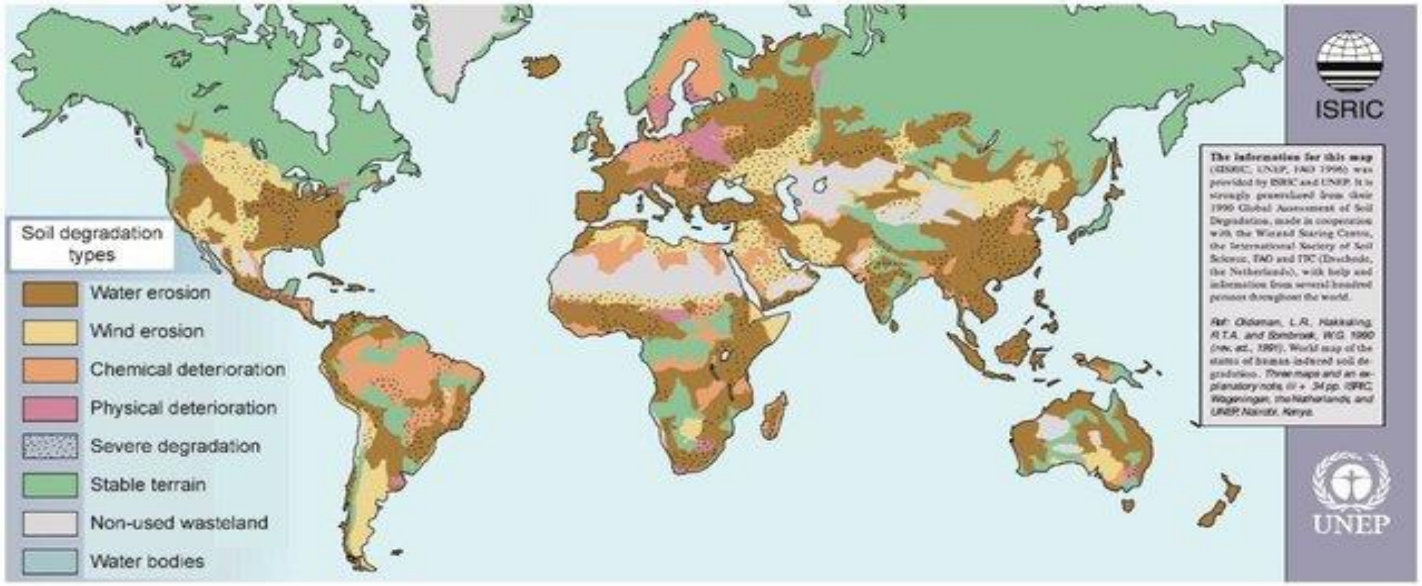
USA,1930

China, 1970

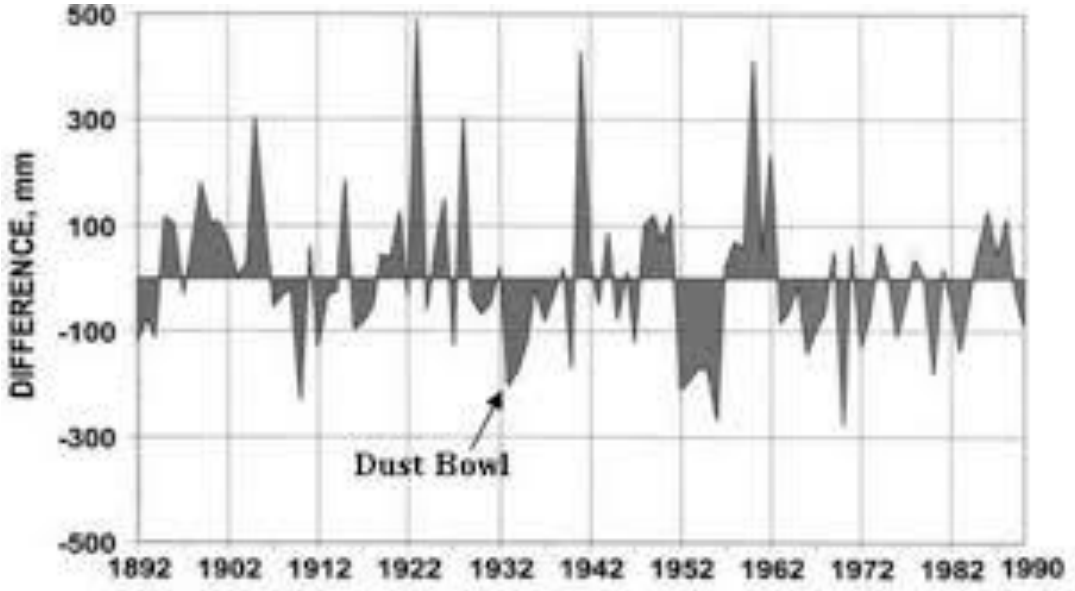
Central Asia, 1990

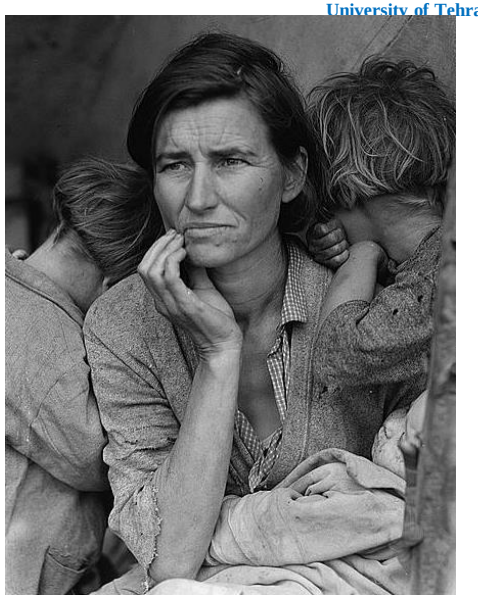
West Asia, 2000





USA, 1930



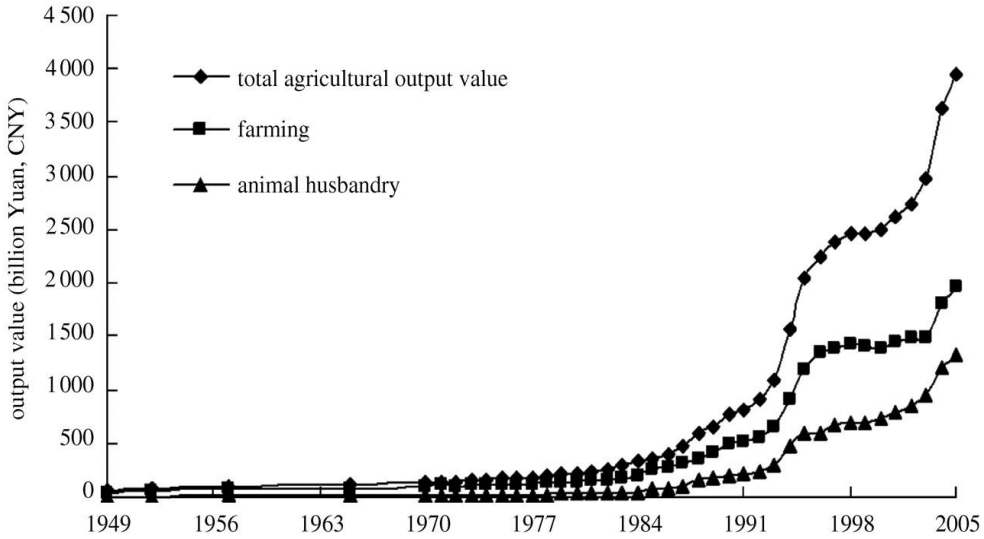


World War I
Jul 28, 1914 – Nov 11, 1918

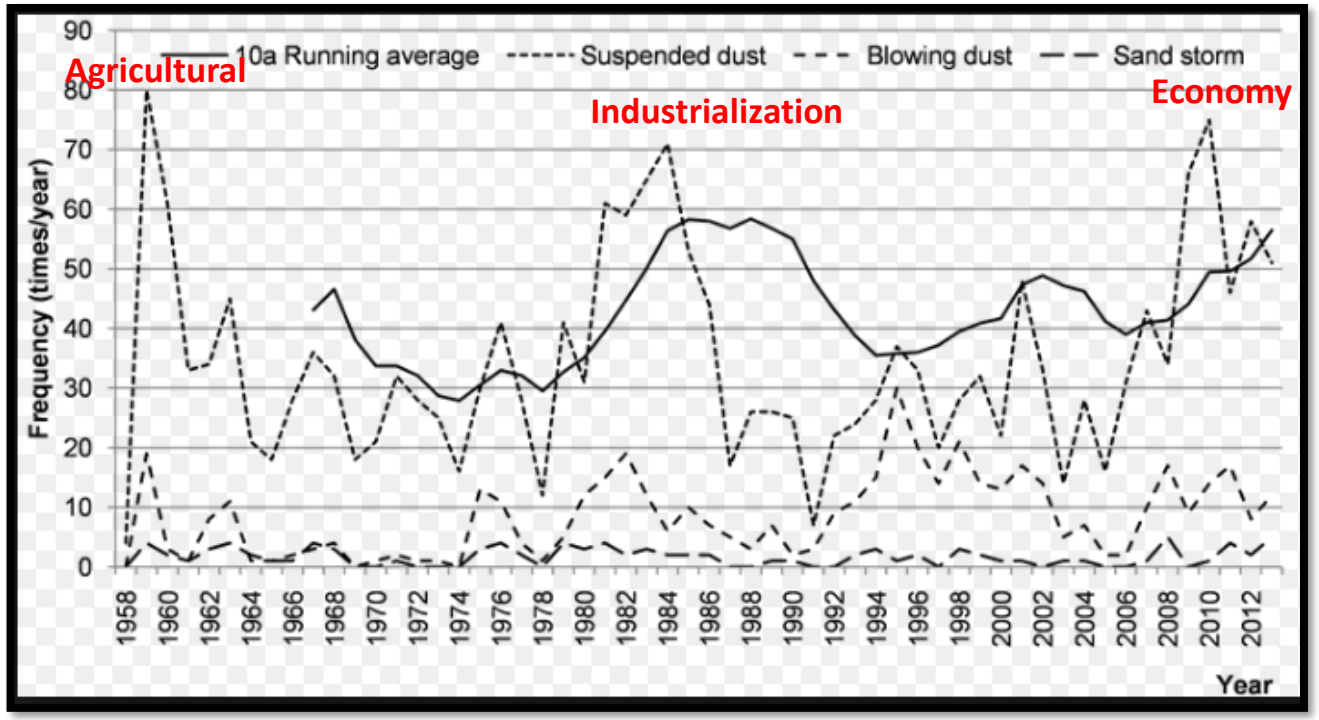
World War II
Sep 1, 1939 – Sep 2, 1945

While it is difficult to determine exactly how many people died as a direct result of the Dust Bowl, it is estimated that hundreds of thousands of people were affected in some way by the environmental crisis.

China, 1970



Great Leap Forward, launched by Mao Zedong in China (1958 and 1962), However, these policies were poorly planned and executed, resulting in widespread famine, environmental degradation, and economic collapse and caused the death of between 18 and 45 million people.



Central Asia, 1990

1.Climate change

2.Deforestation and land conversion

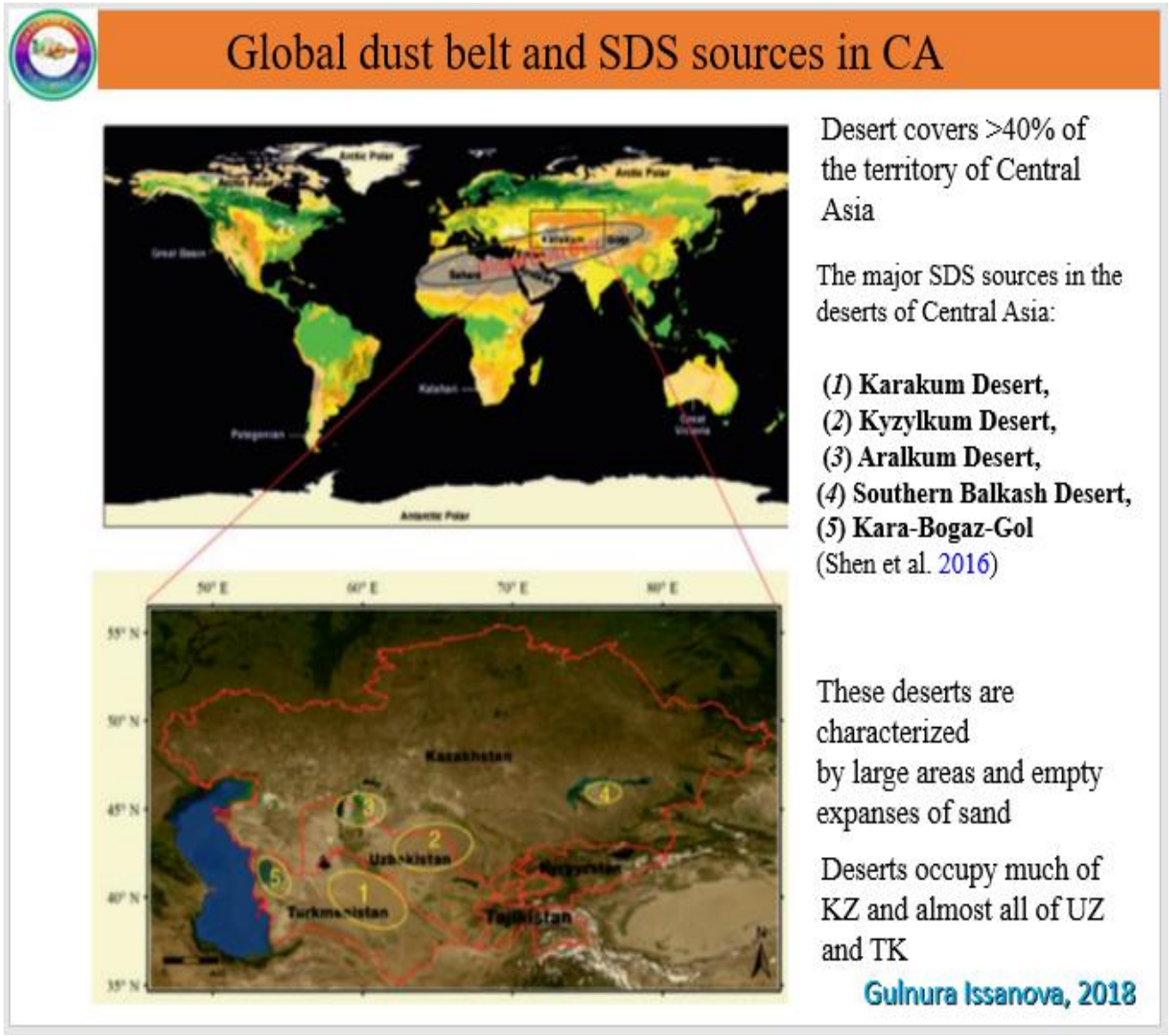
3.Overgrazing

4.Unsustainable agricultural practices

5.Mining activities

6.Development (e.g., infrastructure projects)

7.Political and socioeconomic factors



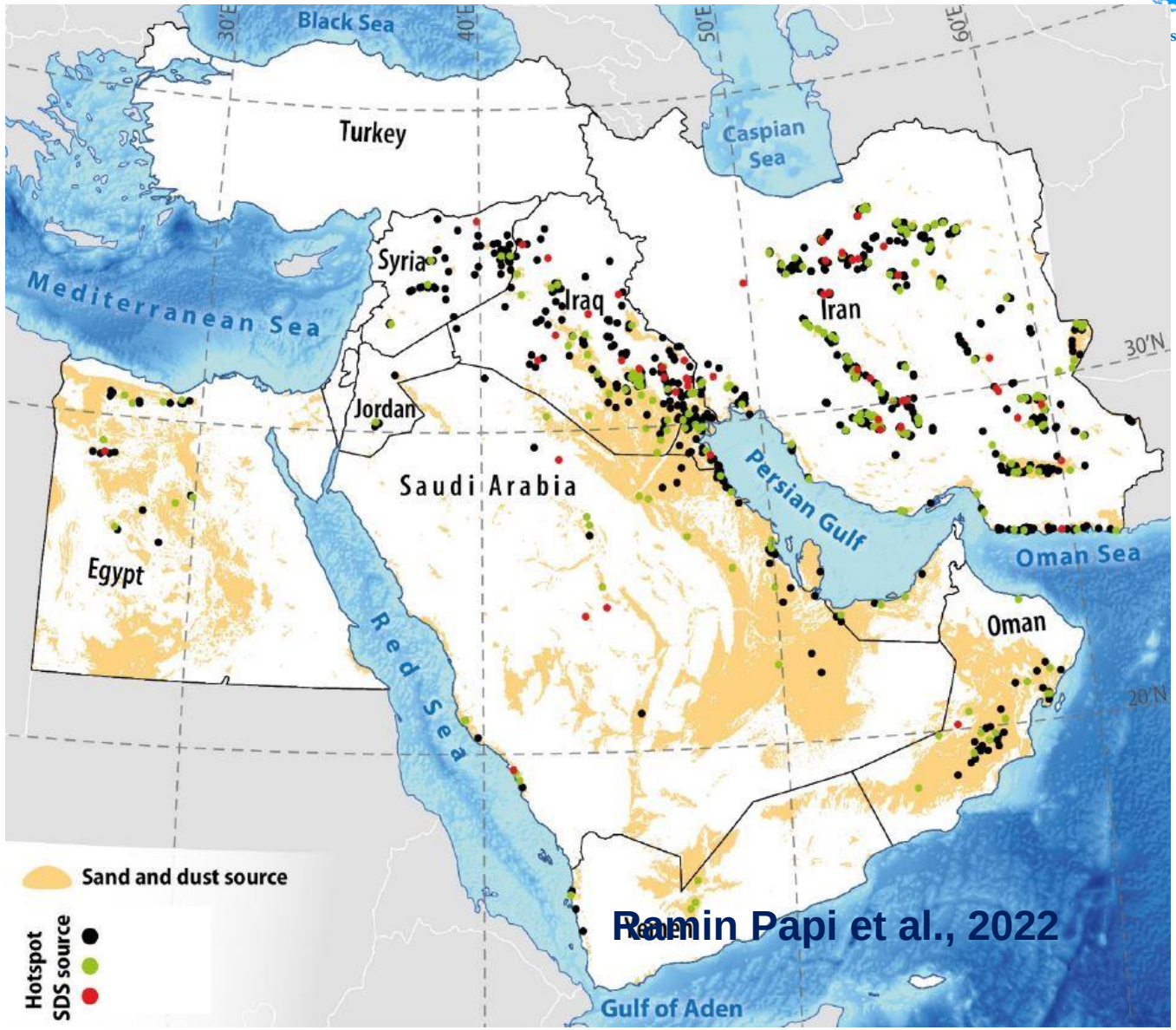
West Asia Dusts, 2000

Natural Drivers:

- Climate change,
- Drought,
- Global warming,
- Desertification.

Anthropogenic Drivers:

- Population fast growth,
- Dam construction,
- Human interventions:
  - Deviations in rivers,
  - Traditional agriculture,
- Land cover changes, and
- Land degradation.



Global Assessment of Sand and Dust Storms

UNEP WMO UNCCD

Sand and Dust Storms Compendium

Information and Guidance on Assessing and Addressing the Risks

United Nations Convention to Combat Desertification

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Dust Sources:

1. Susceptibility Mapping
2. Dust Hotspot Sources Identification
3. Spatial-Temporal Modeling of Dust Drivers

Catena 209 (2022) 105795

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Dust source susceptibility mapping in Tigris and Euphrates basin using remotely sensed imagery

Ali Darvishi Boloorani [a,b,*], Najmeh Neysani Samany [b,*], Ramin Papi [b], Masoud Soleimani [b]

[a] Key Laboratory of Digital Land and Resources, East China University of Technology, Nanchang, Jiangxi, PR China
[b] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran

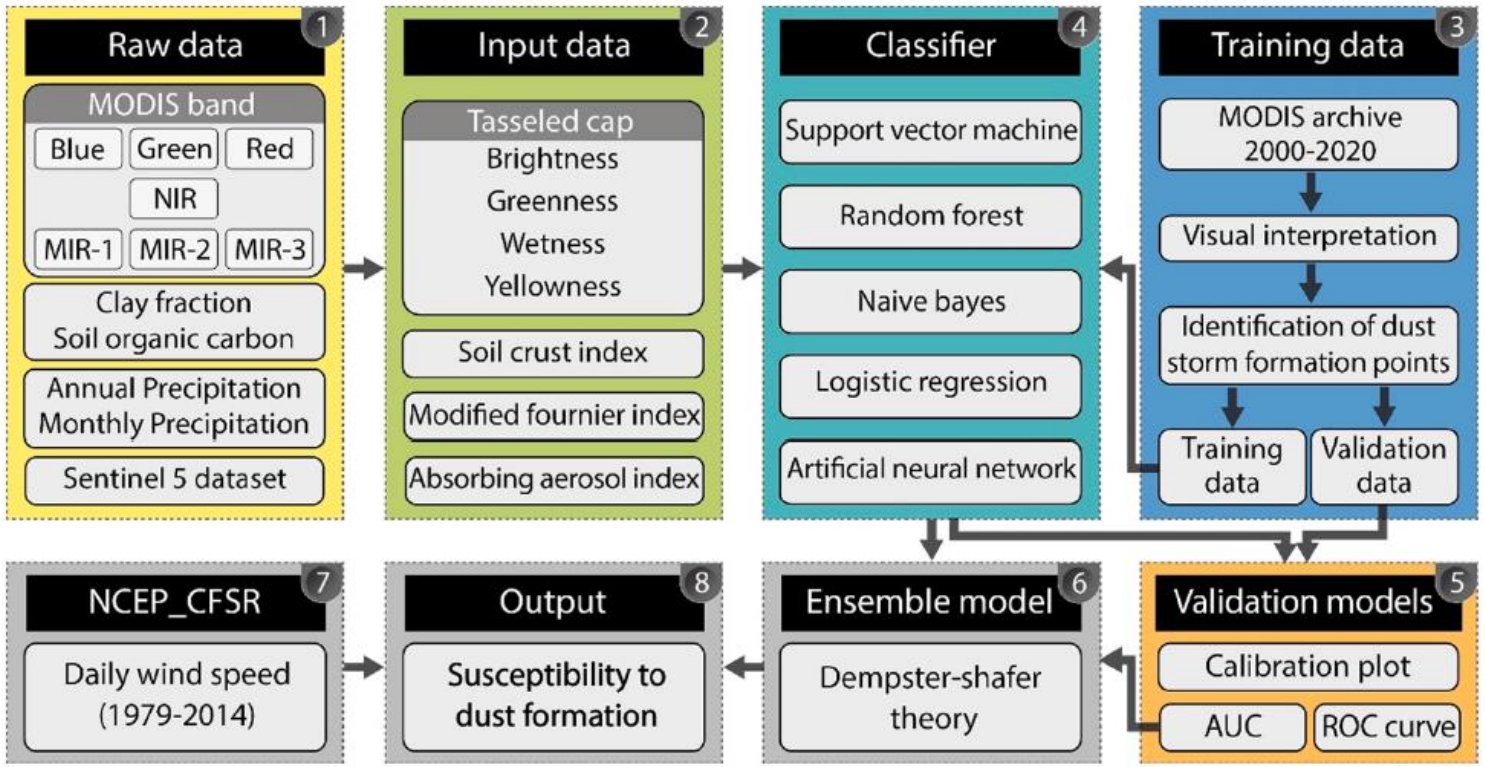
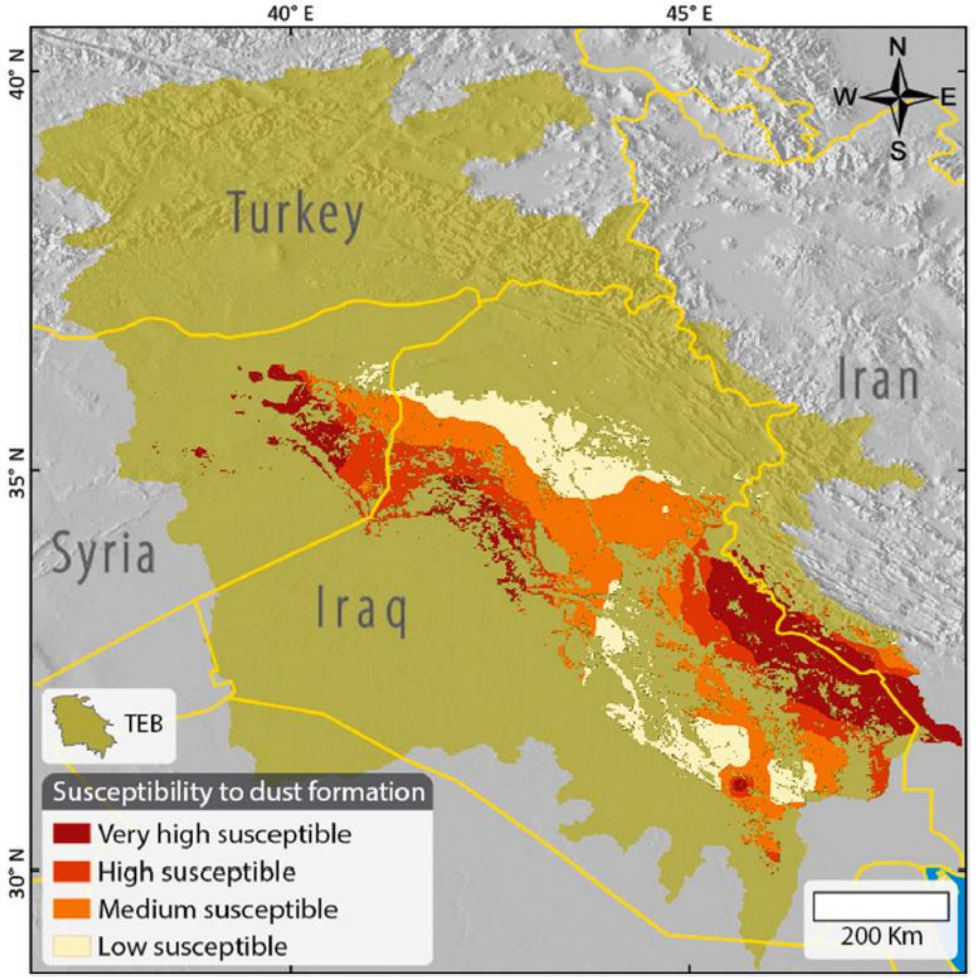


Fig. 2. Stepwise methodology of dust source susceptibility mapping.



Remote Sensing Applications: Society and Environment 29 (2023) 100888

Contents lists available at ScienceDirect

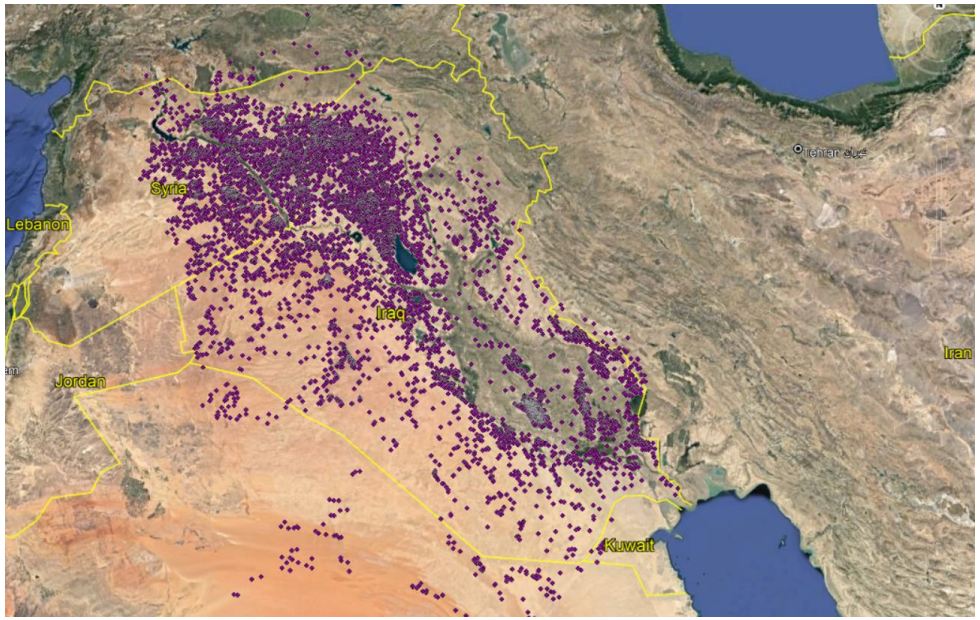
Remote Sensing Applications: Society and Environment

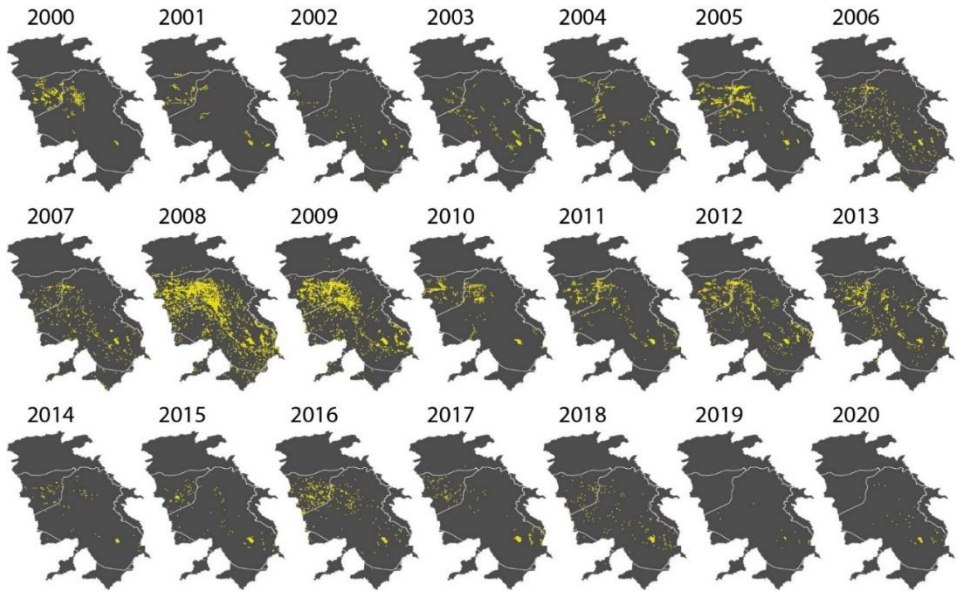
journal homepage: www.elsevier.com/locate/rsase

Visual interpretation of satellite imagery for hotspot dust sources identification

Ali Darvishi Boloorani [a, *], Ramin Papi [a, b], Masoud Soleimani [a], Ali Al-Hemoud [c], Fatemeh Amiri [d], Leyla Karami [e], Najmeh Neysani Samany [a], Mohsen Bakhtiari [a], Saham Mirzaei [a]

[a] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran
[b] National Cartographic Center (NCC), Tehran, Iran
[c] Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, Kuwait
[d] Department of Remote Sensing and GIS, Faculty of Humanities, Tarbiat Modares University, Tehran, Iran
[e] Department of Remote Sensing and GIS, Faculty of Geographical Sciences, Kharazmi University, Tehran, Iran





RGB images (MODIS Terra + MODIS Aqua + Suomi NPP) = 30,029

Hotspots from 2000-2020 = 10,422

- **Iraq : 6927**
- **Syria : 3245**
- **Saudi Arabia : 166**
- **Turkey : 43**
- **Iran : 33**
- **Kuwait: 8**

Paper: https://lnkd.in/e4rS3p2p
Geodatabase: https://lnkd.in/eQfyG7-4
Movie Abstract: https://lnkd.in/eCJgKACZ

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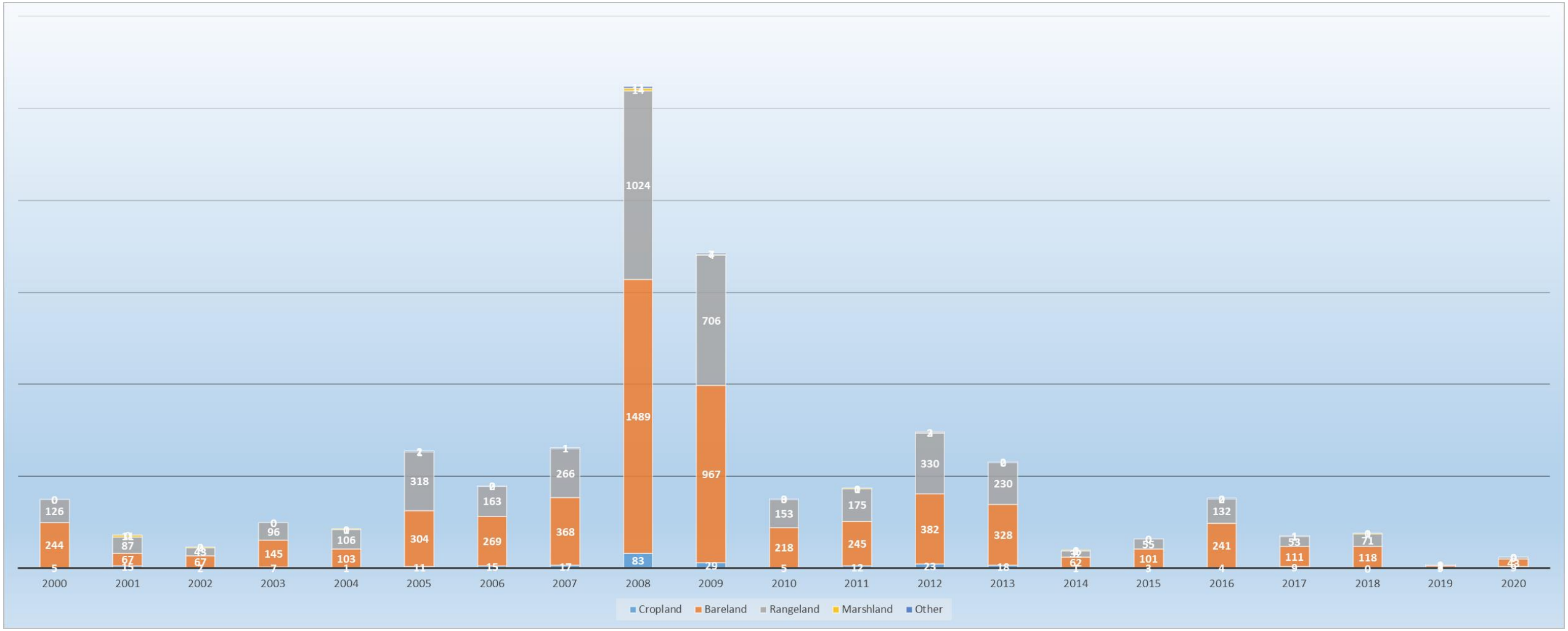
Number of dust events per class per year in TEB (2000-2020)



Atmospheric Environment 224 (2020) 117299

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: http://www.elsevier.com/locate/atmosenv

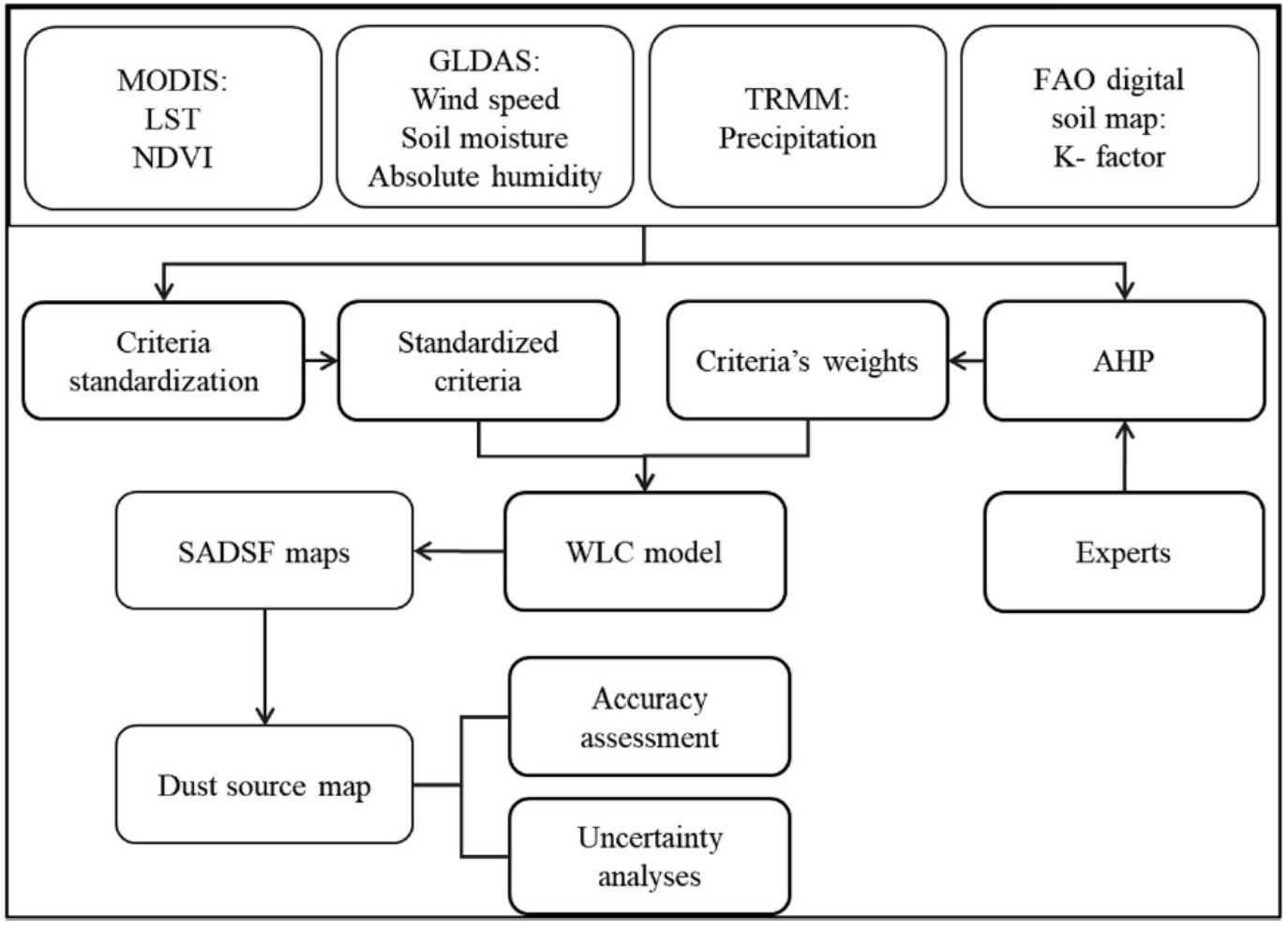
Identification of dust sources using long term satellite and climatic data: A case study of Tigris and Euphrates basin

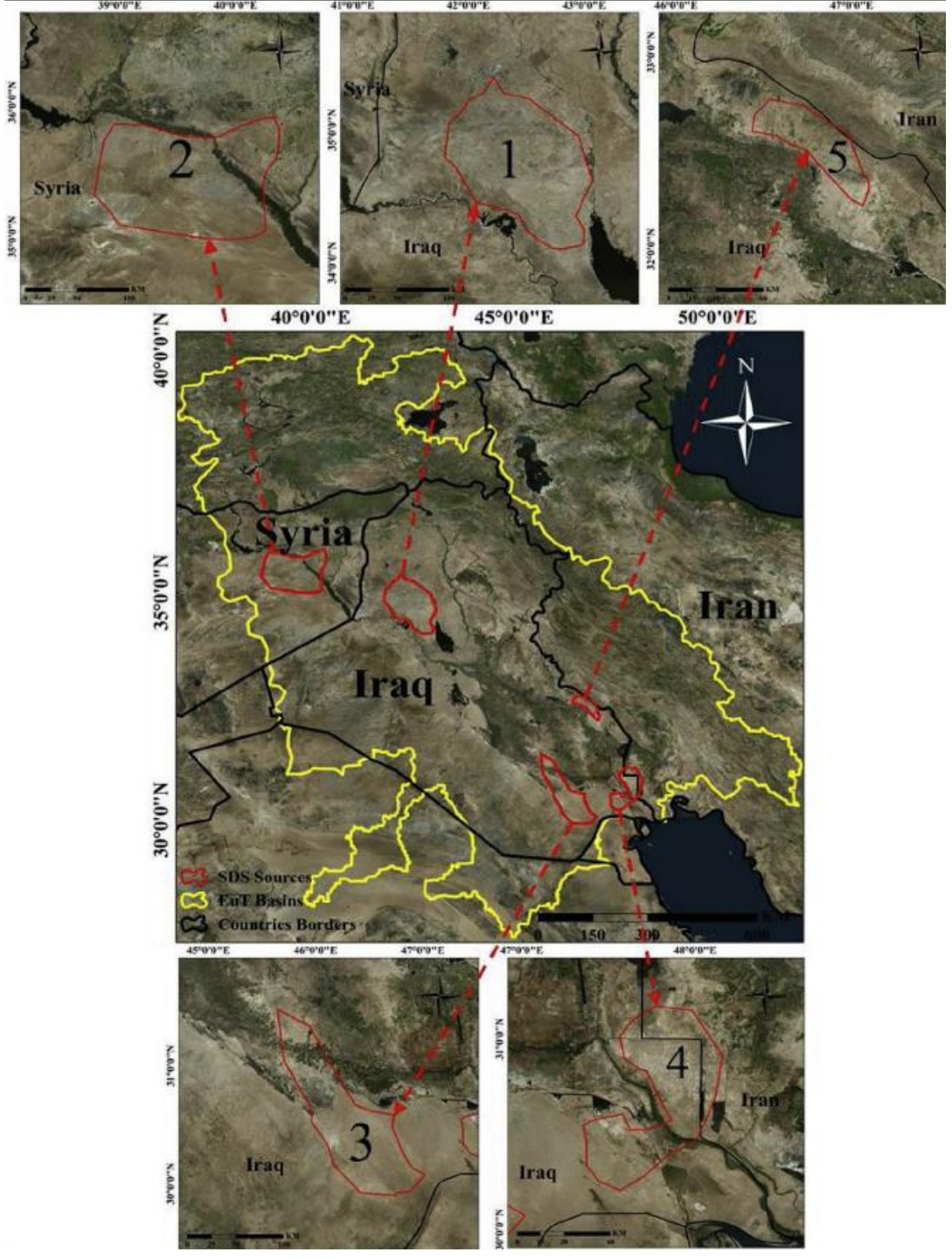
Ali Darvishi Boloorani [a,b,*], Yasin Kazemi [b], Amin Sadeghi [c], Saman Nadizadeh Shorabeh [b], Meysam Argany [b]

[a] Key Laboratory of Digital Land and Resources, East China University of Technology, Nanchang, Jiangxi, PR China
[b] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran
[c] Department of Remote Sensing and GIS, Faculty of Natural Resources and Environment, Science and Research Branch, Islamic Azad University, Tehran, Iran

HIGHLIGHTS

- A temporal Remote sensing and Geoinformatics-based dust storms sources identification is developed.
- Dust sources map of the Tigris and Euphrates basin is created.
- Significant difference in activities of dust sources in the this basin was modeled.


MODIS:
LST
NDVI
GLDAS:
Wind speed
Soil moisture
Absolute humidity
TRMM:
Precipitation
FAO digital
soil map:
K- factor
Criteria
standardization
Standardized
criteria
Criteria's weights
AHP
SADSF maps
WLC model
Experts
Dust source map
Accuracy
assessment
Uncertainty
analyses


Syria
Iraq
Iran
1
2
3
4
5
40°0'0"E
45°0'0"E
50°0'0"E
35°0'0"N
30°0'0"N
N
SDS Sources
EuT Basins
Countries Borders
0
150
300

Remote Sensing Applications: Society and Environment 32 (2023) 101027

Contents lists available at ScienceDirect

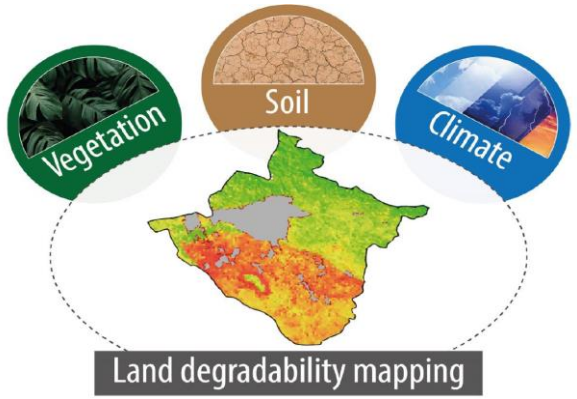
Remote Sensing Applications: Society and Environment

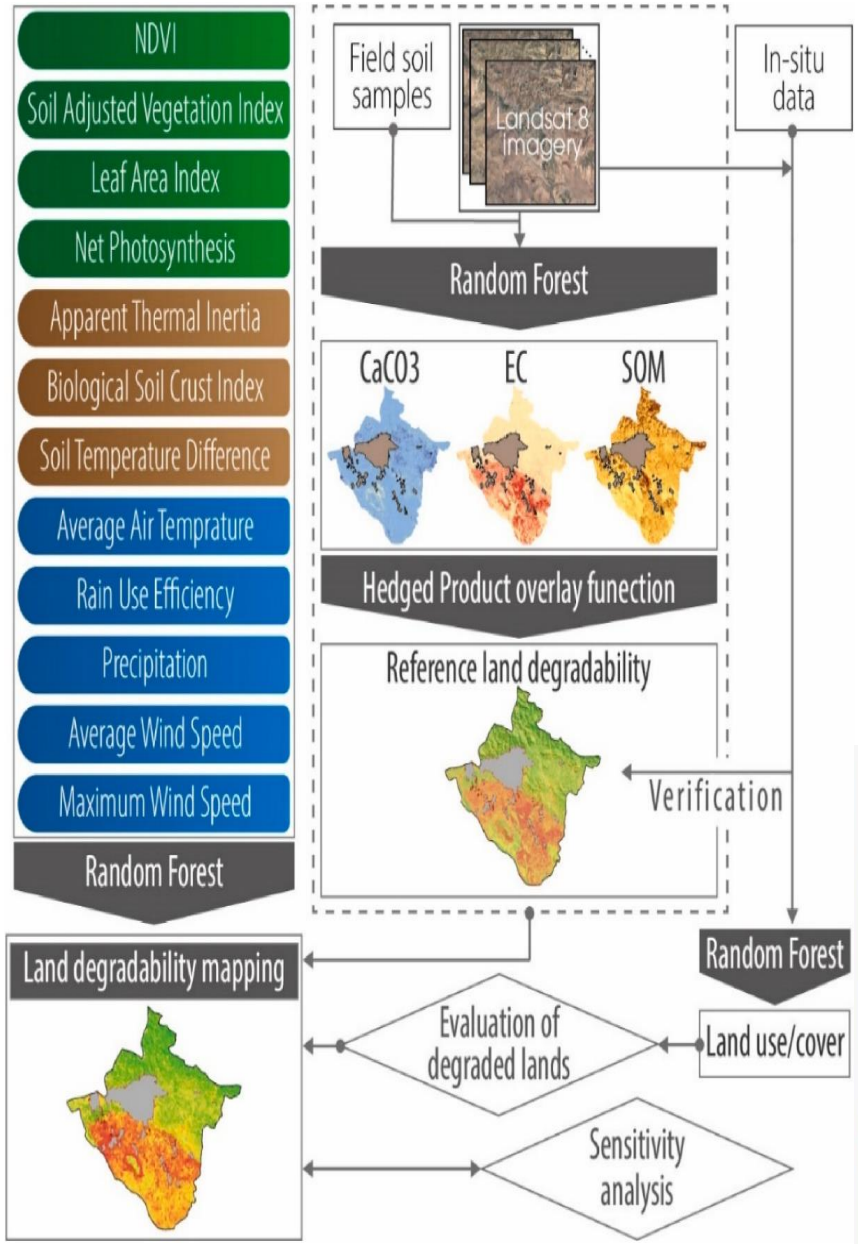
journal homepage: www.elsevier.com/locate/rsase

Land degradability mapping using remote sensing data and soil chemical properties

Ali Darvishi Boloorani [a, *], Mohsen Bakhtiari [a], Najmeh Neysani Samany [a], Ramin Papi [a, b], Masoud Soleimani [a], Saham Mirzaei [c], Hossein Ali Bahrami [d]

[a] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran
[b] Department of GIS and SDI, National Cartographic Center (NCC), Tehran, Iran
[c] Institute of Methodologies for Environmental Analysis, Italian National Research Council, 85050, Potenza, Italy
[d] Department of Soil Sciences, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran





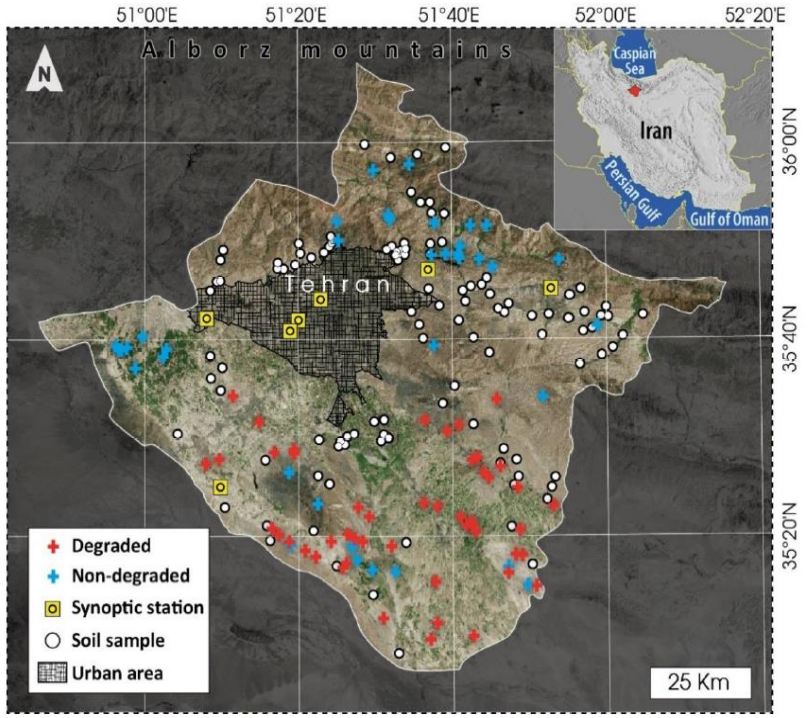
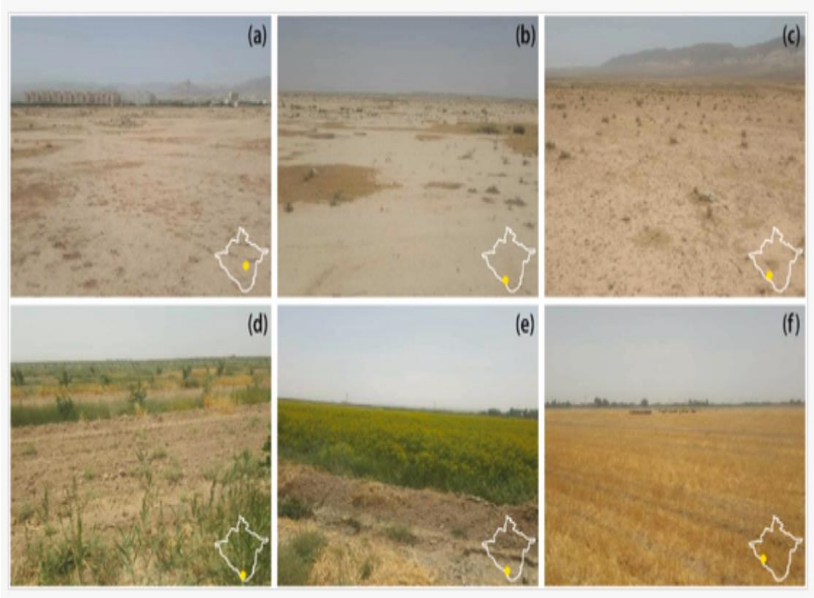
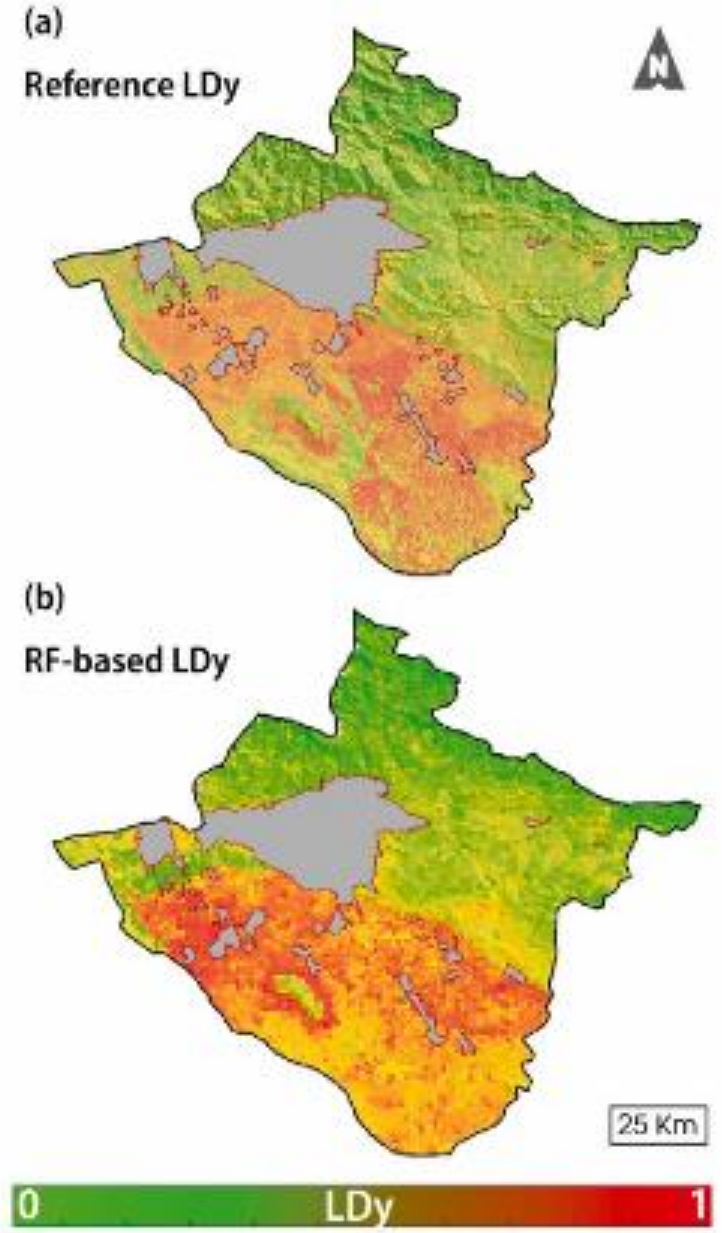


Fig. 1. Geographical location of Jajrud and Karaj basin located on the southern Alborz in the north of Iran and spatial distribution of soil samples, synoptic stations, and field observation sites (degraded and non-degraded lands).





Journal of Arid Environments 190 (2021) 104507

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

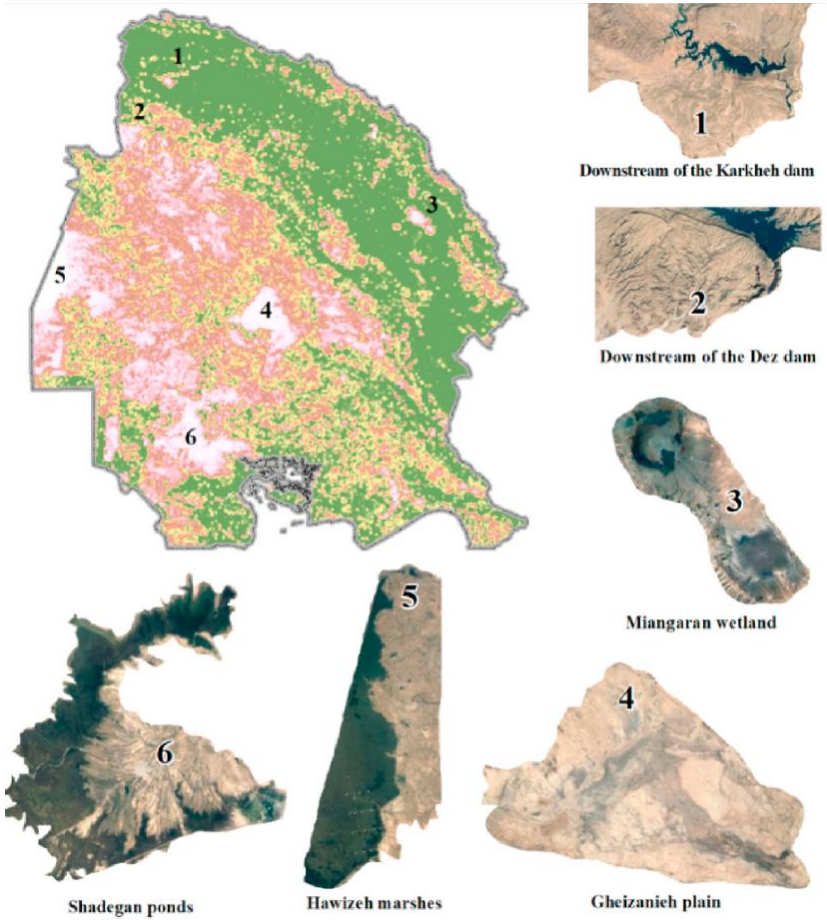
Land degradation modeling of dust storm sources using MODIS and meteorological time series data

Mohsen Bakhtiari [a], Ali Darvishi Boloorani [a,*], Ataollah Abdollahi Kakroodi [a], Kazem Rangzan [b], Alijafar Mousivand [c]

[a] Dept. of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Azin Alley. 50, Vesal Str, Tehran, Iran
[b] Shahid Chamran University of Ahvaz, Faculty of Earth Sciences, Department of Remote Sensing and GIS, Ahvaz, Iran
[c] Tarbiat Modares University, Department of Remote Sensing & GIS, Jalal AleAhmad, Nasr Bridge, Tehran, Iran

University of Tehran

Component	Input layer	Equation	Elements	Data source	Reference
Vegetation	Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{R_{Nir} - R_r}{R_{Nir} + R_r}$	R_{Nir} and R_r are the reflectances in the near-infrared and red bands, respectively. L is the soil brightness correction factor	MODIS products	Jensen & Lulla (1987)
	Soil Adjusted Vegetation Index (SAVI)	$SAVI = \frac{R_{Nir} - R_r}{R_{Nir} + R_r + L}(1 + L)$			Lu et al. (2015)
	Leaf Area Index (LAI)				
	Net Photosynthesis (NetP)				
Climate	Rain Use Efficiency (RUE)	$RUE = NPP/P$	NPP and P are the sum of Net Primary Production and Precipitation for the studied period, respectively	NPP and P	Dardel et al. (2014)
	Difference in land surface temperature between day and night (ΔT_S)	$\Delta T_S = \lvert DLST - NLST \rvert$	DLST and NLST are daytime and night-time LSTs, respectively	DLST and NLST extracted from MODIS	
	Precipitation (P)			Meteorological point data	
	Maximum Wind Speed (MWS)			Meteorological point data	
	Erosivity of Wind Speed (EWS)			MWS and thresholds of wind erosion	
	Wind Erosion Index (WEI)	$WEI = 100\frac{V^3}{(P-E)^2}$ $P - E = \frac{R+1}{T+2}$	V, P-E, R, and T are the average wind velocity for the given period, evapotranspiration index of Thornthwaite, P (mm) and AAT (K), respectively	Average Air Temperature (AAT), Average Wind Speed (AWS), and P	Chepil et al., 1963
Soil	Apparent Thermal Inertia (ATI)	$ATI = \frac{1 - A}{\Delta T_S}$	A is WSA	DLST, NDLST and White Sky Albedo (WSA)	Price (1985)
	Biological Soil Crust index (BSCI)	$BSCI = \frac{1 - F \times \lvert R_r - R_g \rvert}{\left[\frac{(R_g + R_r + R_{Nir})}{3}\right]}$	R_g is reflectance in the green band and F is an adjustment factor in order to amplify the difference between R_g and R_r	Rr, RNIR and Rg	Price (1985)
	Satellite Based Aridity Index (SBAI)	$SBAI = \frac{\Delta T_S}{R_S}$ $R_S = (1 - A)$ $S_0 \cos \theta_C$	R_S is the absorbed solar radiation calculated from the broadband WSA (A), the solar constant (S_0), and the solar zenith at the Sun's apex (θ_C)	DLST, NDLST, WSA and solar zenith angle	Reiji Kimura and Moriyama, 2014



Contents lists available at ScienceDirect

Aeolian Research

journal homepage: www.elsevier.com/locate/aeolia

Invited Research Article

Water bodies changes in Tigris and Euphrates basin has impacted dust storms phenomena

Ali Darvishi Boloorani [a,b,*], Ramin Papi [b], Masoud Soleimani [b], Leyla Karami [c], Fatemeh Amiri [d], Najmeh Neysani Samany [b]

[a] Key Laboratory of Digital Land and Resources, East China University of Technology, Nanchang, Jiangxi, PR China
[b] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran
[c] Department of Remote Sensing and GIS, Faculty of Geographical Sciences, Kharazmi University, Tehran, Iran
[d] Department of Remote Sensing and GIS, Faculty of Humanities, Tarbiat Modares University, Tehran, Iran

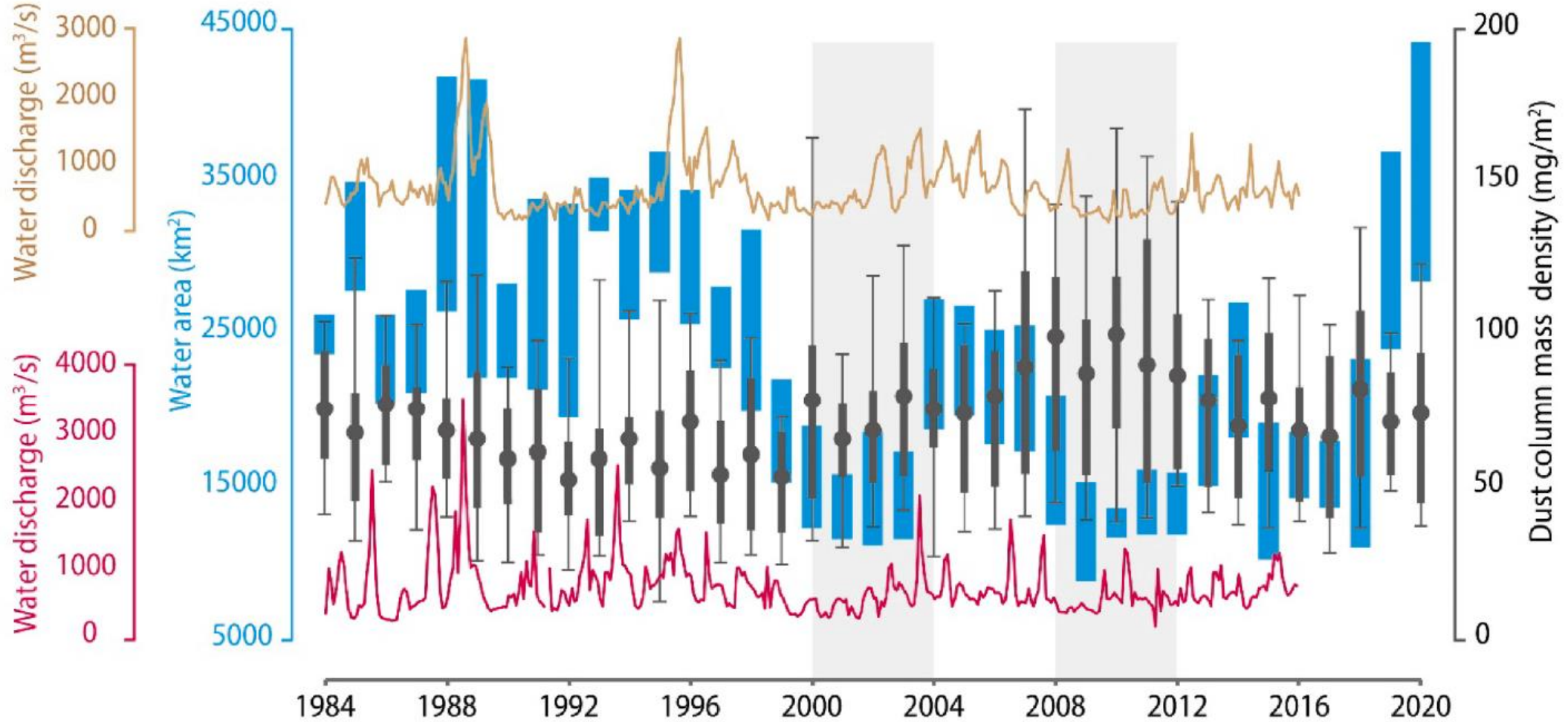
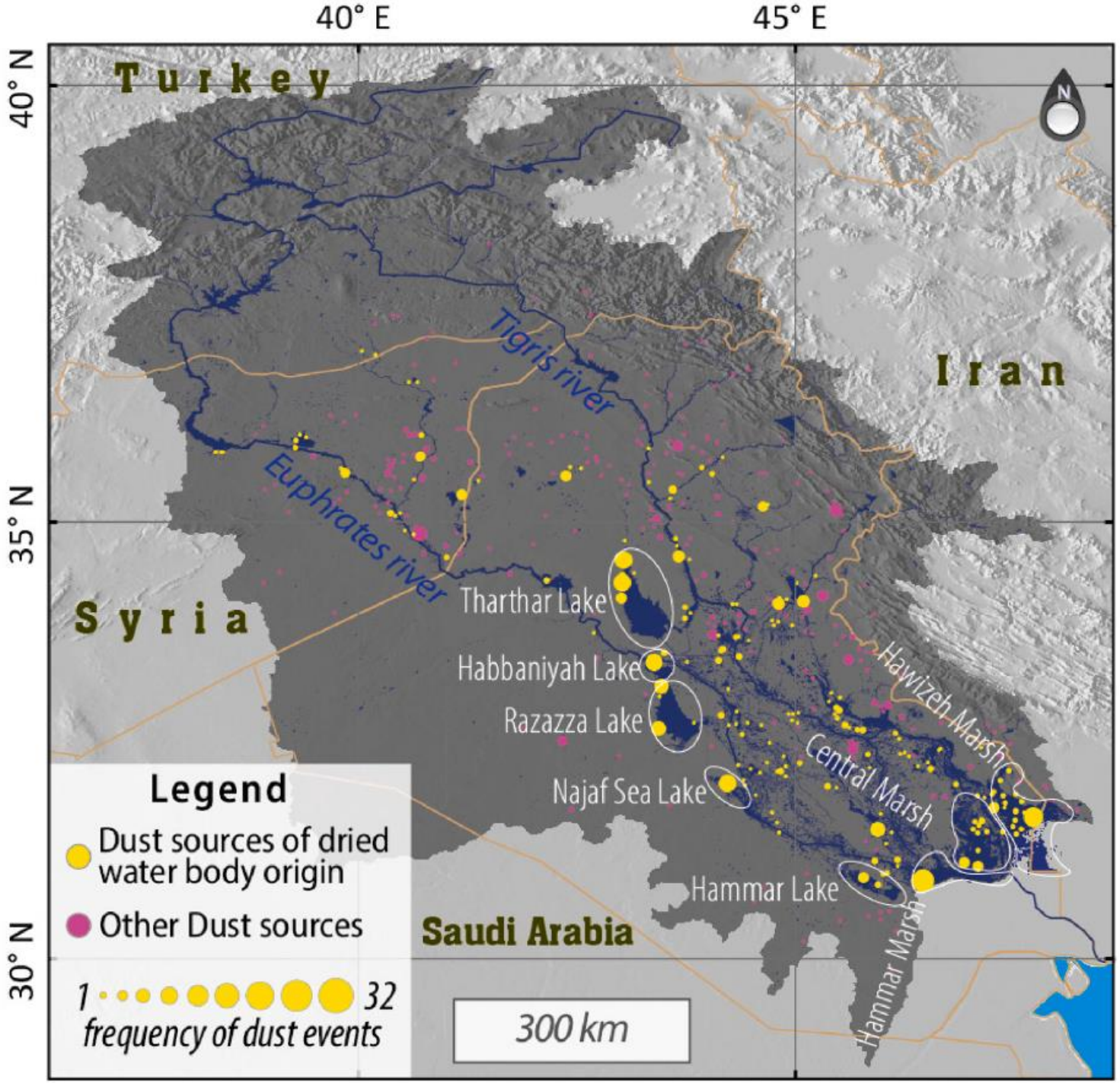


Fig. 10. Time series of the estimated total area of water bodies using Landsat archive multispectral images and estimated average dust column density using MERRA-2 data from 1984 to 2020. The red and brown lines are Tigris discharge (based on Mosul station data) and Euphrates discharge (based on Husaybah station data), respectively. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)


40° E
45° E
40° N
35° N
30° N
Turkey
Iran
Syria
Saudi Arabia
Tigris river
Euphrates river
Tharthar Lake
Habbaniyah Lake
Razazza Lake
Najaf Sea Lake
Hammar Lake
Hawizeh Marsh
Central Marsh
Hammar Marsh
N
Legend
Dust sources of dried water body origin
Other Dust sources
1
32
frequency of dust events
300 km

land

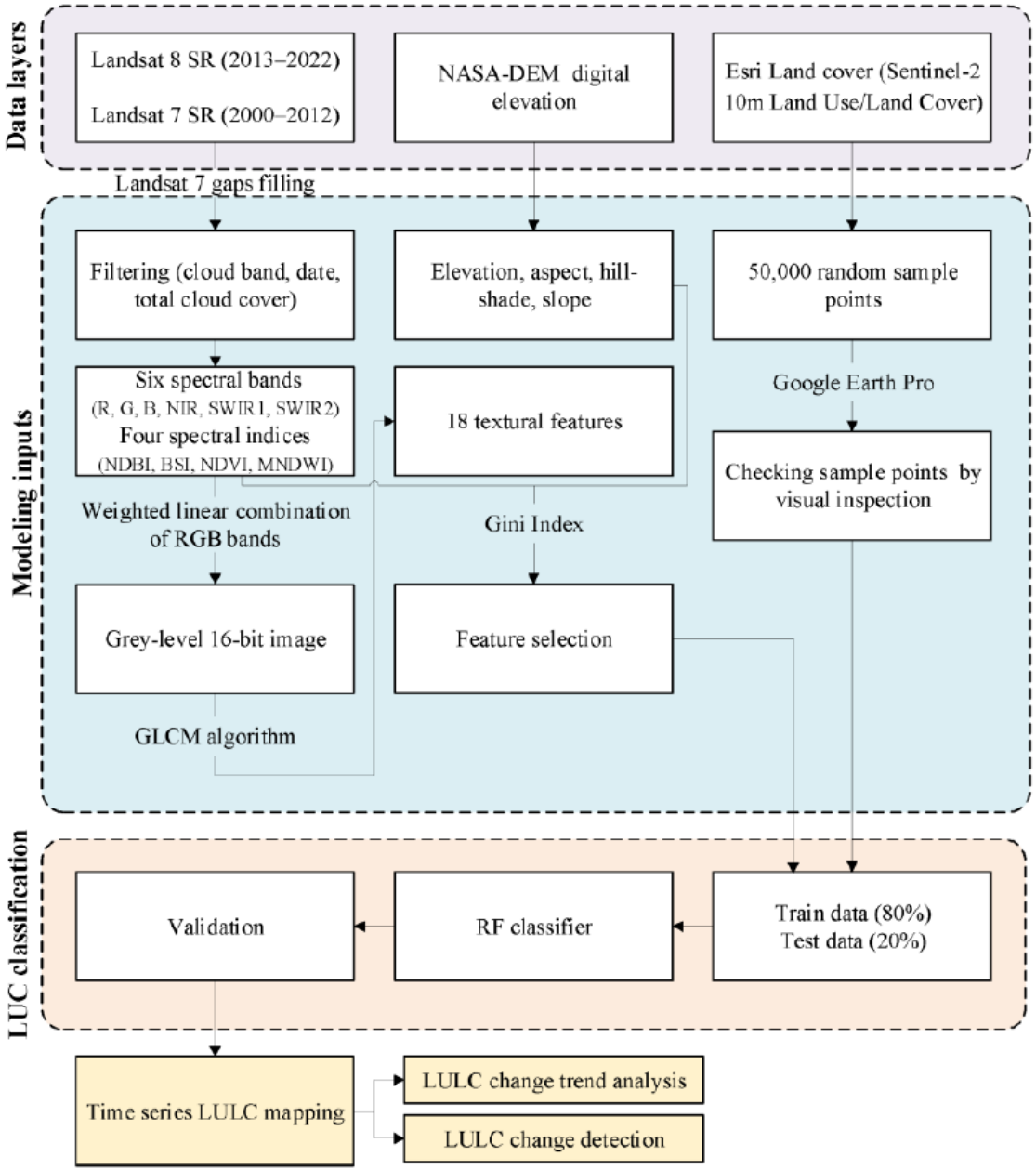
MDPI

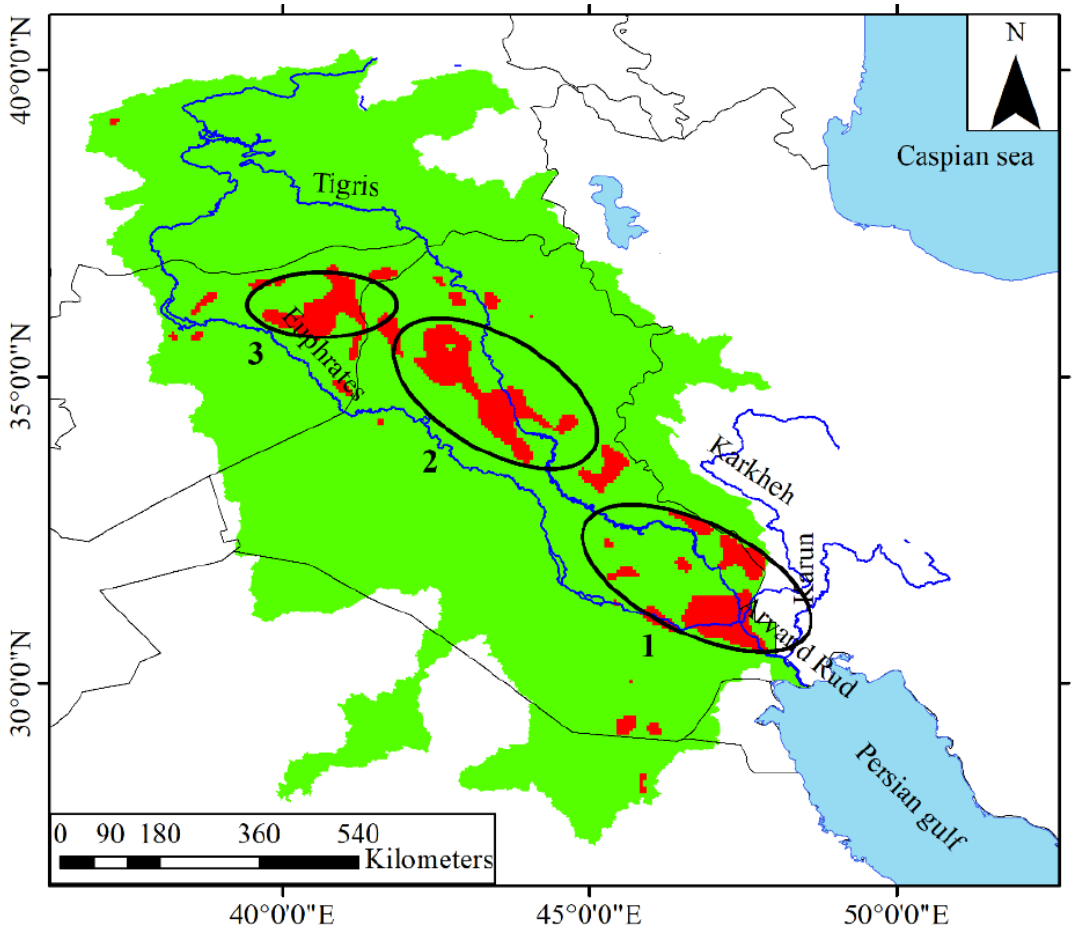
Article

Land Use/Land Cover Change Analysis Using Multi-Temporal Remote Sensing Data: A Case Study of Tigris and Euphrates Rivers Basin

Azher Ibrahim Al-Taei [1,*], Ali Asghar Alesheikh [1] and Ali Darvishi Boloorani [2]

[1] Faculty of Geodesy and Geomatics Engineering, K. N. Toosi University of Technology, Tehran 19967-15433, Iran
[2] Department of Remote Sensing & GIS, Faculty of Geography, University of Tehran, Tehran 14155-4665, Iran
* Correspondence: azher.altaei@email.kntu.ac.ir


Data layers
Landsat 8 SR (2013–2022)
Landsat 7 SR (2000–2012)
NASA-DEM digital elevation
Esri Land cover (Sentinel-2 10m Land Use/Land Cover)
Landsat 7 gaps filling
Modeling inputs
Filtering (cloud band, date, total cloud cover)
Elevation, aspect, hill-shade, slope
50,000 random sample points
Six spectral bands
(R, G, B, NIR, SWIR1, SWIR2)
Four spectral indices
(NDBI, BSI, NDVI, MNDWI)
18 textural features
Google Earth Pro
Checking sample points by visual inspection
Weighted linear combination of RGB bands
Gini Index
Grey-level 16-bit image
Feature selection
GLCM algorithm
LUC classification
Validation
RF classifier
Train data (80%)
Test data (20%)
Time series LULC mapping
LULC change trend analysis
LULC change detection


N
Caspian sea
Tigris
Euphrates
Karkheh
Karun
Dwarid Rud
Persian gulf
1
2
3
0 90 180 360 540
Kilometers
40°0'0"N
35°0'0"N
30°0'0"N
40°0'0"E
45°0'0"E
50°0'0"E

atmosphere

MDPI

University of Tehran

Article

Numerical Simulation of Tehran Dust Storm on 2 June 2014: A Case Study of Agricultural Abandoned Lands as Emission Sources

Ana Vukovic Vimic [1,*], Bojan Cvetkovic [2], Theodore M. Giannaros [3], Reza Shahbazi [4], Saviz Sehat Kashani [5], Jose Prieto [6], Vassiliki Kotroni [3], Konstantinos Lagouvardos [3], Goran Pejanovic [2], Slavko Petkovic [2], Slobodan Nickovic [2], Mirjam Vujadinovic Mandic [1], Sara Basart [7], Ali Darvishi Boloorani [8,9] and Enric Terradellas [10]

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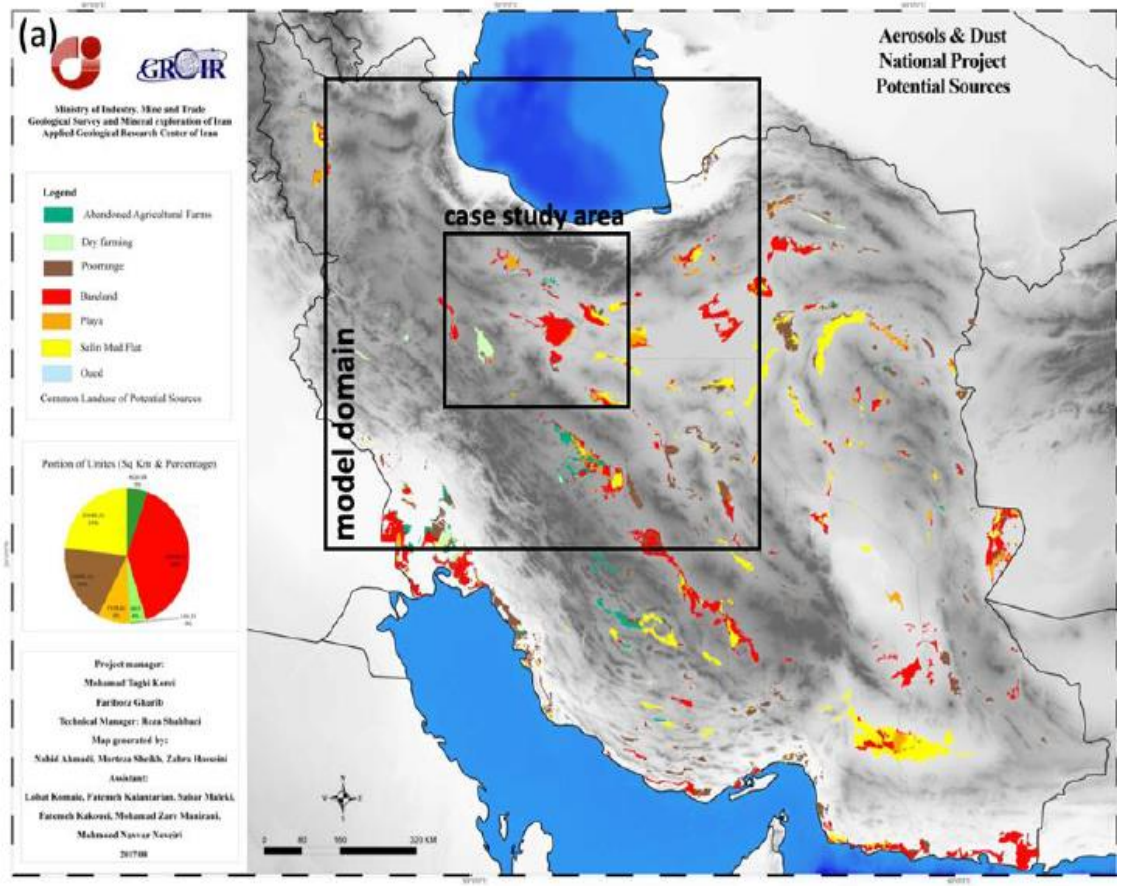
2 Republic Hydrometeorological Service of Serbia (RHMSS), Bulevar Oslobodjenja 8, 11000 Belgrade, Serbia; bojan.cvetkovic@hidmet.gov.rs (B.C.); goran.pejanovic@hidmet.gov.rs (G.P.); slavko.petkovic@hidmet.gov.rs (S.P.); nickovic@gmail.com (S.N.)
3 National Observatory of Athens (NOA), Institute for Environmental Research and Sustainable Development, Vas. Pavlou & I. Metaxa, 15236 Penteli, Greece; thgian@noa.gr (T.M.G.); kotroni@noa.gr (V.K.); lagouvar@noa.gr (K.L.)
4 Geological Survey of Iran (GSI), Meraj Blvd, Azadi Square, Tehran 1387835841, Iran; rezashahbazi@gsi.ir
5 Atmospheric Science and Meteorological Research Center (ASMERC), Pajoohesh Blvd, Shahid Kharrazi Highway, Tehran 1493845161, Iran; sehat-s@asmerc.ac.ir
6 EUMETSAT, Eumetsat Allee 1, D-64295 Darmstadt, Germany; training@eumetsat.int
7 Earth Sciences Department, Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS), Plaça Eusebi Güell 1-3, 08034 Barcelona, Spain; sara.basart@bsc.es
8 Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Azin Alley. 50, Vesal Str., Tehran 1417853933, Iran; ali.darvishi@ut.ac.ir or ali@ecut.edu.cn
9 Key Laboratory of Digital Land and Resources, East China University of Technology, Nanchang 330013, China
10 State Meteorological Agency (AEMET), Arquitecte Sert, 1, 08005 Barcelona, Spain; enric.terradellas@gmail.com

Citation: Vukovic Vimic, A.; Cvetkovic, B.; Giannaros, T.M.; Shahbazi, R.; Sehat Kashani, S.; Prieto, J.; Kotroni, V.; Lagouvardos, K.; Pejanovic, G.; Petkovic, S.; et al. Numerical Simulation of Tehran Dust Storm on 2 June 2014: A Case Study

Figure 5. Photo of the Tehran dust storm on 2 June 2014; the photo was taken by Alireza Naseri (at the time, a photography student) from Tehran's Aghdasieh neighborhood (northern part of Tehran at a higher altitude area of the city); the image is from: https://news.yahoo.com/deadly-wall-dust-devours-tehran-photo-182346241.html, accessed on 10 July 2021).



Dust emission sources generally fall into five types:

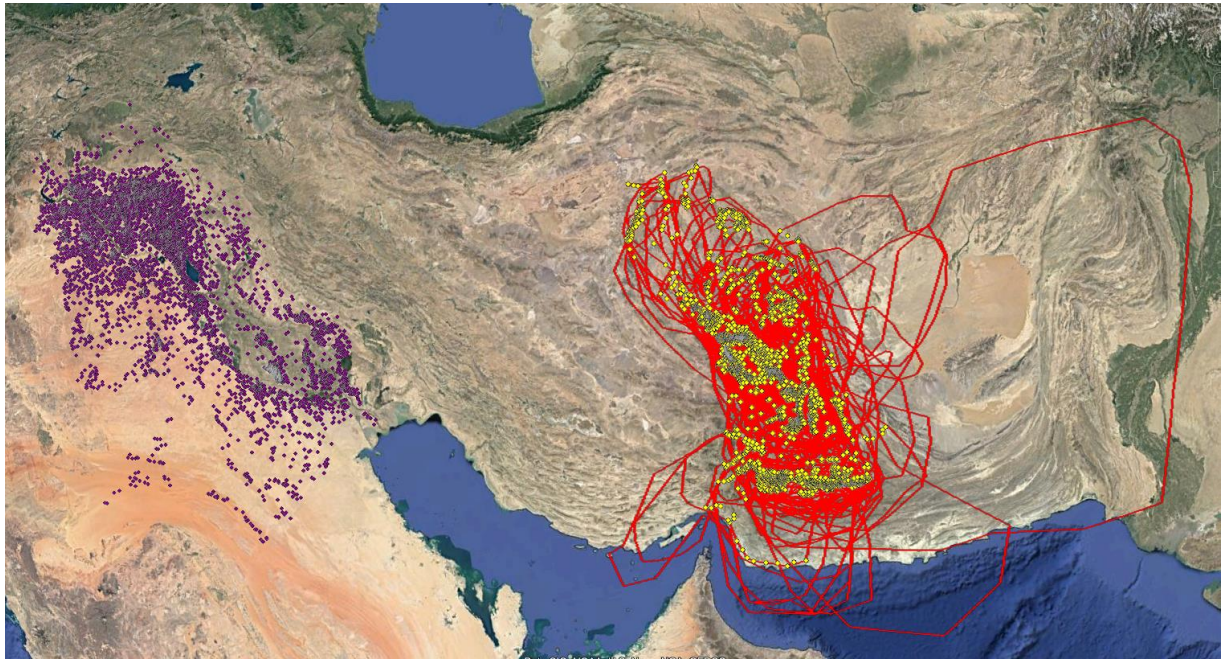
(i) agricultural lands,

(ii)dried and seasonal wetlands and lakes,

(iii)dried riverbeds,

(iv)degraded rangelands,

(v)desert areas.

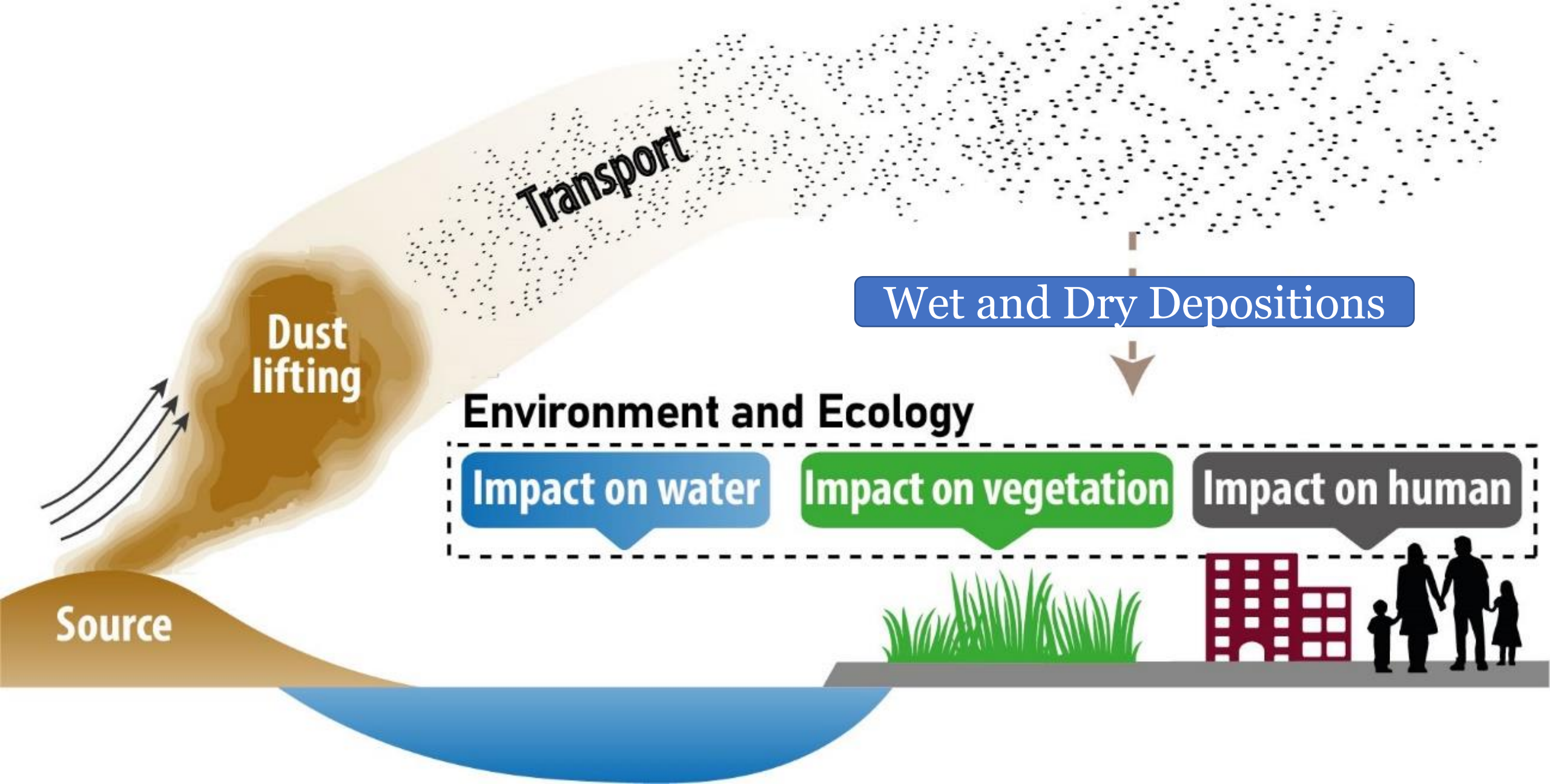


And each source requires specific treatment, therefore I strongly believe that each dust event must have unique Identification record including exact location of source, LULC type, impact area, intensity, and continuity to be able to control it.

Dust Impacts:

1. Human health,
2. Socio-economy
3. Vegetation cover
4. Radiative forcing (Climate conditions)

Sand and Dust Storm Process



Dust Storm Simulation Design in 2015

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SDS Simulation: Portable Wind Erosion Tunnel

Lab: Greenhouse, Medical Lab, Soil Lab, etc

SDS Tension Simulation: Similar to Ahvaz

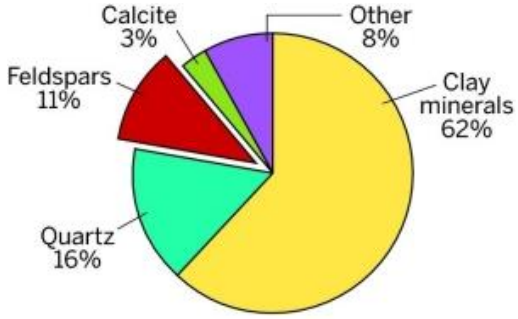
Time Periods: From 1 to 6 Days

Concentration:

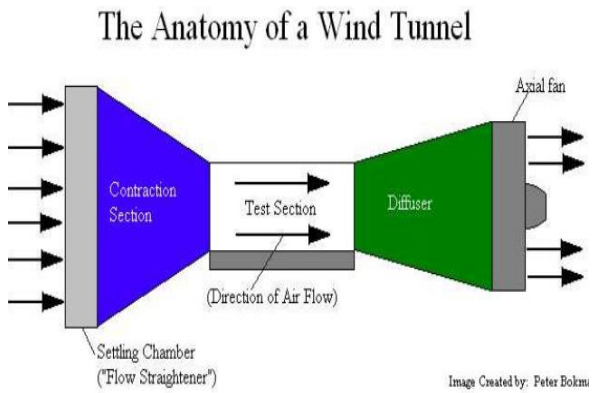
- Low (350 mg/m^3)
- Medium (750 mg/m^3)
- High (1500 mg/m^3)

Dust samples: Ahvaz

By: UT and TMU



Mineral dust composition, by mass



Microdust pro detector and how to measure airborne dust

Sand and Dust Storms Compendium

Information and Guidance on Assessing and Addressing the Risks

United Nations Convention to Combat Desertification | Uni[illegible]or land

7/17/2023

University of Tehran

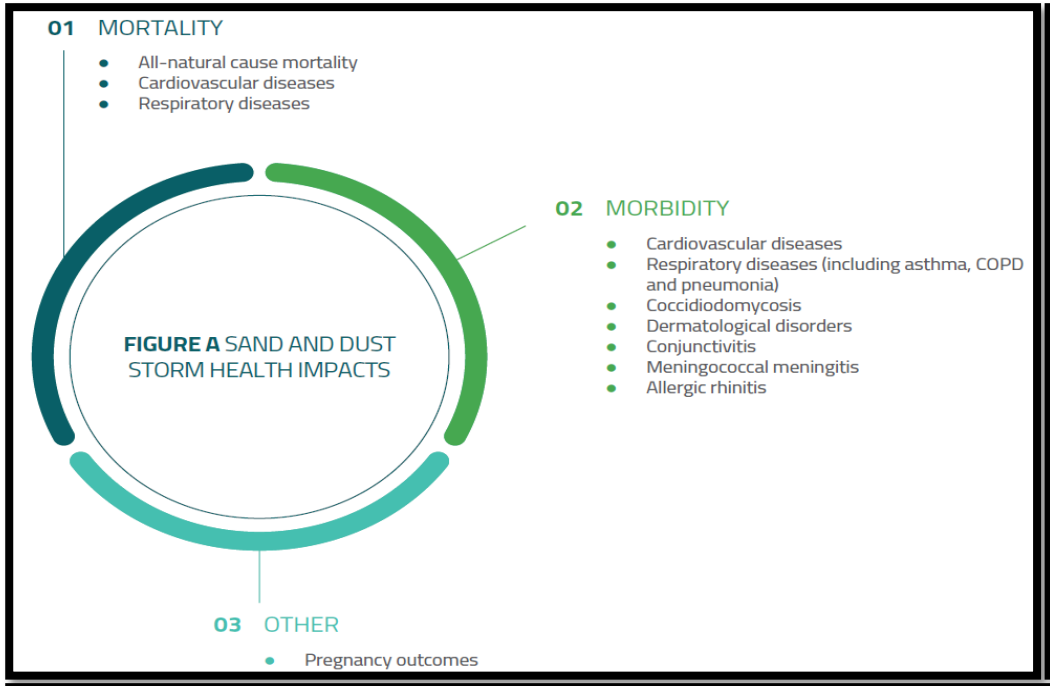
7. A geographic information system-based sand and dust storm vulnerability mapping framework

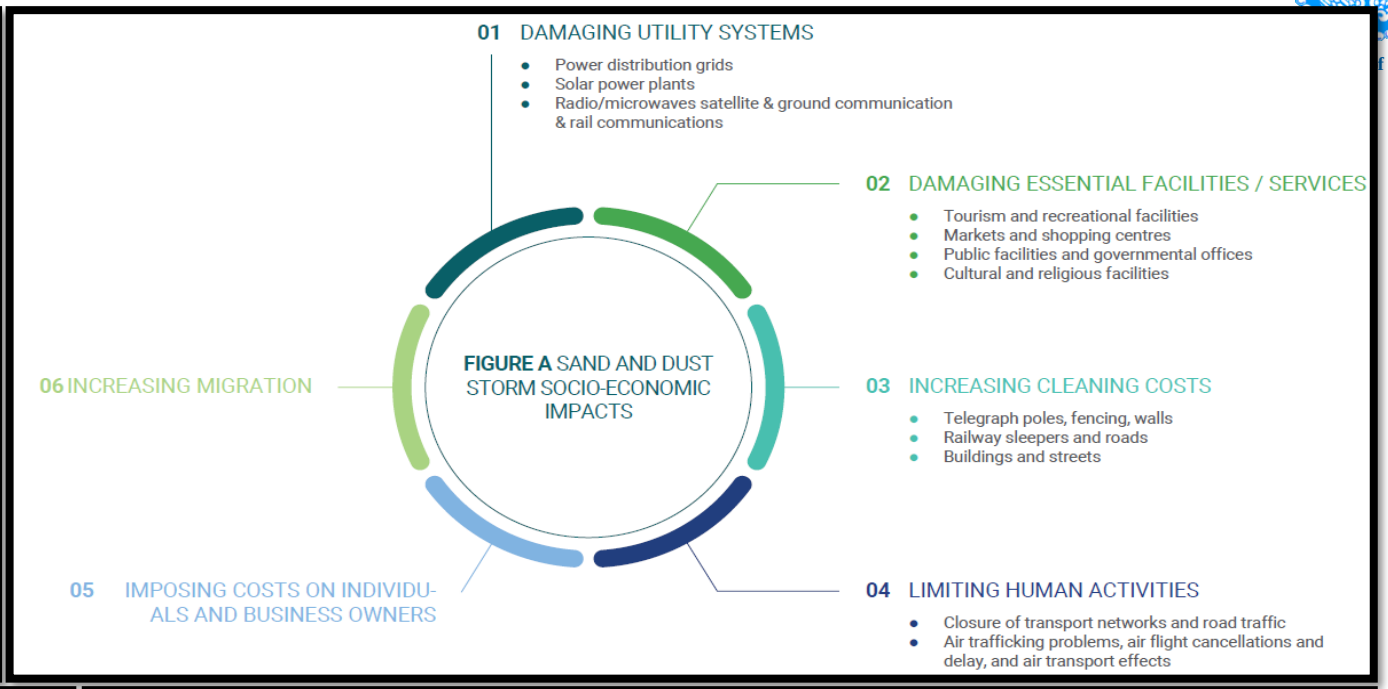
Chapter overview

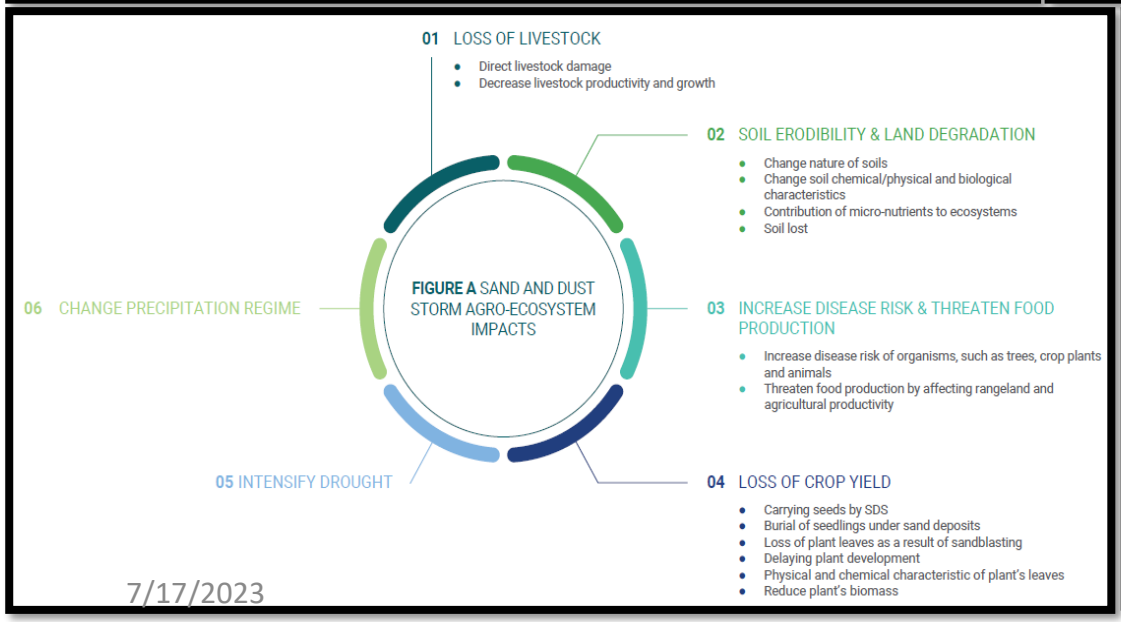
This chapter provides a sand and dust storms (SDS)-focused process to assess vulnerability using geographic information system (GIS) procedures where data availability or quality is not a critical issue. The chapter provides a flow chart for GIS-based vulnerability assessment and conceptual models of how SDS affect the health, socio-economic, environmental and agro-ecological domains of a vulnerable area (from local to global). Detailed attention is paid to the selection of vulnerability indicators (including tables of possible indicators). The chapter includes specific formula to produce vulnerability maps using a GIS platform.

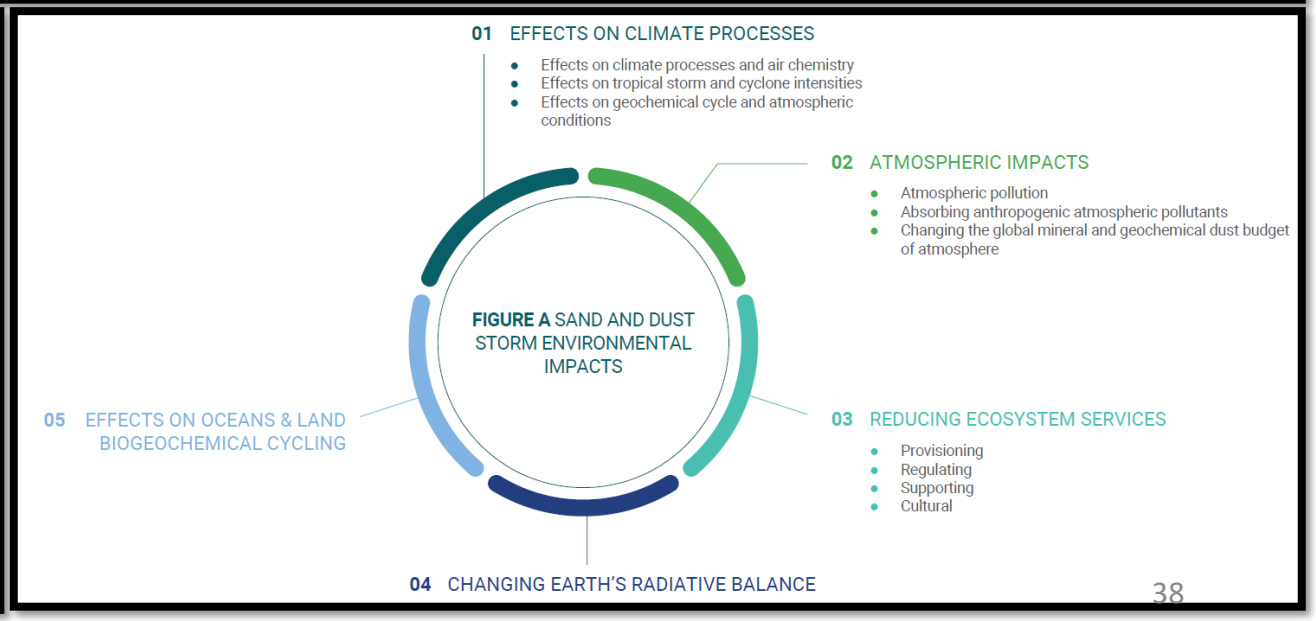
This chapter should be read in conjunction with chapters 3, 4, 5 and 6.

Four main domains of the vulnerability of a system to SDS (UNCCD, 2023)

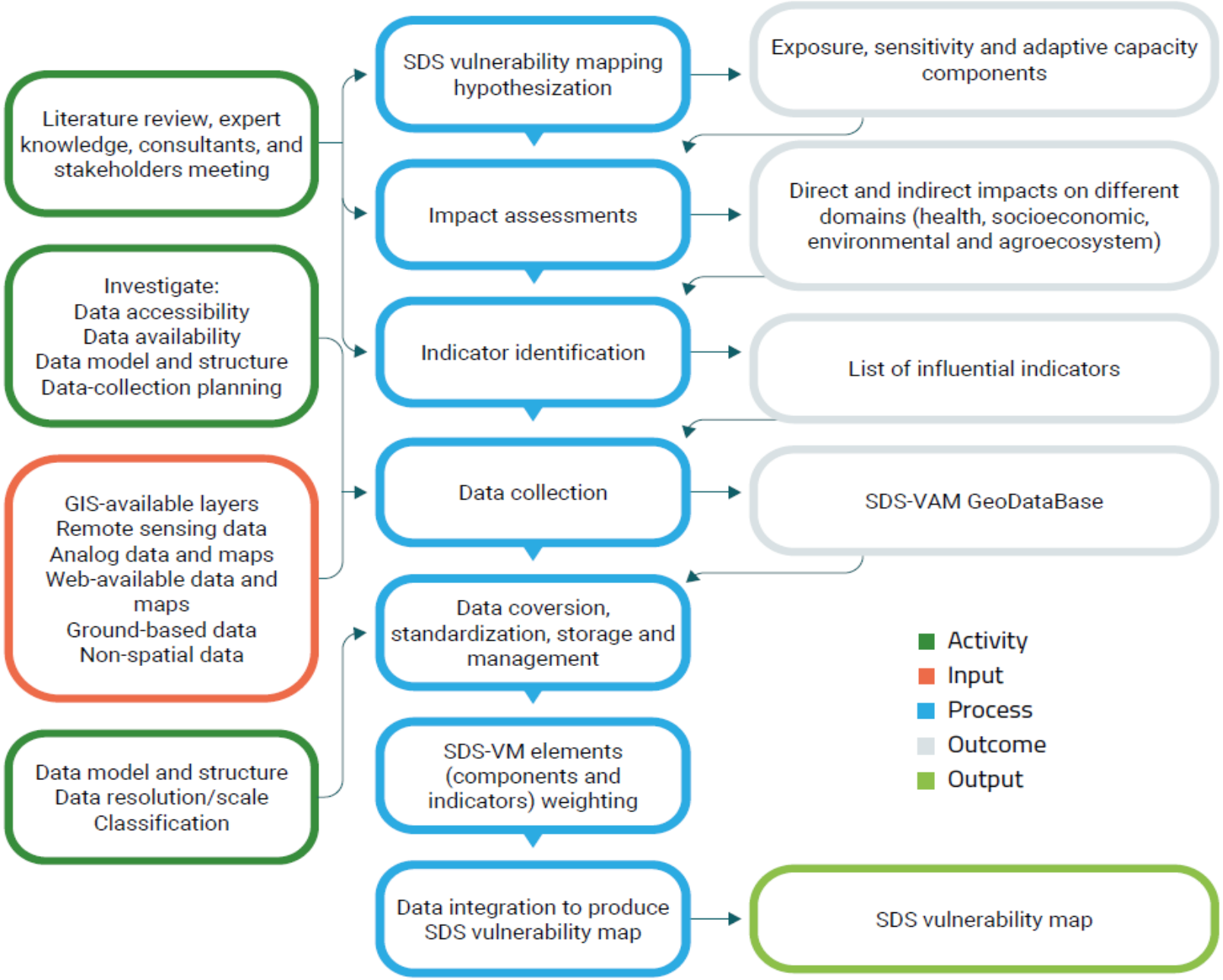








GIS-based SDS vulnerability mapping procedure (UNCCD, 2023)



Environmental Pollution 279 (2021) 116859

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

University of Tehran

Vulnerability mapping and risk analysis of sand and dust storms in Ahvaz, IRAN☆

Ali Darvishi Boloorani [a, b, *], Saman Nadizadeh Shorabeh [b], Najmeh Neysani Samany [b], Alijafar Mousivand [c], Yasin Kazemi [b], Nemat Jaafarzadeh [d], Amir Zahedi [d], Javad Rabiei [e]

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[d] Environmental Technology Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[e] Department of Geography, Faculty of Literature and Humanities, Islamic Azad University Central Tehran Branch, Iran

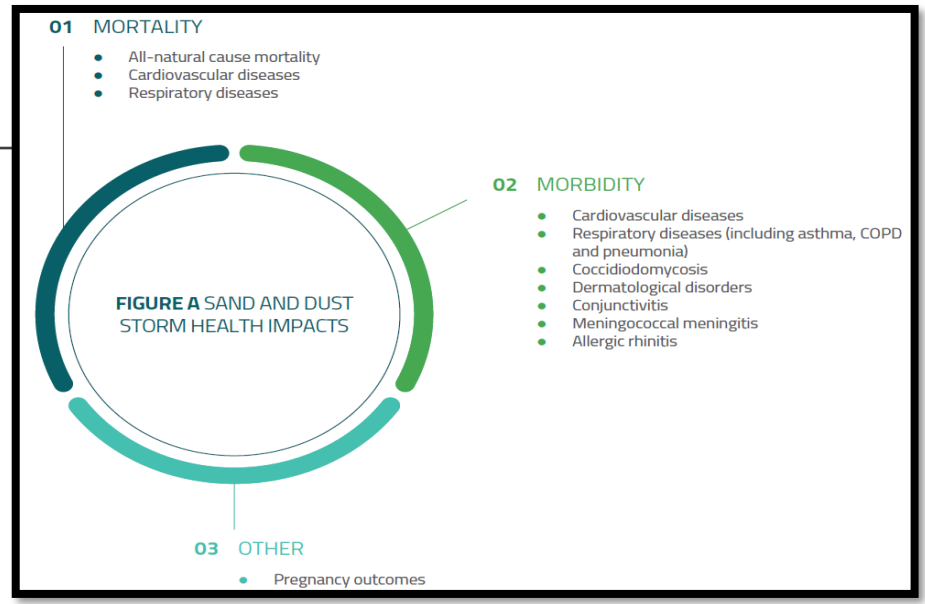

FIGURE A SAND AND DUST STORM HEALTH IMPACTS

SDS-VM in Ahvaz

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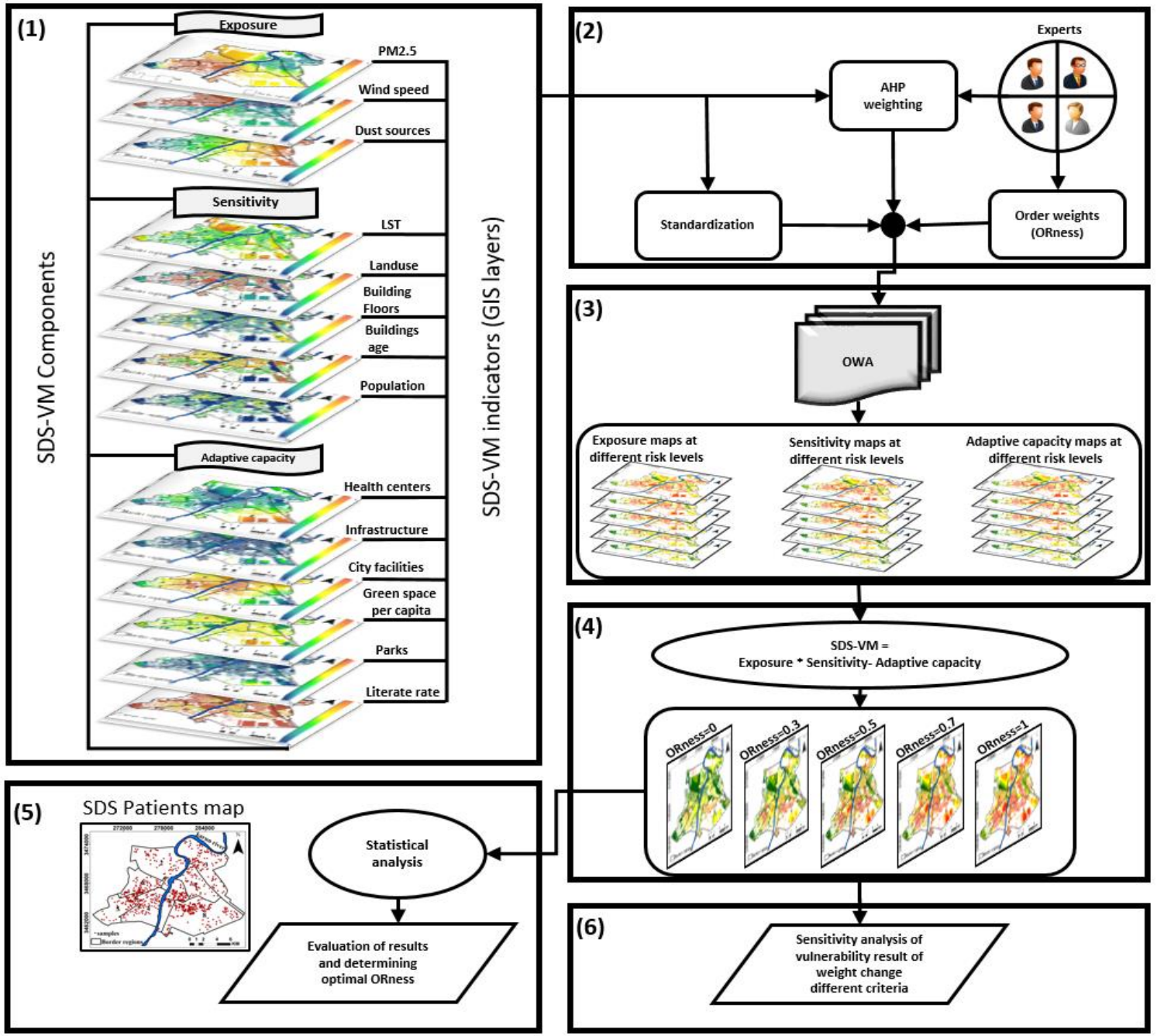

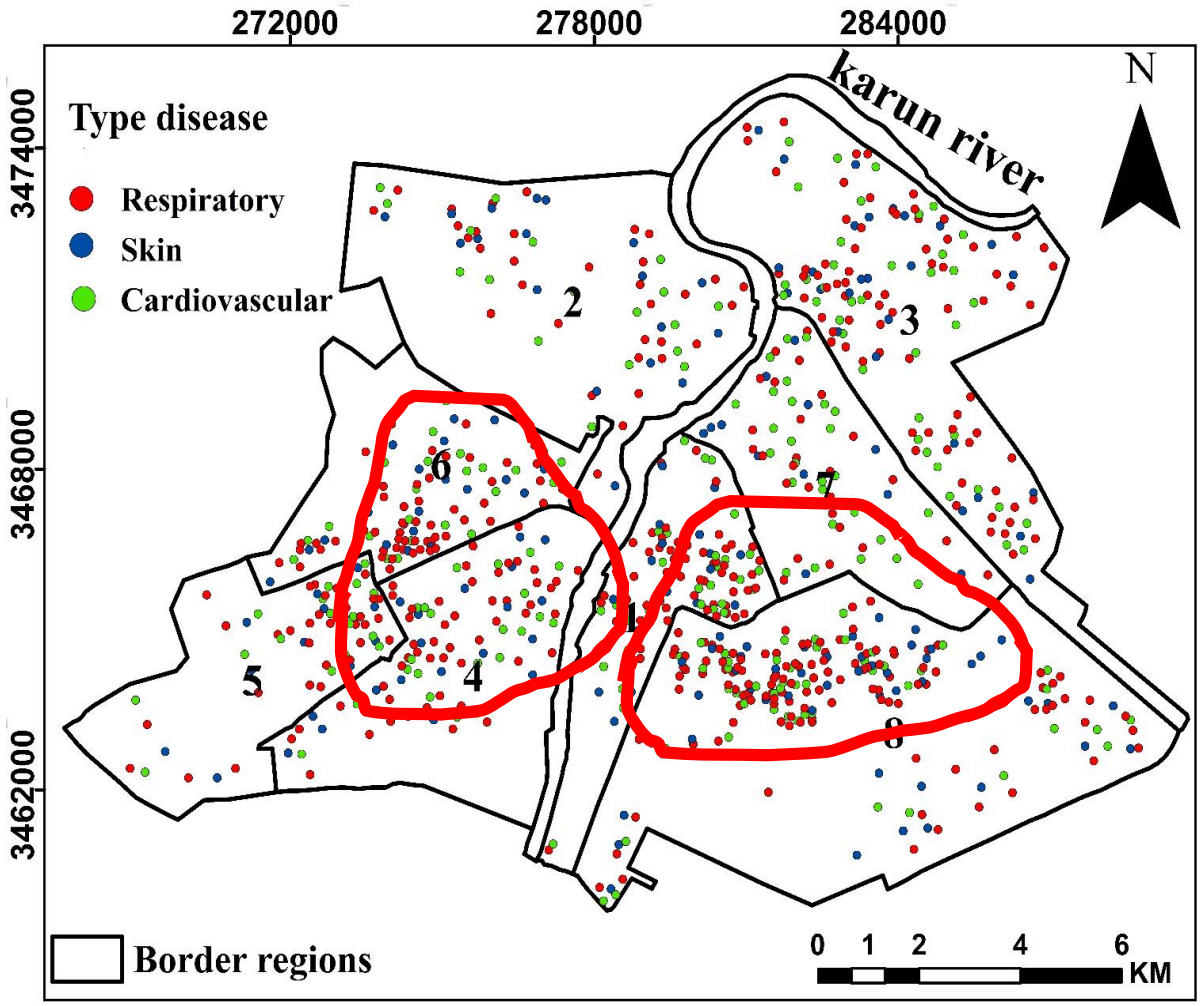

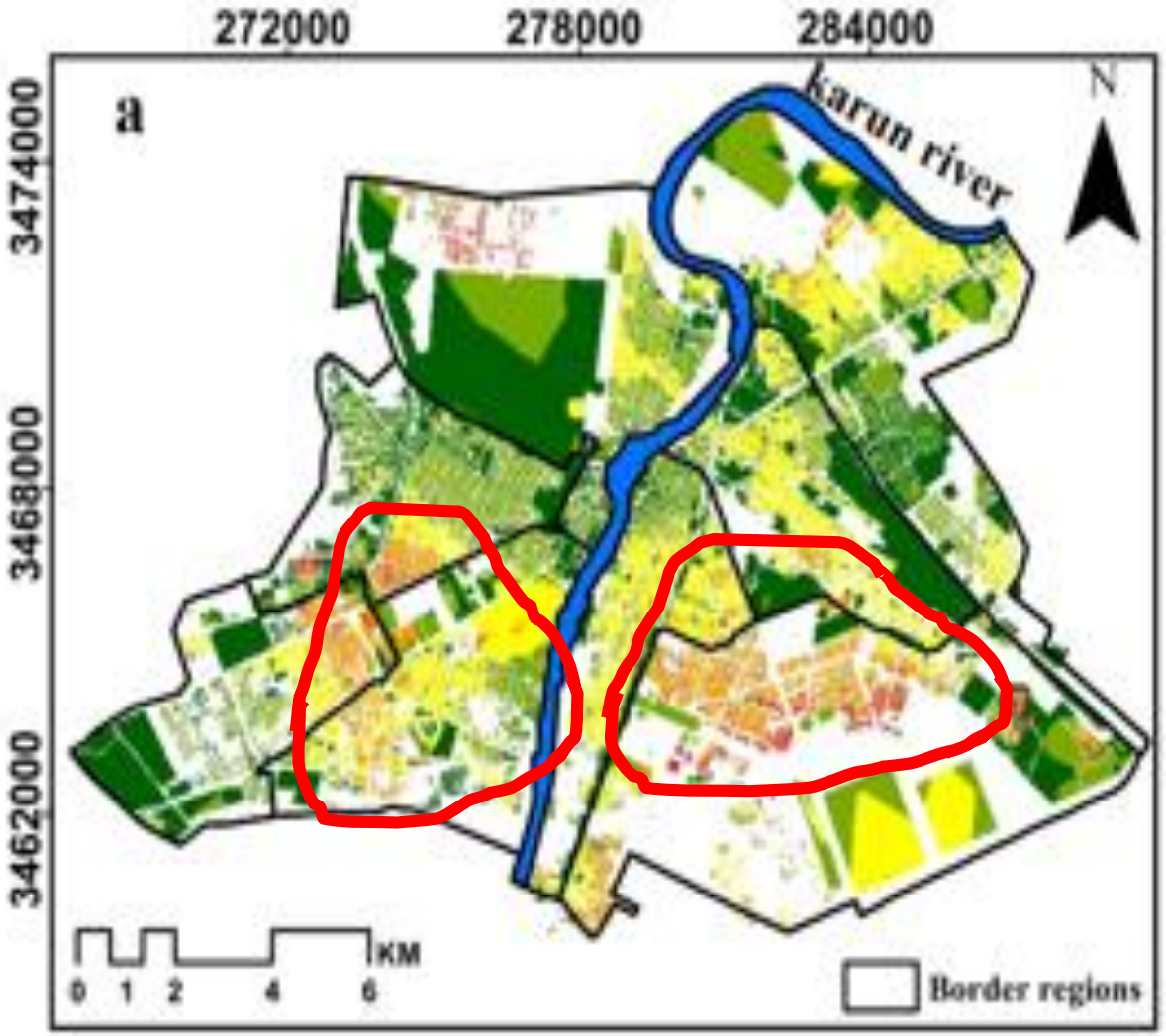

Atmospheric Environment 209 (2019) 233–239

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

University of Tehran

Air pollution and respiratory hospital admissions in Shiraz, Iran, 2009 to 2015

Zahra Soleimani[a,b], Ali Darvishi Boloorani[c], Reza Khalifeh[d], Pari Teymouri[e,f], Alireza Mesdaghinia[a,g,*], Dale W. Griffin[h,**]

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[b] Department of Environmental Health Engineering, School of Public Health, Semnan University of Medical Sciences, Semnan, Iran
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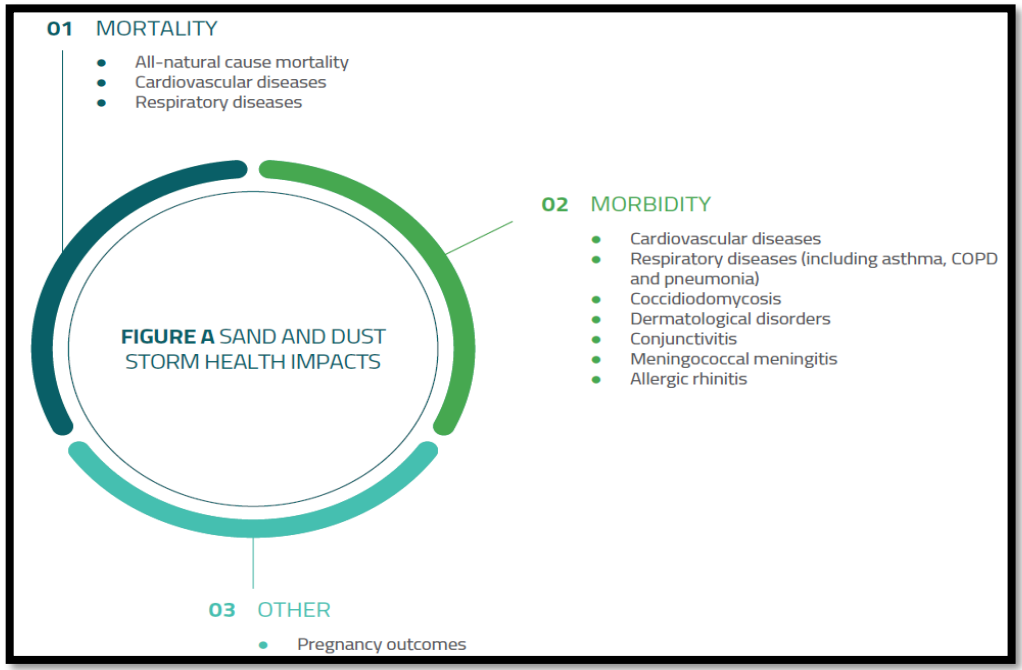
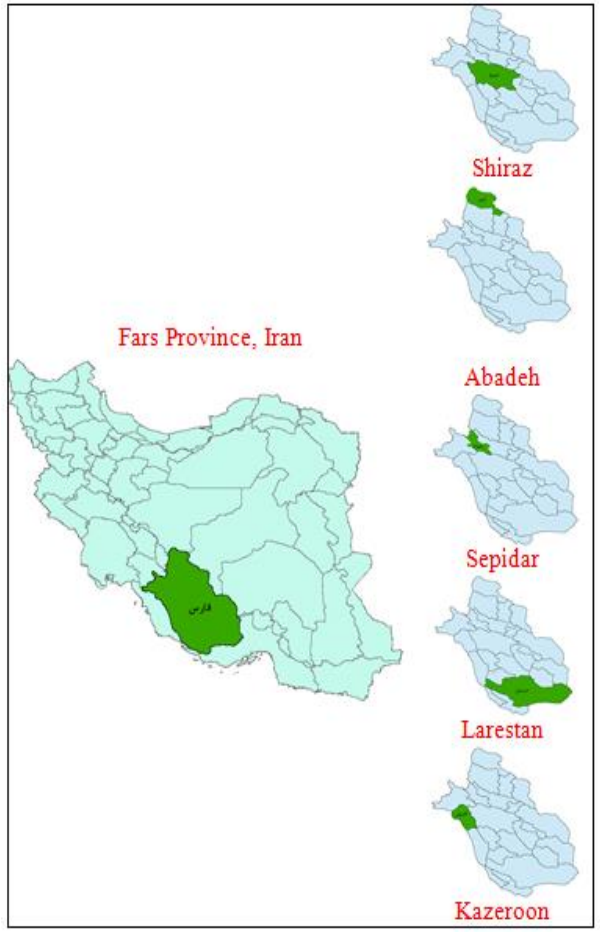
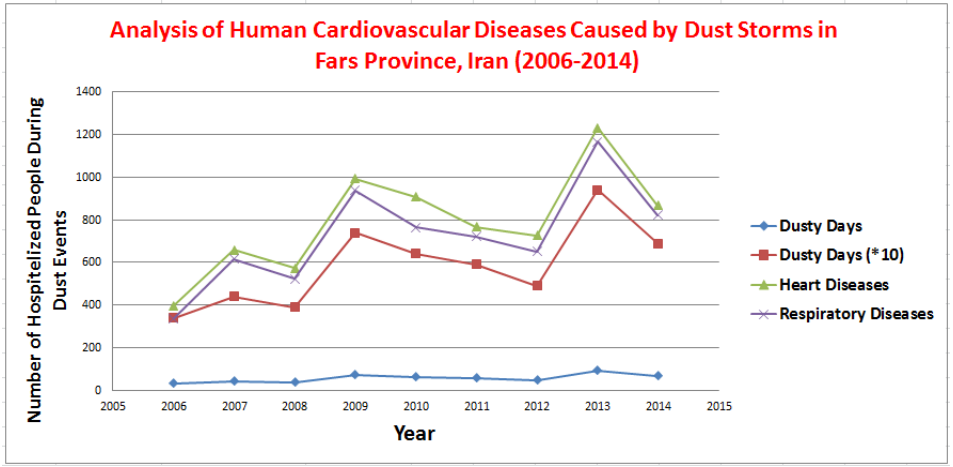
[d] Department of Statistics, Mathematical Science and Computer School, Tehran of University, Tehran, Iran
[e] Health and Environment Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[f] Department of Environmental Health Engineering, Tabriz University of Medical Sciences, Tabriz, Iran
[g] Institute for Environmental Research, Tehran University of Medical Sciences, Tehran, Iran
[h] U.G. Survey, Coastal Marine Science Center, St. Petersburg, Florida, USA



Human Diseases caused by dust storms (2015-16)





Location: Fars Province, Southwest of Iran

Time Period: 8 years (21 March 2006 – 22 March 2014)

Cities: Shiraz, Abadeh, Sepidar, Larestan & Kazeroon

Hospitalized People: **13661**

Respiratory Diseases: Asthma, COPD, Pneumonia, and ARD

Heart Diseases:
Heart Failure, Ischemic, Cerebrovas Cular, Mitral Regurgitatia, Cardiomypathy, and Angina.

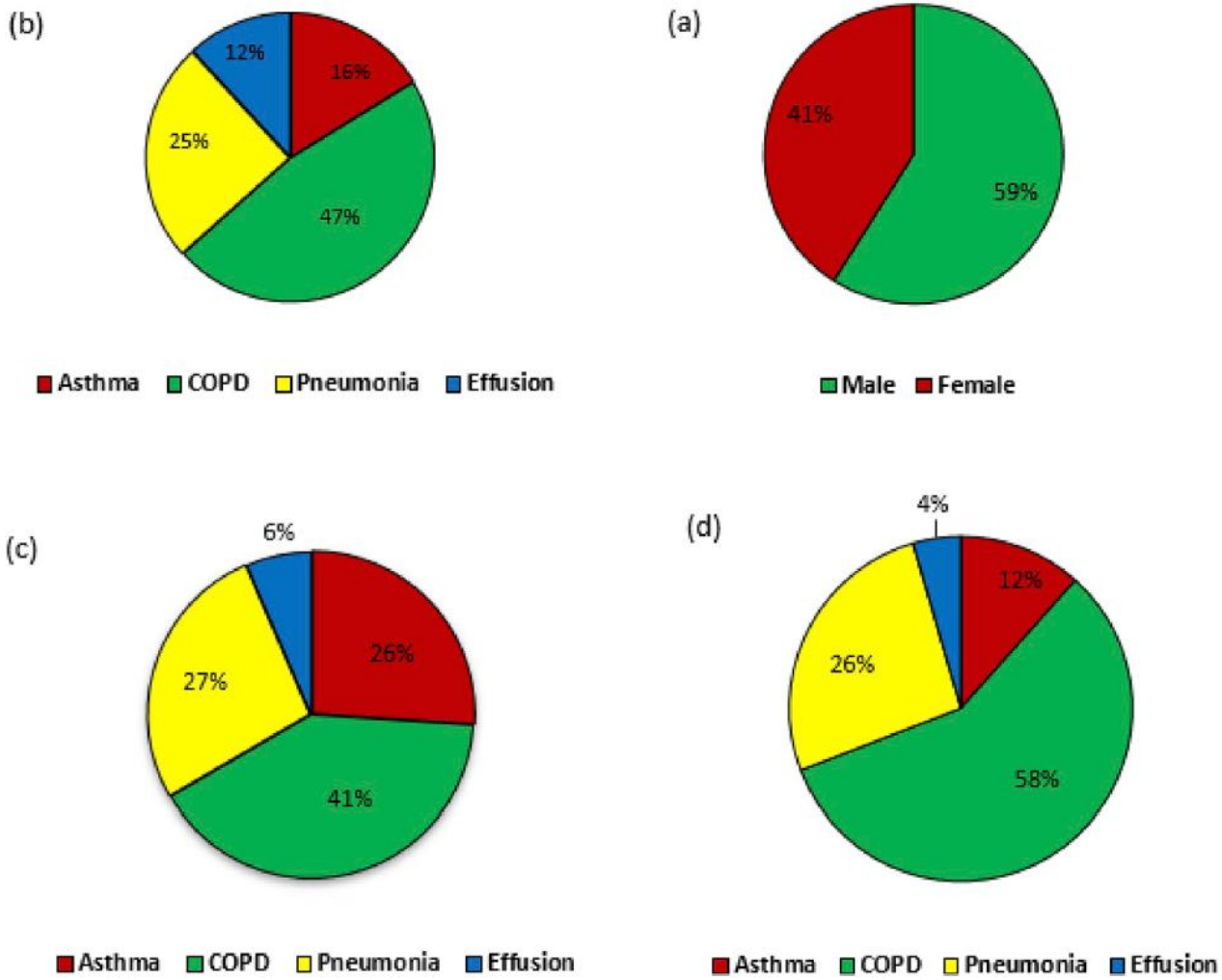


Fig. 1. Adults' Hospital - (a) admission based on gender, (b) admission based on respiratory diseases, (c) admission of respiratory diseases in females, (d) admission of respiratory diseases in males.

atmosphere

MDPI

Article

Assessment of Rural Vulnerability to Sand and Dust Storms in Iran

Ali Darvishi Boloorani [1,*], Masoud Soleimani [1], Najmeh Neysani Samany [1,*], Mohsen Bakhtiari [1], Masomeh Qareqani [1], Ramin Papi [2,3] and Saham Mirzaei [4]

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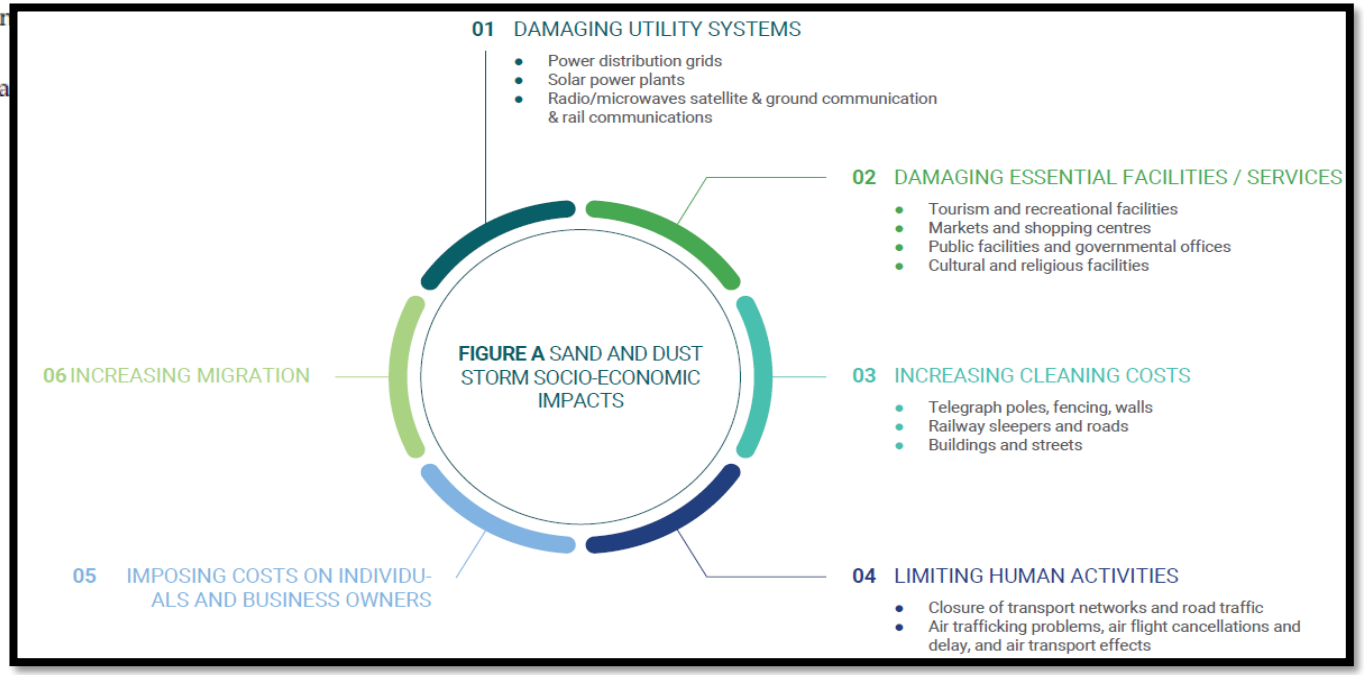
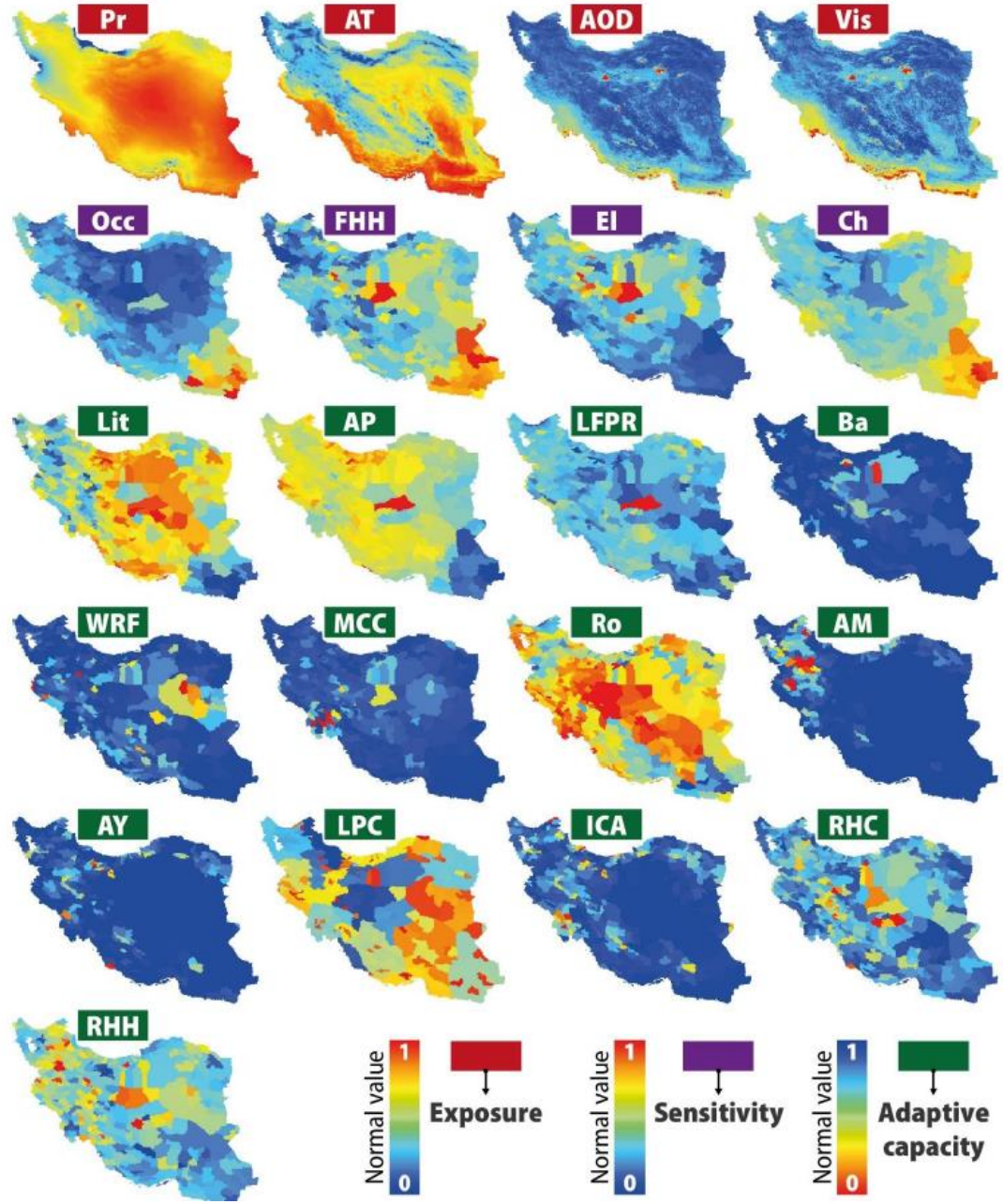
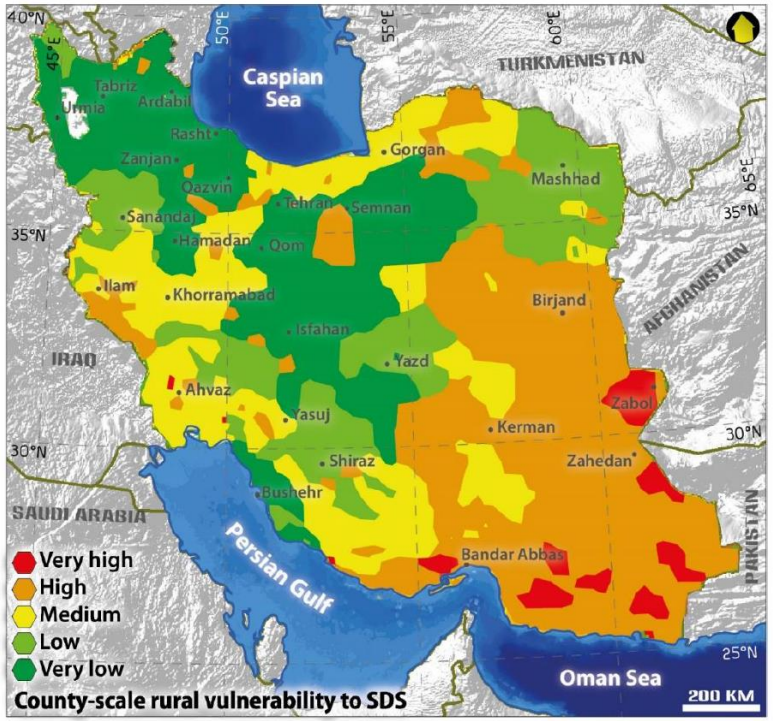
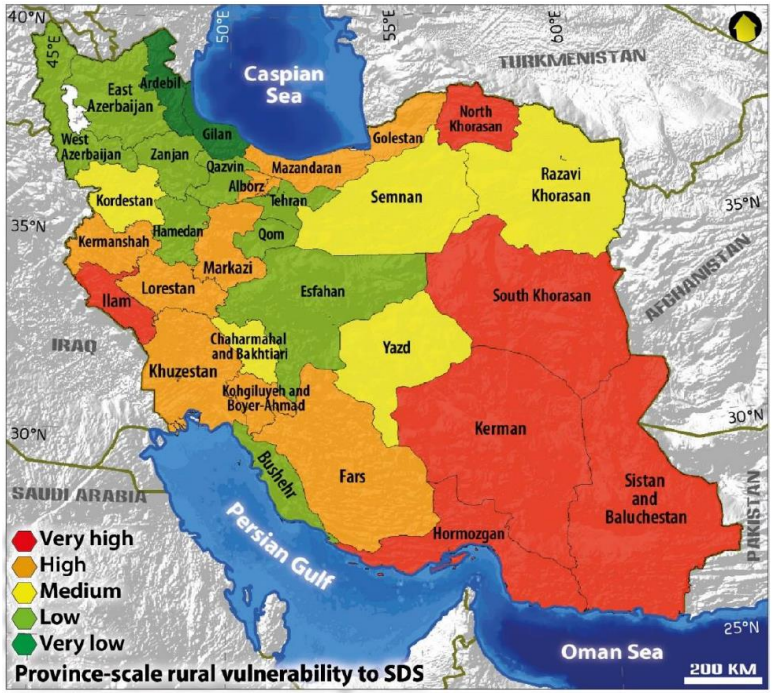
4 Institute of Methodologies for Environmental Analysis, Italian 85050 Potenza, Italy
* Correspondence: ali.darvishi@ut.ac.ir (A.D.B.); nneysani@ut.a

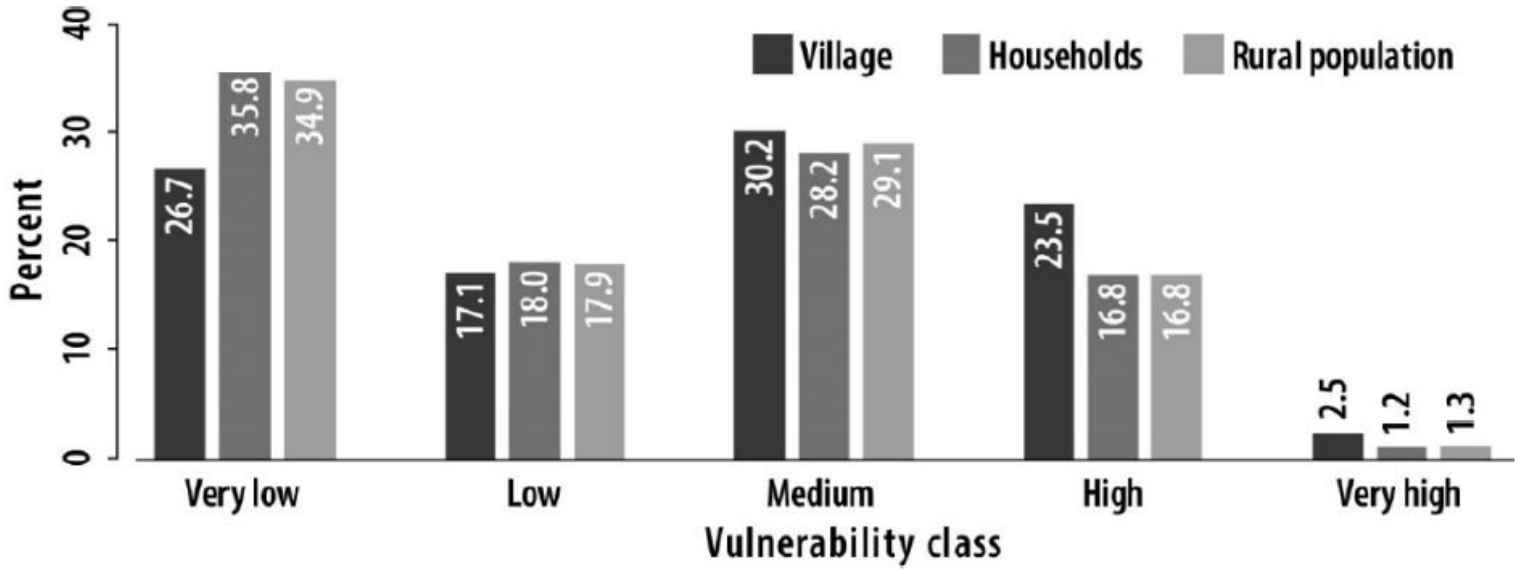


Component	Indicator	Description	Time Scale	Relationship	BWM Weight	Data Source	Reference
Exposure	Precipitation (Pr)	Average annual cumulative precipitation	2000–2021	-	0.331	TerraClimate	[54,55]
	Air temperature (AT)	Average annual air temperature	2000–2021	+	0.169	FLDAS	
	Aerosol optical depth (AOD)	Average AOD as a measure of the columnar atmospheric aerosol concentration	2000–2021	+	0.331	MODIS-Terra/Aqua	[16,56]
	Visibility (Vis)	It is the measure of the distance at which an object can be clearly observed by unaided eye	2000–2021	-	0.169	Meteorological stations	[57]
Sensitivity	Occupancy (Occ)	Ratio of people per dwelling	2016	+	0.252	Population and Housing Censuses	[58–60]
	Female-headed households (FHH)	Ratio of Female-headed households to total female population	2016	+	0.224	Population and Housing Censuses	[43,54,60]
	Elderly (El)	Ratio of >65 years old to total population	2016	+	0.125	Population and Housing Censuses	[55]
	Children (Ch)	Ratio of 0–4 age group to total population	2016	+	0.399	Population and Housing Censuses	
Adaptive Capacity	Literacy (Lit)	Ratio of literate people to rural population >6 years old	2016	+	0.050	Population and Housing Censuses	[54,60,61]
	Active population (AP)	Ratio of 15–64 age group to total population	2016	+	0.150	Population and Housing Censuses	[62]
	Labor force participation rate (LFPR)	Ratio of labor force to active population	2016	+	0.088	Population and Housing Censuses	[63]
	Bank (Ba)	Ratio of banks to 10,000 people	2016	+	0.032	Statistical yearbook of Iran	[58,60]
	Women's rural funds (WRF)	Ratio of women's rural funds to 10,000 people	2019	+	0.040	Agricultural Research Education and Extension Organization (AREEO)	-
	Membership in cooperative companies (MCC)	Ratio of rural cooperative companies to 10,000 people	2016	+	0.040	Statistical yearbook of Iran	[64]
	Road (Ro)	Ratio of rural asphalt roads to total rural roads	2016	+	0.105	Statistical yearbook of Iran	[54,61,64]
	Agricultural machinery (AM)	Ratio of number of combine harvester + tractor to agricultural land to county area	2016	+	0.095	Statistical yearbook of Iran	-
	Agricultural yield (AY)	Ratio of agricultural production to cultivated area	2018	+	0.075	AREEO	-




Caspian Sea
TURKMENISTAN
Tabriz
Ardabil
Urmia
Rasht
Zanjan
Qazvin
Gorgan
Mashhad
Tehran
Semnan
Sanandaj
Hamadan
Qom
Ilam
Khorramabad
Birjand
Isfahan
Yazd
IRAQ
Ahvaz
Yasuj
Zabol
Kerman
Shiraz
Zahedan
Bushehr
SAUDI ARABIA
Persian Gulf
Bandar Abbas
AFGHANISTAN
PAKISTAN
Oman Sea
Very high
High
Medium
Low
Very low
County-scale rural vulnerability to SDS
200 KM


Caspian Sea
TURKMENISTAN
East Azerbaijan
Ardebil
West Azerbaijan
Gilan
Zanjan
Qazvin
Golestan
North Khorasan
Mazandaran
Alborz
Razavi Khorasan
Kordestan
Tehran
Semnan
Hamedan
Qom
Kermanshah
Markazi
Lorestan
Esfahan
South Khorasan
Ilam
IRAQ
Chaharmahal and Bakhtiari
Yazd
Khuzestan
Kohgiluyeh and Boyer-Ahmad
Kerman
Bushehr
Fars
Sistan and Baluchestan
SAUDI ARABIA
Persian Gulf
Hormozgan
AFGHANISTAN
PAKISTAN
Oman Sea
Very high
High
Medium
Low
Very low
Province-scale rural vulnerability to SDS
200 KM


Percent
0
10
20
30
40
Village
Households
Rural population
26.7
35.8
34.9
17.1
18.0
17.9
30.2
28.2
29.1
23.5
16.8
16.8
2.5
1.2
1.3
Very low
Low
Medium
High
Very high
Vulnerability class

Int J Appl Earth Obs Geoinformation 88 (2020) 102082

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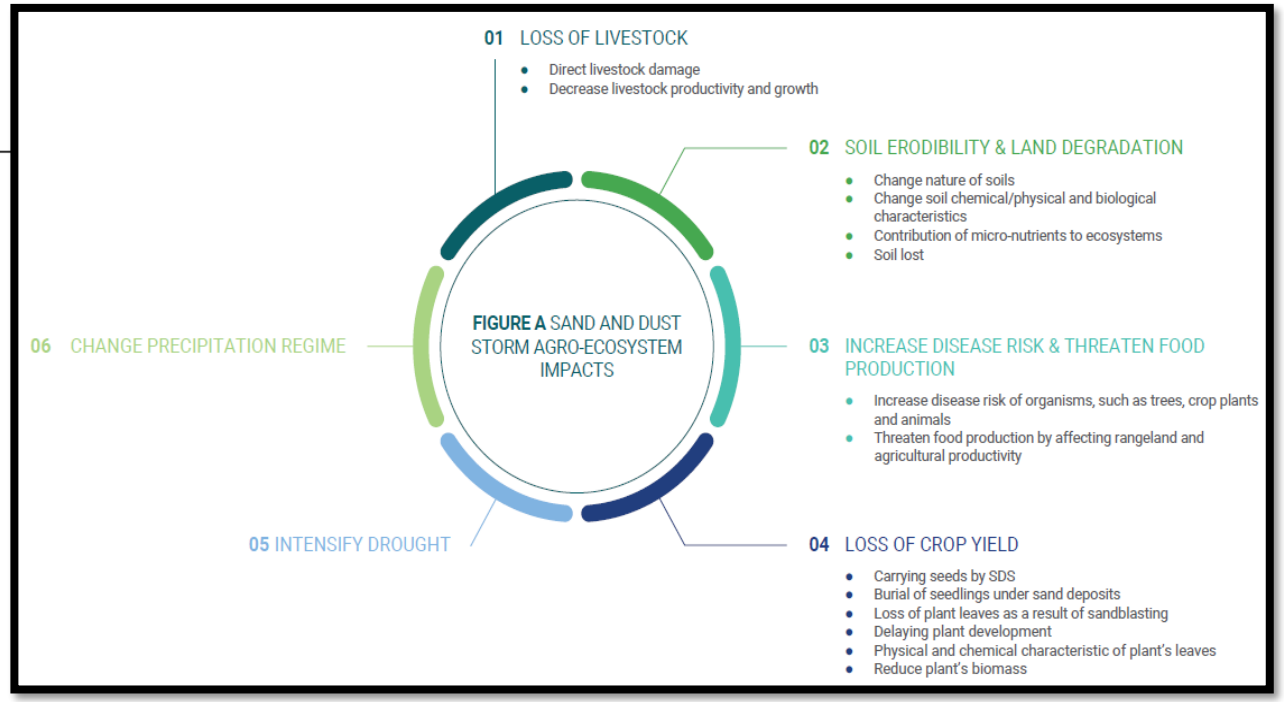
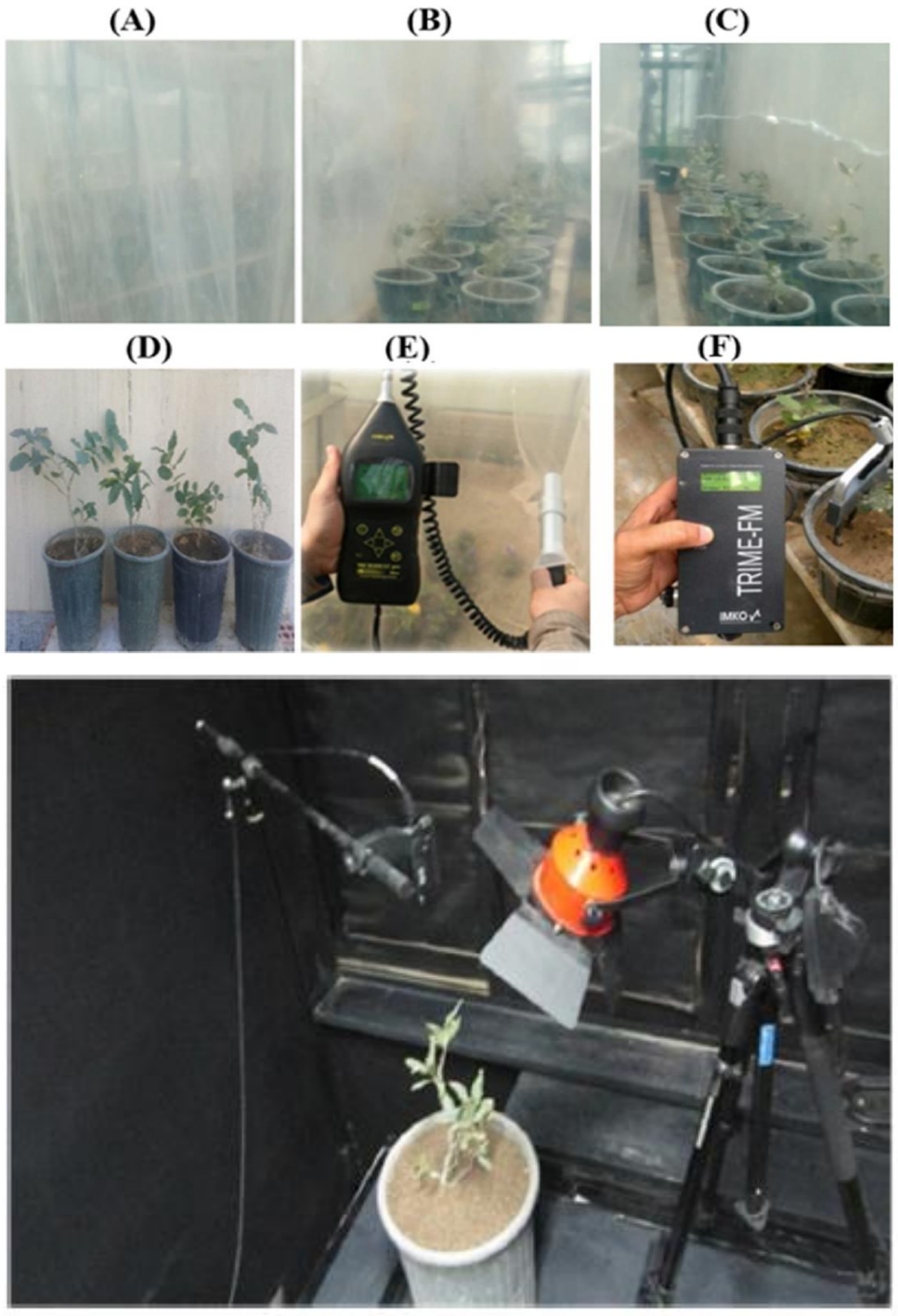
University of Tehran

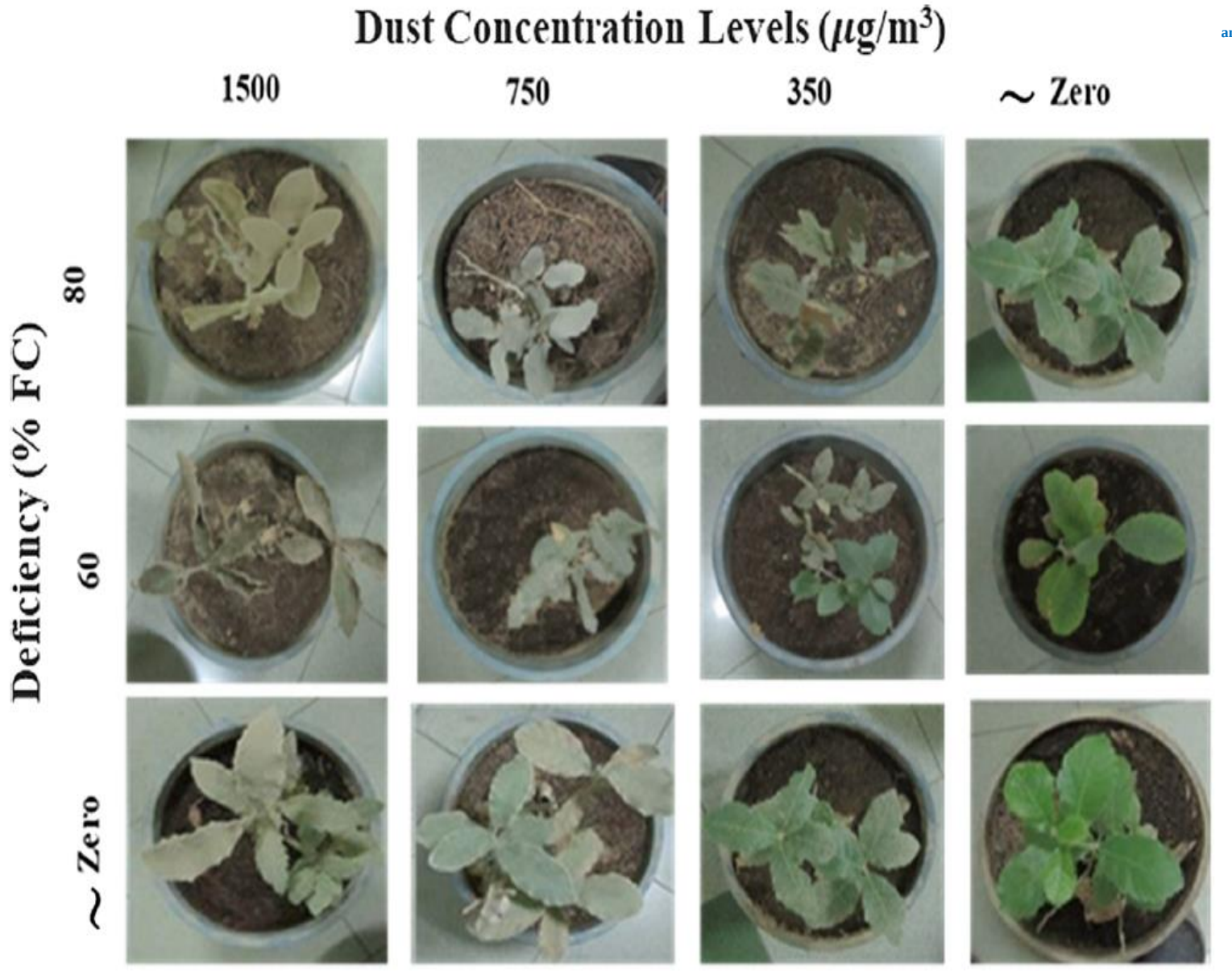
Spectral behavior of Persian oak under compound stress of water deficit and dust storm

Ali Darvishi Boloorani[a,b,*], Saba Ranjbareslamloo[b], Saham Mirzaie[b], Hossein Ali Bahrami[c], Fardin Mirzapour[d], Nadia Abbaszadeh Tehrani[e]

[a] Key Laboratory of Digital Land and Resources, East China University of Technology, Nanchang, Jiangxi, PR China
[b] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran
[c] Department of Soil Science, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran
[d] Department of Electrical Engineering-Sadra Institute of Higher Education, Tehran, Iran
[e] Aerospace Research Institute, Ministry of Science, Research and Technology of Iran, Tehran, Iran




(A)
(B)
(C)
(D)
(E)
(F)
TRIME-FM
IMKO


Dust Concentration Levels (μg/m³)
1500
750
350
~ Zero
Deficiency (% FC)
80
60
~ Zero

Atmospheric Research 272 (2022) 106152

University of Tehran

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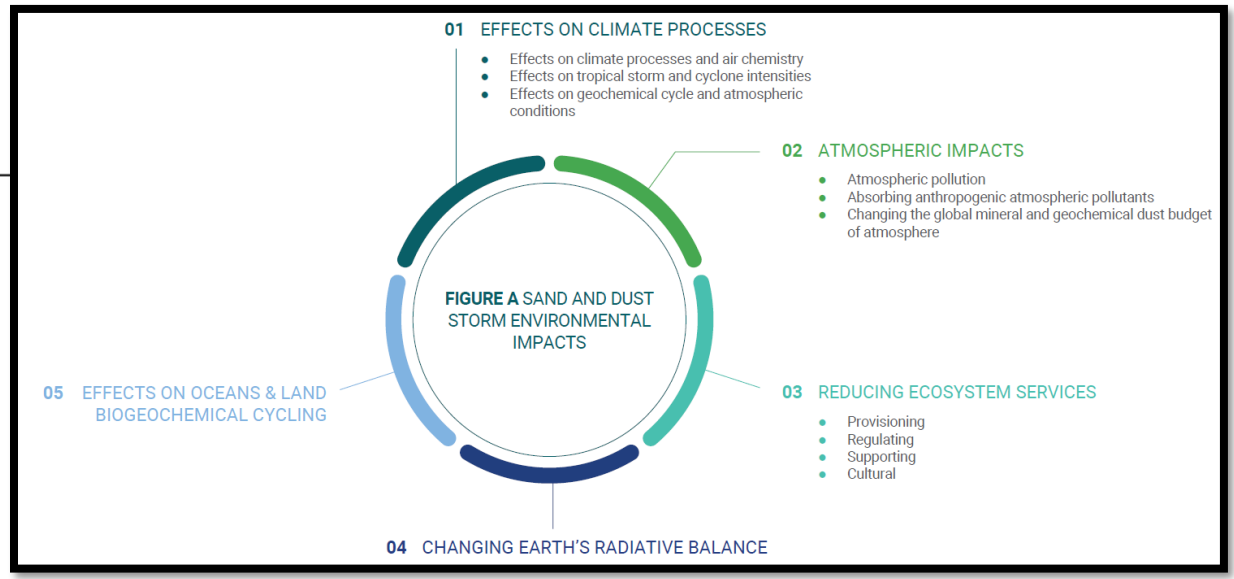
journal homepage: www.elsevier.com/locate/atmosres

Influence of Hamoun Lakes' dry conditions on dust emission and radiative forcing over Sistan plain, Iran

Ali Darvishi Boloorani [a,*], Mohammad Saeed Najafi [b], Masoud Soleimani [a], Ramin Papi [a,c], Omid Torabi [b]

[a] Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran, Tehran, Iran
[b] Department of Water Resources Study and Research, Water Research Institute, Tehran, Iran
[c] National Cartographic Center (NCC), Tehran, Iran



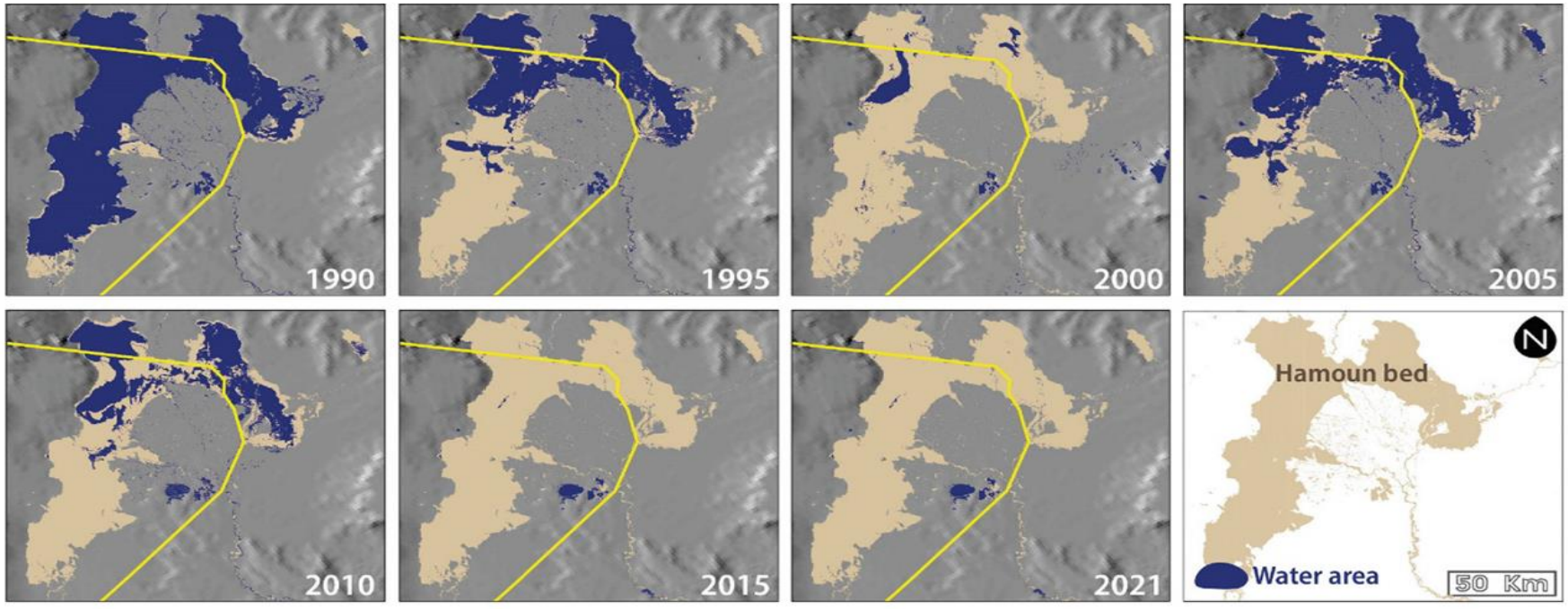
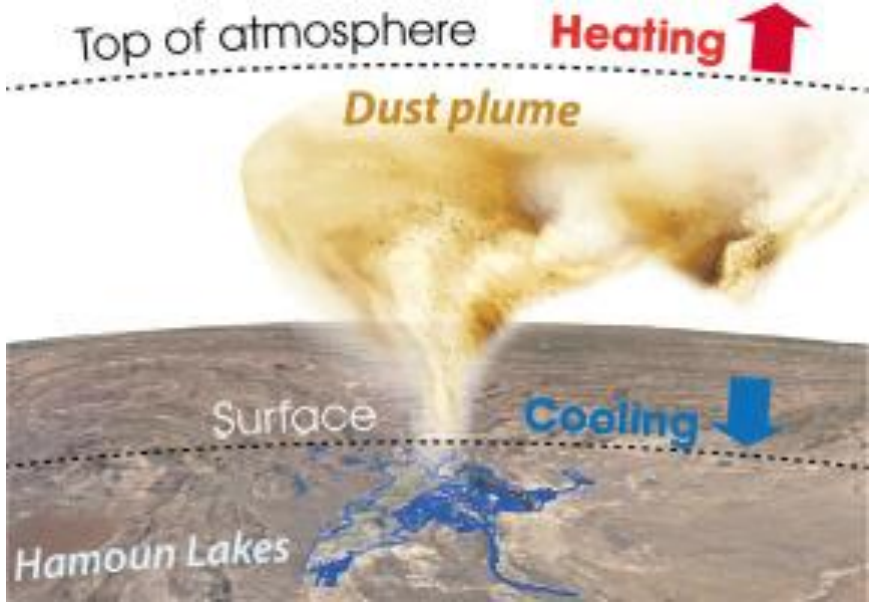


Fig. 4. The 5-year spatial-temporal changes in the area of water bodies in Sistan plain, extracted from MNDWI based on Landsat 5, 7, and 8 long-term multi-spectral data archive.



Natural Hazards
https://doi.org/10.1007/s11069-021-04828-0

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ORIGINAL PAPER

Check for updates

Role of land surface parameter change in dust emission and impacts of dust on climate in Southwest Asia

Ali Darvishi Boloorani[1,2] · Mohammad Saeed Najafi[3] · Saham Mirzaie[2]

Received: 7 September 2020 / Accepted: 26 May 2021

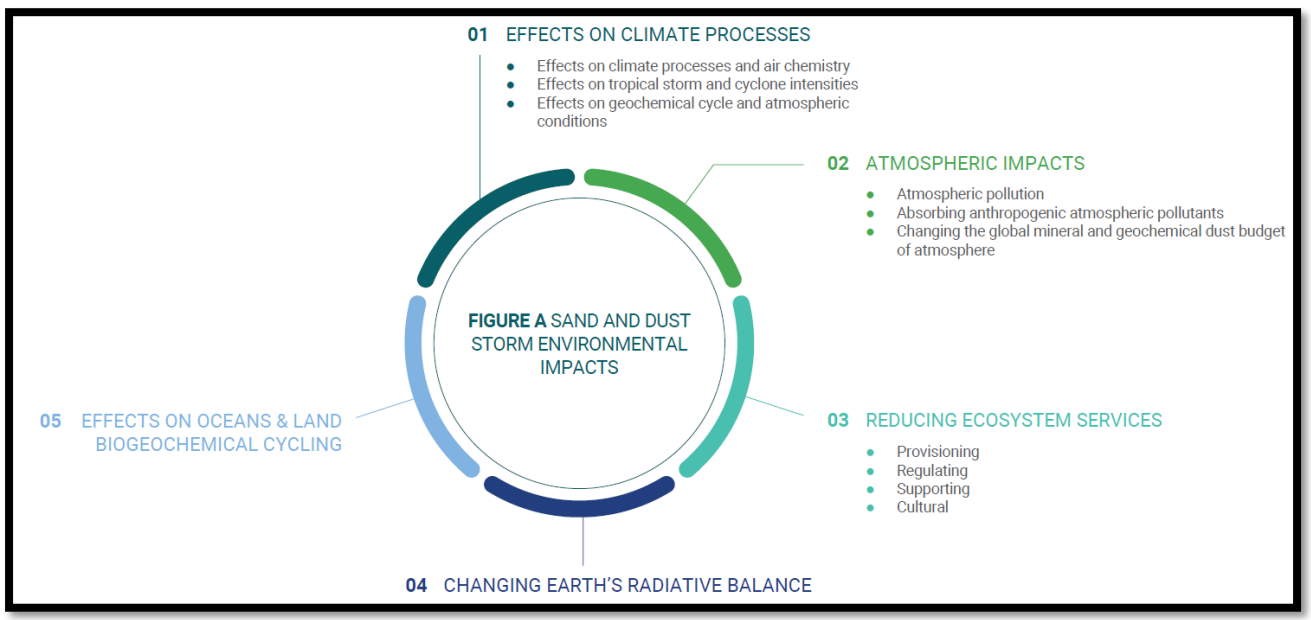

FIGURE A SAND AND DUST STORM ENVIRONMENTAL IMPACTS

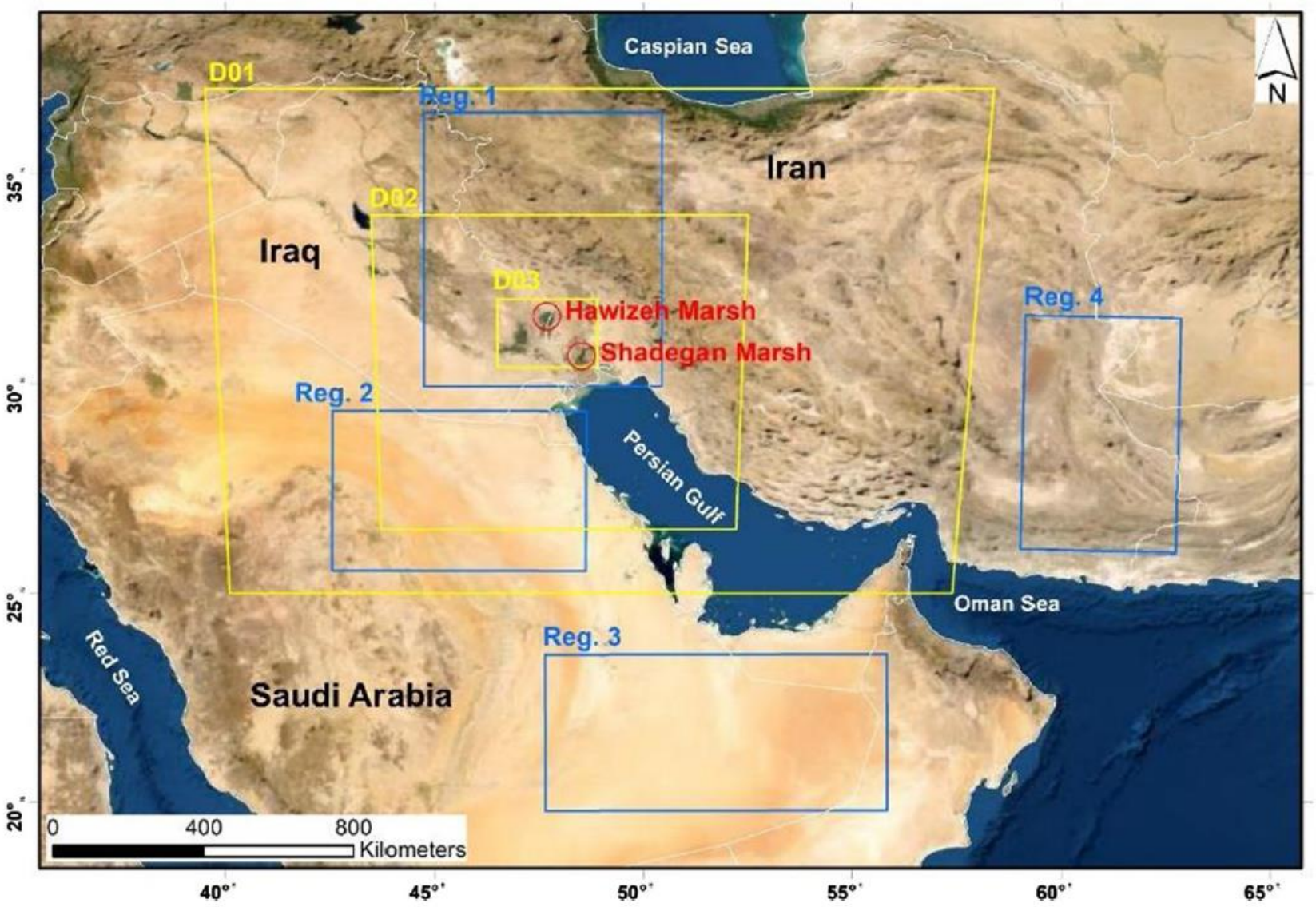

Fig. 1 Study area in Southwest Asia. Blue boxes are the target regions (Reg.) of RegCM simulation modeling. Yellow boxes are multiple-nested domains (D) model configuration for numerical simulations of WRF-Chem, with the horizontal grid spacing (spatial resolution) of 24 km, 8 km, and 2.66 km, respectively. Red circles are two marshes with the highest changes in land surface parameters

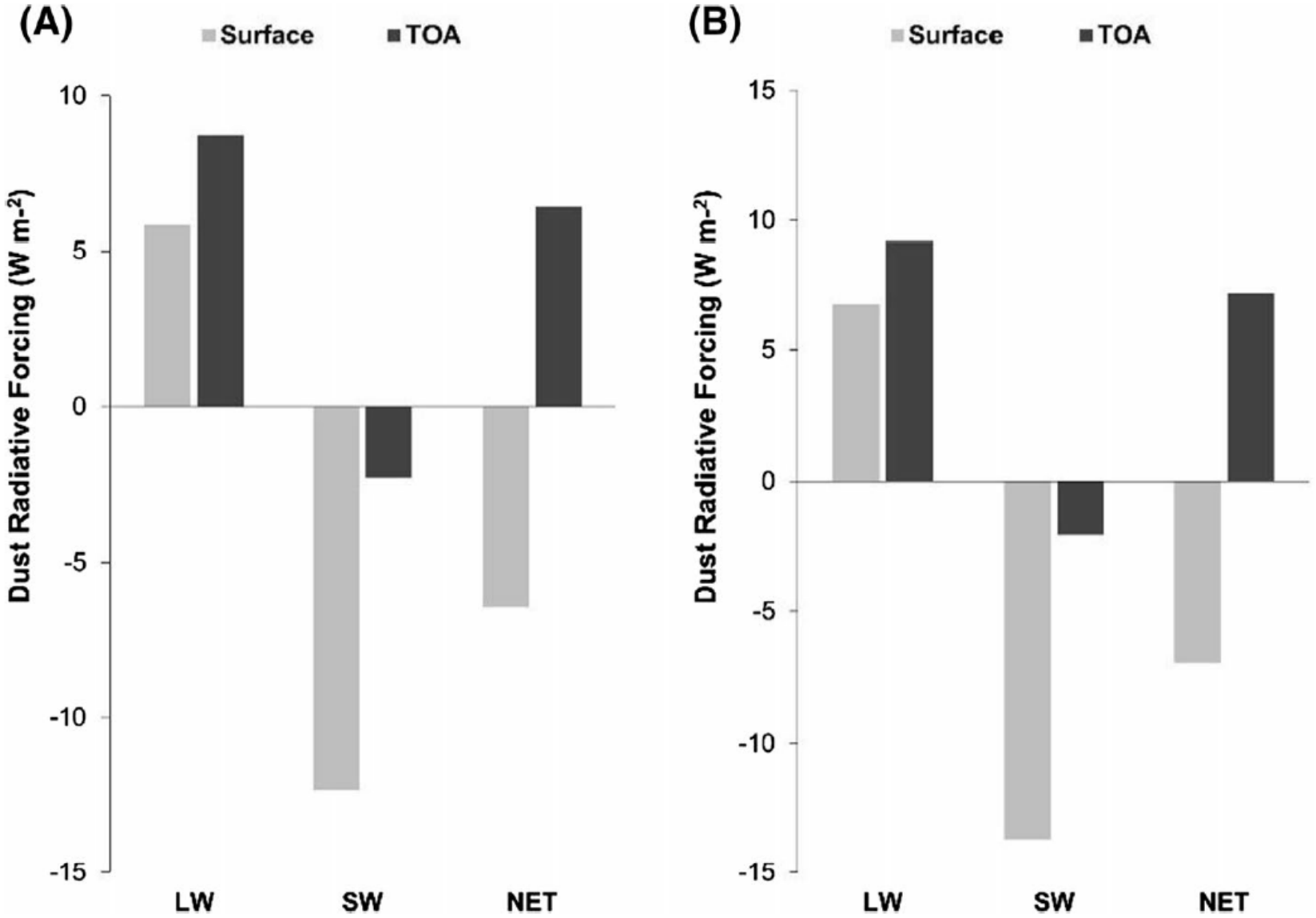

Fig. 12 Surface and TOAs' different dust radiative forcing (longwave LW, shortwave SW, and net radiation NET) using WRF-Chem simulations on the investigation area of Fig. 10a, in two modes: **a** unchanged land cover (Fig. 10b) and **b** changed land cover (Fig. 10c)

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Dust Disaster Risk Reduction by Contingency Planning

General Steps of Contingency Planning for the Reduction and Management of Dust Disaster Risks

I. **Identify and assess risks:** Conduct a comprehensive assessment of potential hazards and vulnerabilities in your area, taking into account historical data and local conditions.

II. **Develop a plan:** Create a disaster risk reduction plan that outlines strategies for prevention, preparedness, response, and recovery.

III. **Implement the plan:** Put the plan into action by building infrastructure, establishing early warning systems, developing community-based disaster management teams, and training personnel.

IV. **Monitor and evaluate:** Continuously monitor the effectiveness of the plan to ensure it is functioning as intended and make necessary adjustments based on feedback and results.

V. **Maintain preparedness:** Keep emergency supplies stocked and regularly practice procedures to ensure readiness in the event of a disaster.

VI. **Educate and inform the public:** Raise awareness about disaster risks and encourage individuals and communities to take action to reduce their vulnerability.

Contingency Planning for the Reduction and Management of Dust Disaster Risks for Achieving SDGs and Sendai Framework Priorities

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It directly works towards achieving SDGs 2, 3, 11, 13, 15.

SDG2 (Zero hunger): SDS can harm crops, livestock, and agriculture, affecting food quality and security. Tackling it at the source helps enhance productivity.

SDG3 (Good health and well-being): SDS air pollution threatens human health, linked to respiratory and cardiovascular diseases.

SDG11 (Sustainable cities and communities): Taking measures to reduce SDS disasters will result in fewer people affected and less economic damage, promoting safer, sustainable, and resilient human settlements.

SDG13 (Climate action): Enhancing the utilization and supervision of land/water resources in SDS source regions will play a significant role in establishing landscapes and communities that are resilient to climate change.

SDG16 (Life and land): Enhancing the sustainable utilization of terrestrial ecosystems can be achieved by mitigating SDS source regions, thereby promoting land degradation neutrality.

It also aligns with the Sendai Framework Priorities 1, 2, and 4

Priority 1 (Understanding of SDS risk),

Priority 2 (Strengthening SDS risk governance),

Priority 4 (Enhancing SDS disaster preparedness) for Disaster Risk Reduction.

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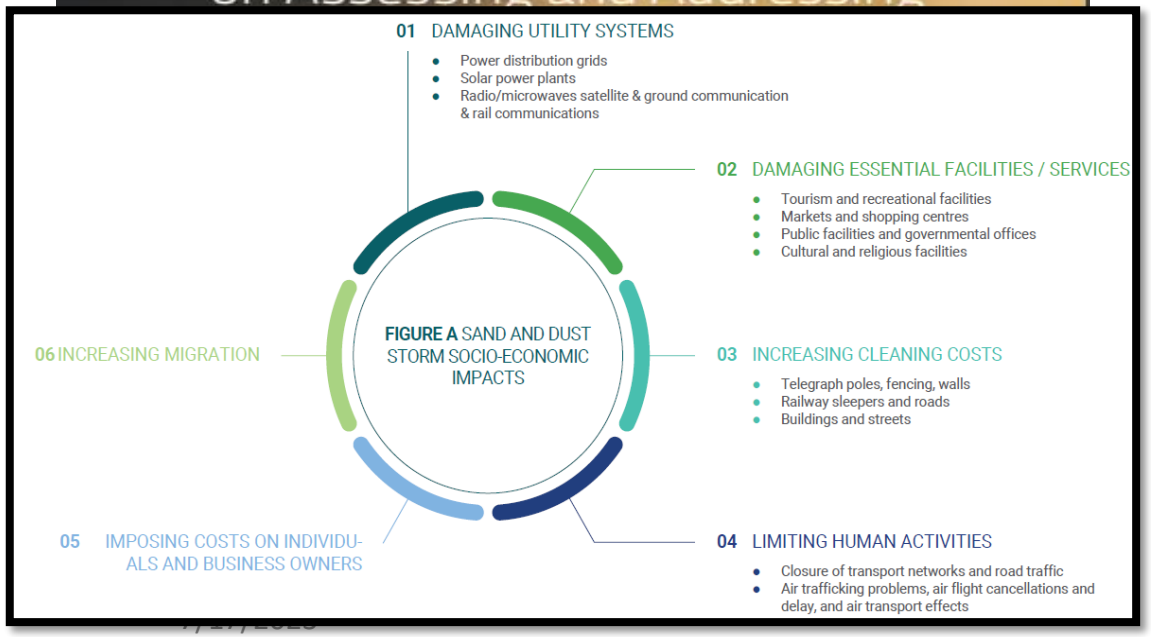
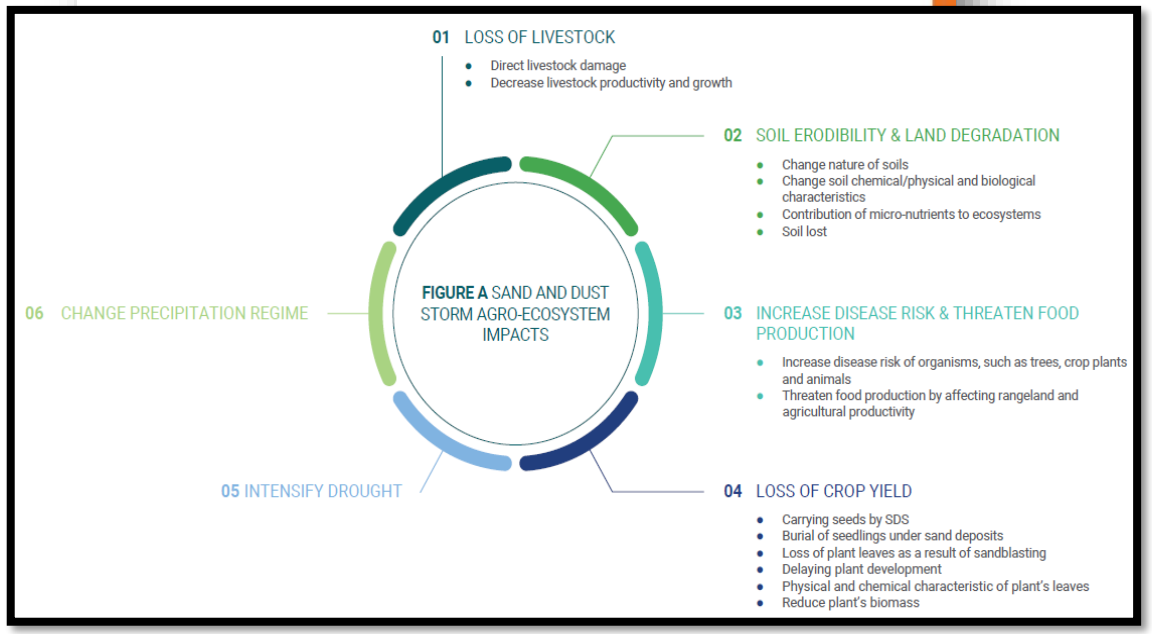
7. A geographic information system-based sand and dust storm vulnerability mapping framework

Chapter overview

This chapter provides a sand and dust storms (SDS)-focused process to assess vulnerability using geographic information system (GIS) procedures where data availability or quality is not a critical issue. The chapter provides a flow chart for GIS-based vulnerability assessment and conceptual models of how SDS affect the health, socio-economic, environmental and agro-ecological domains of a vulnerable area (from local to global). Detailed attention is paid to the selection of vulnerability indicators (including tables of possible indicators). The chapter includes specific formula to produce vulnerability maps using a GIS platform.

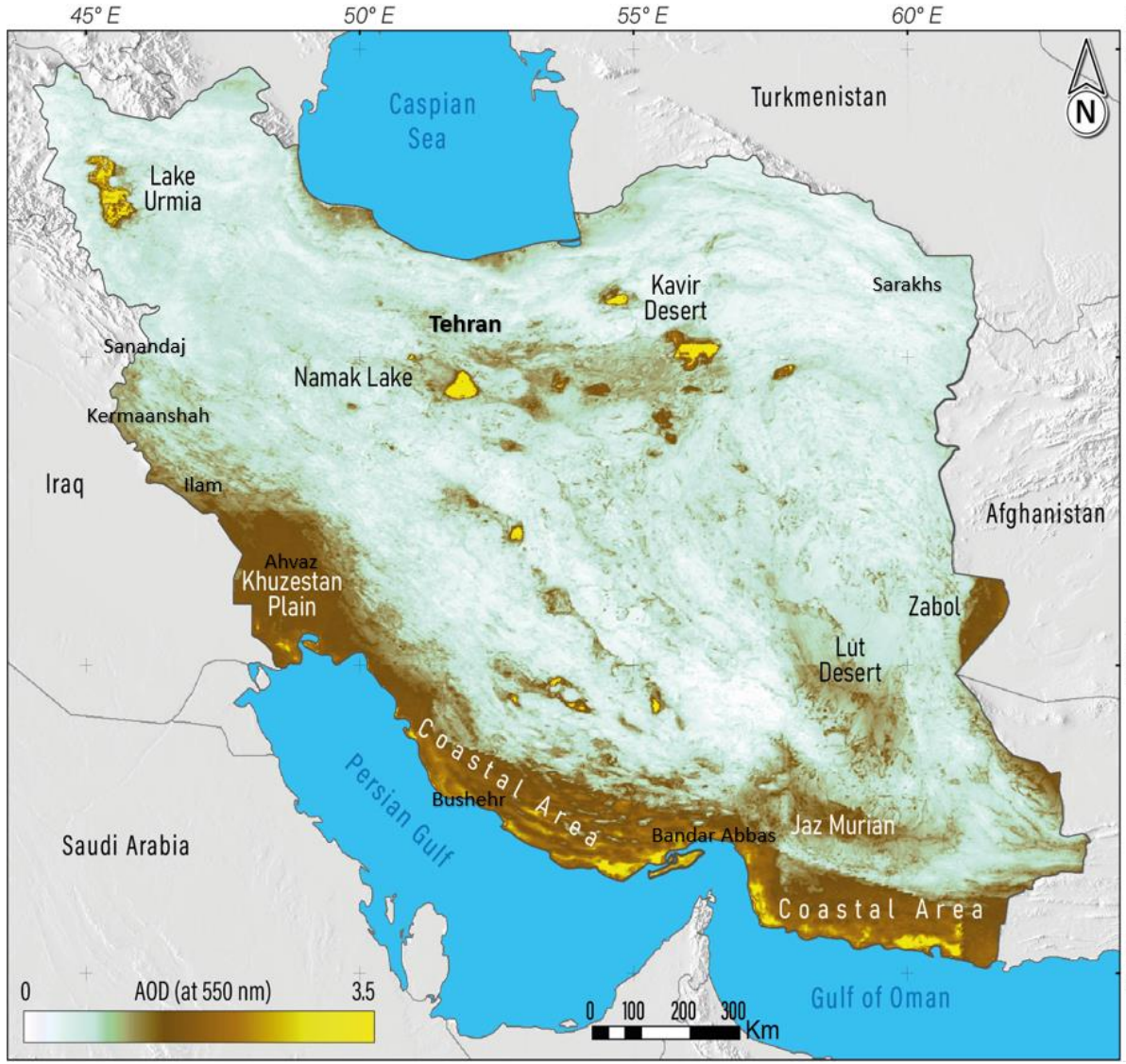
This chapter should be read in conjunction with chapters 3, 4, 5 and 6.

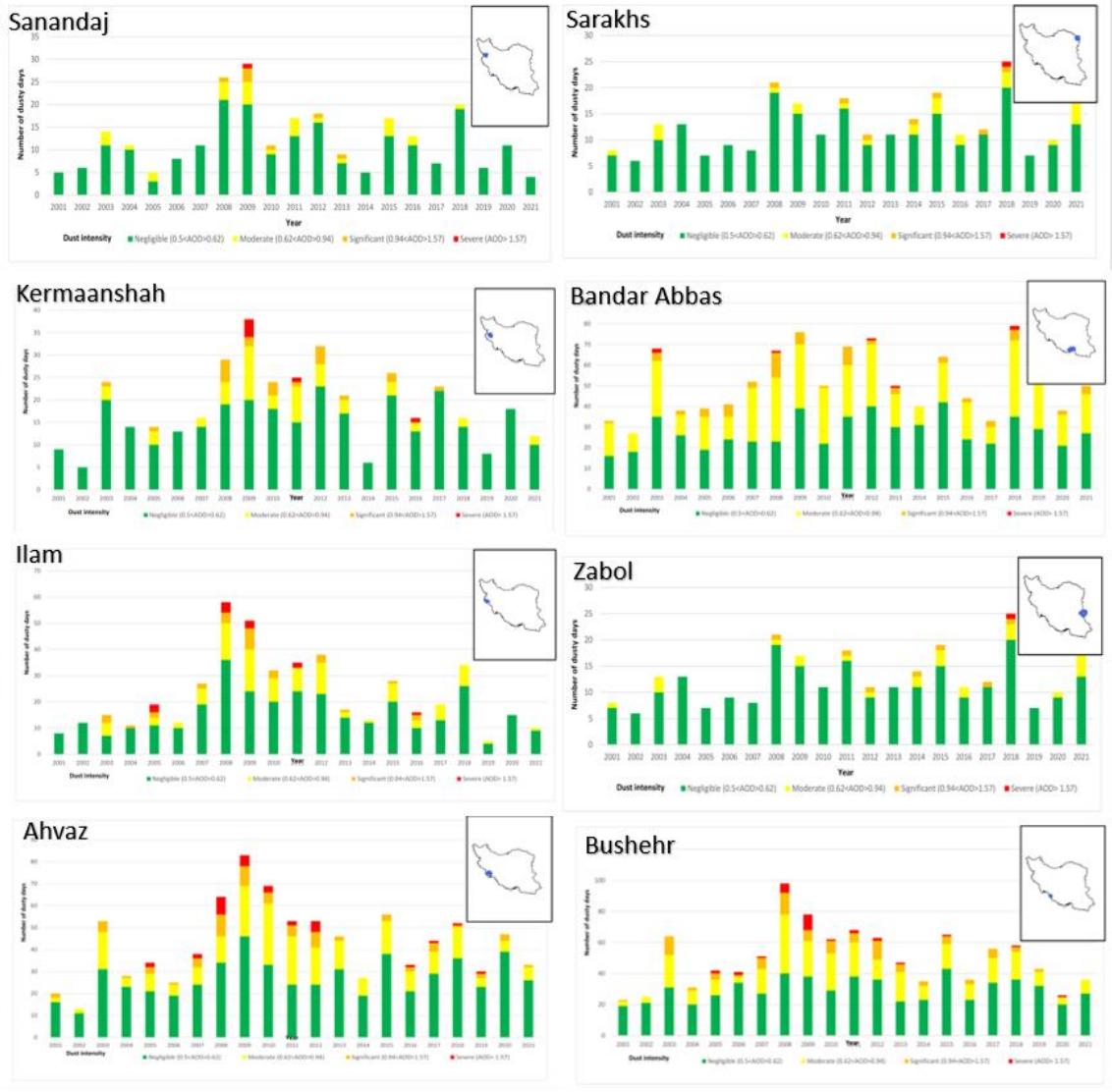


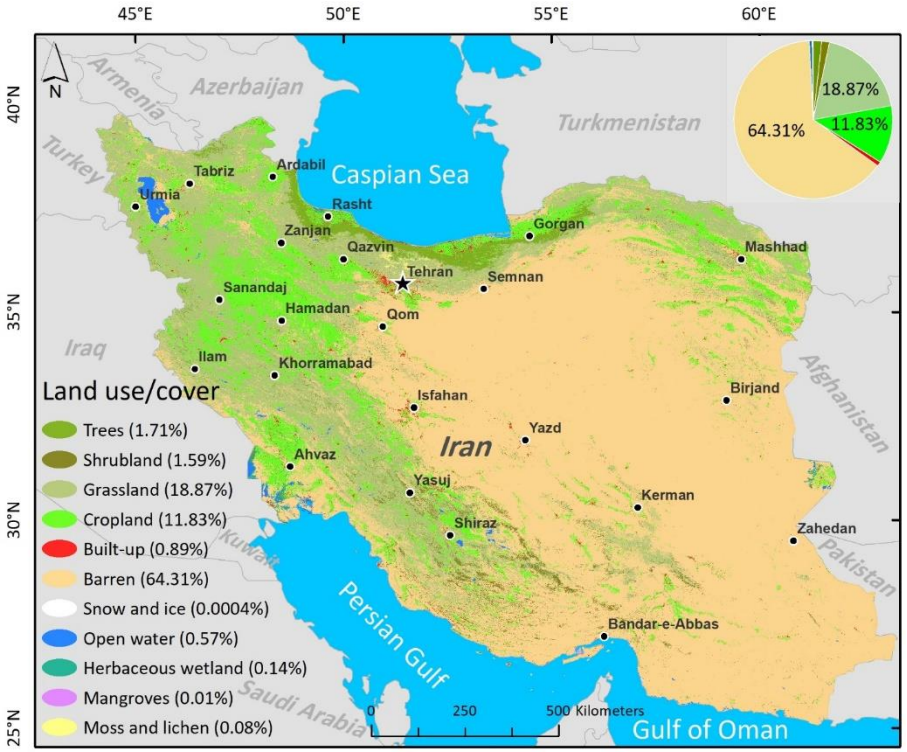


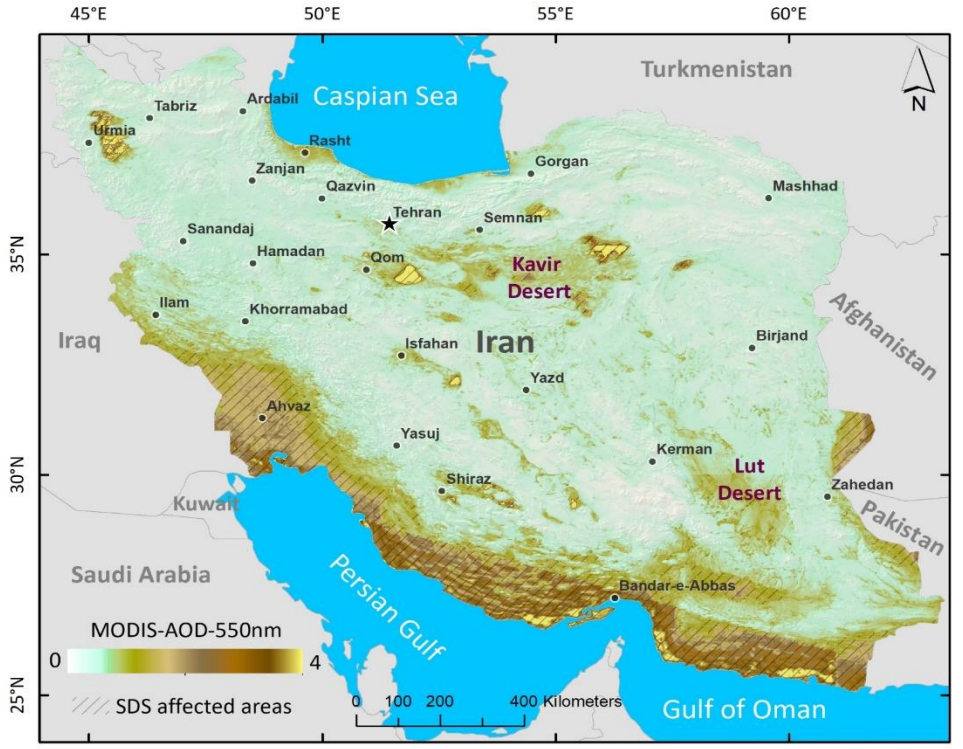
FAO-Project (2021-2022):

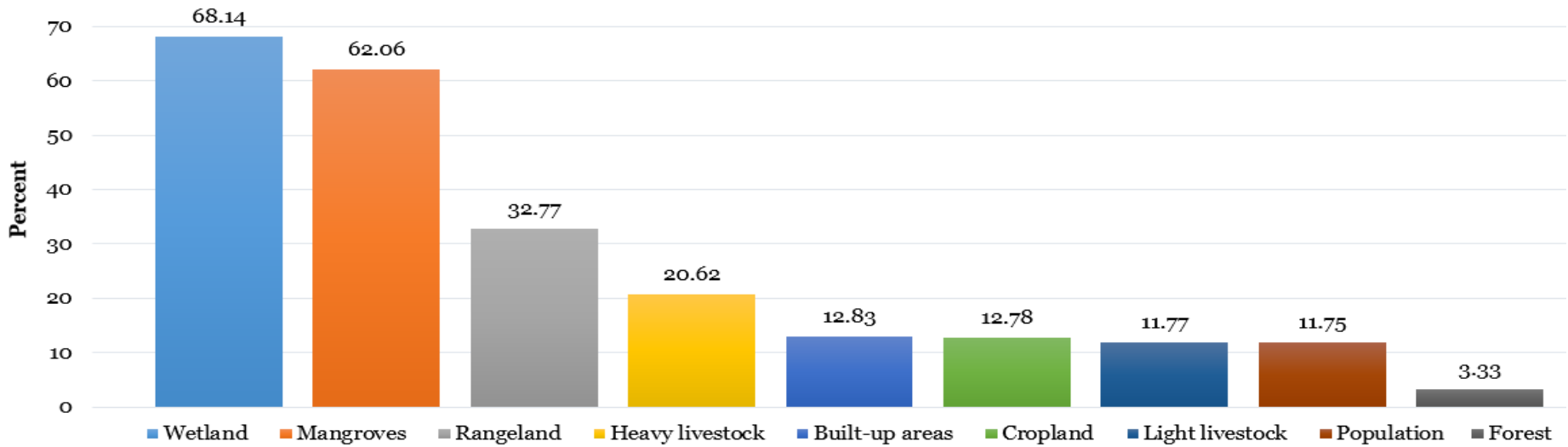
Develop contingency plan for catalysing investments and actions to enhance resilience against sand and dust storms in agriculture in Iran - an agricultural perspective


45° E
50° E
55° E
60° E
40° N
35° N
30° N
25° N
N
Caspian Sea
Turkmenistan
Lake Urmia
Kavir Desert
Sarakhs
Tehran
Sanandaj
Namak Lake
Kermaanshah
Iraq
Ilam
Afghanistan
Ahvaz Khuzestan Plain
Zabol
Lut Desert
Coastal Area
Persian Gulf
Bushehr
Bandar Abbas
Jaz Murian
Saudi Arabia
Coastal Area
Gulf of Oman
0
AOD (at 550 nm)
3.5
0 100 200 300
Km


Sanandaj
Sarakhs
Kermaanshah
Bandar Abbas
Ilam
Zabol
Ahvaz
Bushehr
Number of dusty days
Year
Dust intensity


45°E
50°E
55°E
60°E
40°N
35°N
30°N
25°N
N
Armenia
Azerbaijan
Turkmenistan
Turkey
Iraq
Kuwait
Saudi Arabia
Afghanistan
Pakistan
Caspian Sea
Persian Gulf
Gulf of Oman
Iran
Tabriz
Ardabil
Urmia
Rasht
Zanjan
Qazvin
Gorgan
Mashhad
Tehran
Semnan
Sanandaj
Hamadan
Qom
Ilam
Khorramabad
Isfahan
Birjand
Yazd
Ahvaz
Yasuj
Kerman
Shiraz
Zahedan
Bandar-e-Abbas
18.87%
64.31%
11.83%
Land use/cover
Trees (1.71%)
Shrubland (1.59%)
Grassland (18.87%)
Cropland (11.83%)
Built-up (0.89%)
Barren (64.31%)
Snow and ice (0.0004%)
Open water (0.57%)
Herbaceous wetland (0.14%)
Mangroves (0.01%)
Moss and lichen (0.08%)
0
250
500 Kilometers


45°E
50°E
55°E
60°E
35°N
30°N
25°N
N
Turkmenistan
Caspian Sea
Iraq
Kuwait
Saudi Arabia
Afghanistan
Pakistan
Persian Gulf
Gulf of Oman
Iran
Kavir Desert
Lut Desert
Tabriz
Ardabil
Urmia
Rasht
Zanjan
Qazvin
Gorgan
Mashhad
Tehran
Semnan
Sanandaj
Hamadan
Qom
Ilam
Khorramabad
Isfahan
Birjand
Yazd
Ahvaz
Yasuj
Kerman
Shiraz
Zahedan
Bandar-e-Abbas
MODIS-AOD-550nm
0
4
SDS affected areas
0
100
200
400 Kilometers


Percent
70
60
50
40
30
20
10
0
68.14
62.06
32.77
20.62
12.83
12.78
11.77
11.75
3.33
Wetland
Mangroves
Rangeland
Heavy livestock
Built-up areas
Cropland
Light livestock
Population
Forest

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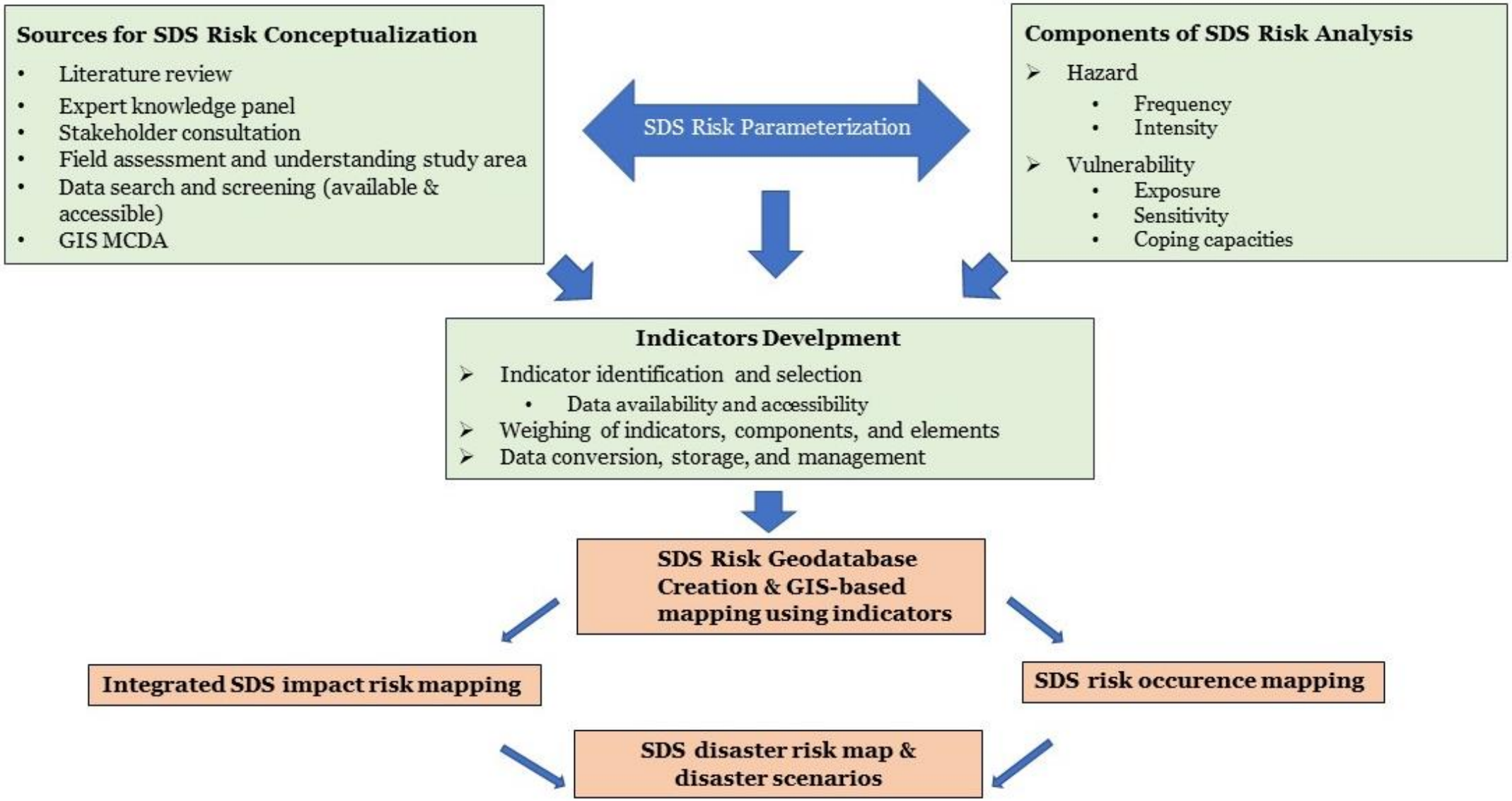
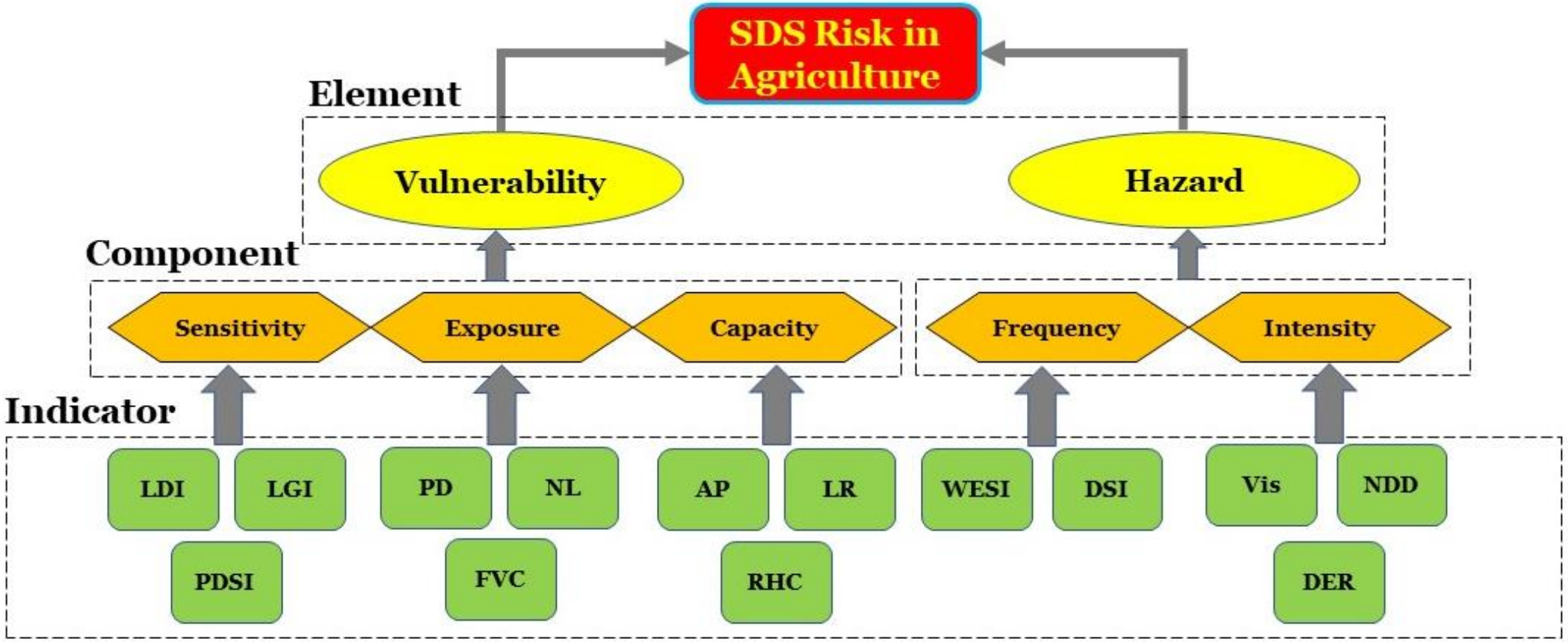
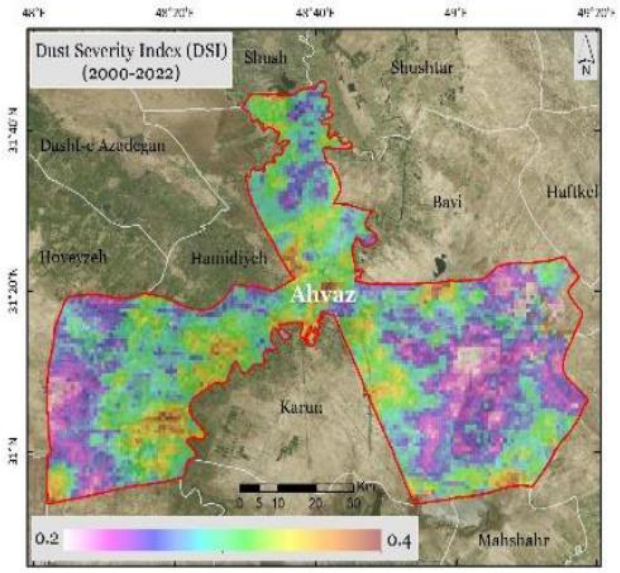
Sand and Dust Storms Risk Conceptualization

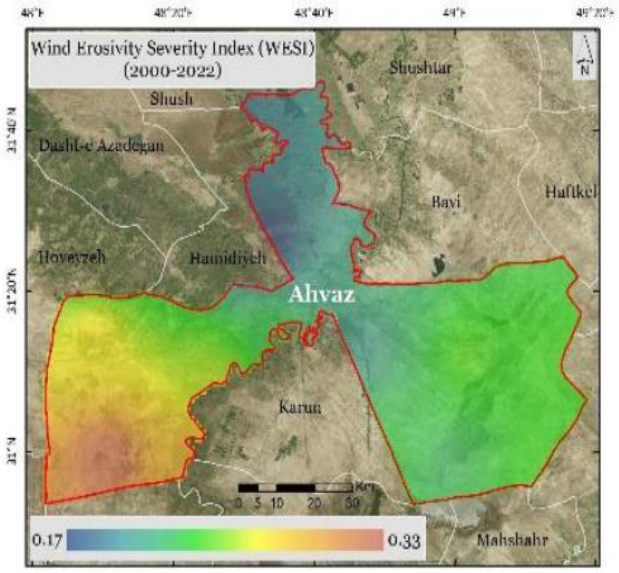


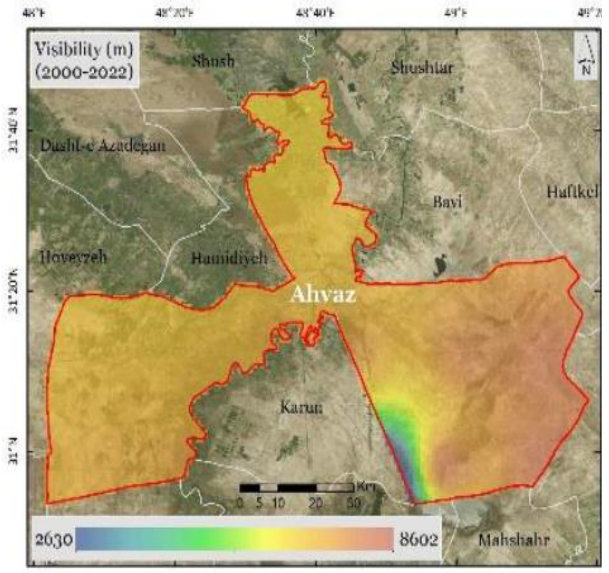


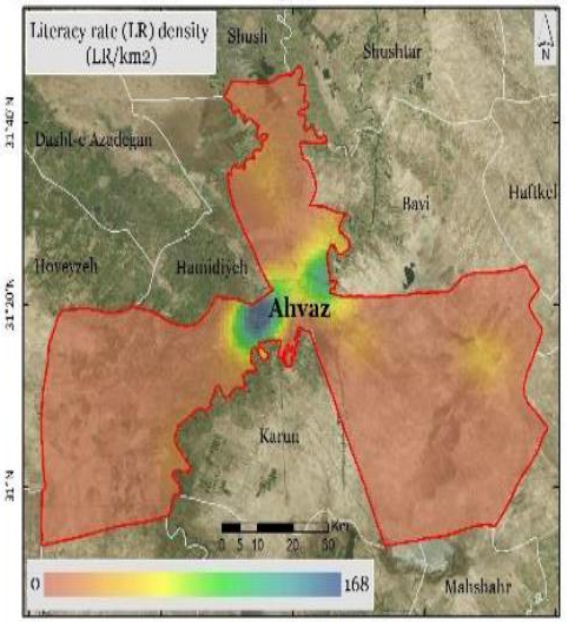
Indicator
Dust severity index (DSI)
Wind erosivity severity index (WESI)
Visibility (Vis)
Net dust deposition (NDD)
Dust emission rate (DER)
Palmer drought severity index (PDSI)
Livestock grazing index (LGI)
Land degradability index (LDI)
Population density (PD)
Number of livestock (NL)
Fractional vegetation cover (FVC)
Active population (AP) (15<age<65)
Literacy rate (LR)
Rural health centre (RHC)

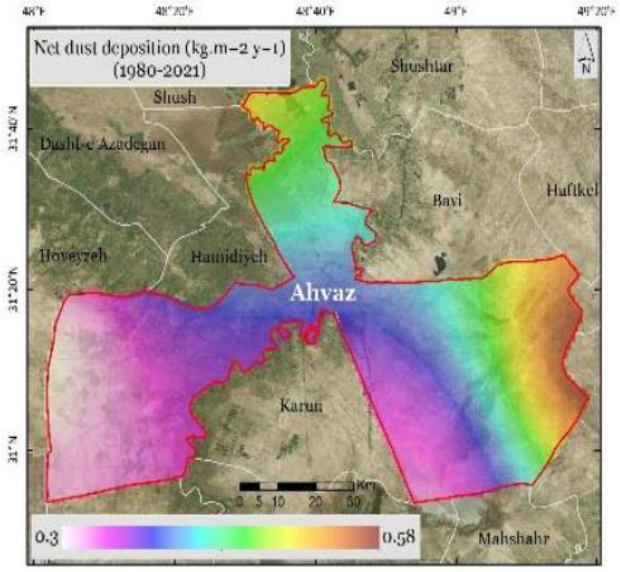
Concept	Element	Component	Indicator	Description	Source	Alternative source
SDS Risk	Hazard	Frequency	Dust severity index (DSI)	Dusty days in a year	(MODIS) products	Aerosol Robotic Network (AERONET)
			Wind erosivity severity index (WESI)	Wind speed (m/s) per dusty day	ERA5	National meteorological stations and Automated Surface Observing System
		Intensity	Visibility (Vis)	Average monthly visibility	Meteorological station	ASOS / AWOS METAR data
			Net dust deposition (NDD)	Net deposition (wet deposition + dry deposition)	MERRA-2	
			Dust emission rate (DER)	Direct impact on agriculture	MERRA-2 reanalysis products	
	Vulnerability	Sensitivity	Palmer drought severity index (PDSI)	Drought results in vegetation loss and topsoil erosion that reduces agricultural productivity	National Oceanic and Atmospheric Administration	
			Livestock grazing index (LGI)	Net primary production (NPP)-based grazing index	FAO NPP	Ground-based NPP and livestock statistics
			Land degradability index (LDI)	Land degradation is one of the main drivers of dust formation		
		Exposure	Population density (PD)	Number of people per unit area	National population and housing census	WorldPop
			Number of livestock (NL)	NL per unit area	National agriculture census	
			Fractional vegetation cover (FVC)	Calculated using the normalized difference vegetation index	MODIS NDVI	Landsat and Sentinel-2
		Coping capacity	Active population (AP) (15<age<65)	Ratio of active people to population		National population and housing census
			Literacy rate (LR)	Ratio of literate people to population		
			Rural health centre (RHC)	Ratio of number of health centres to population		

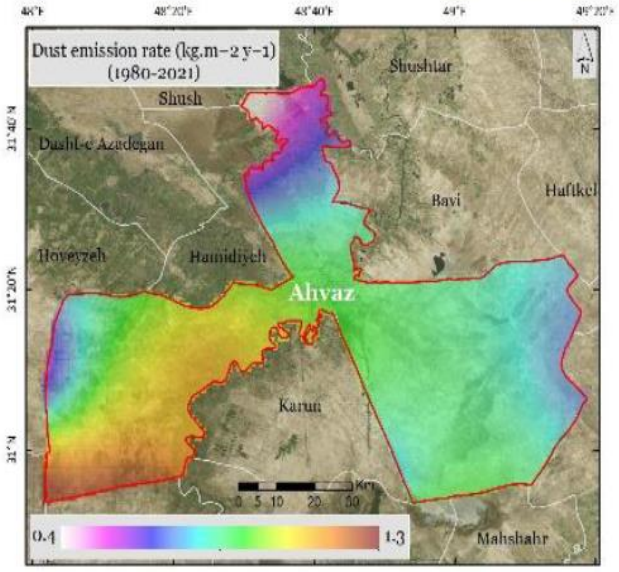

Dust Severity Index (DSI)
(2000-2022)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0.2
0.4

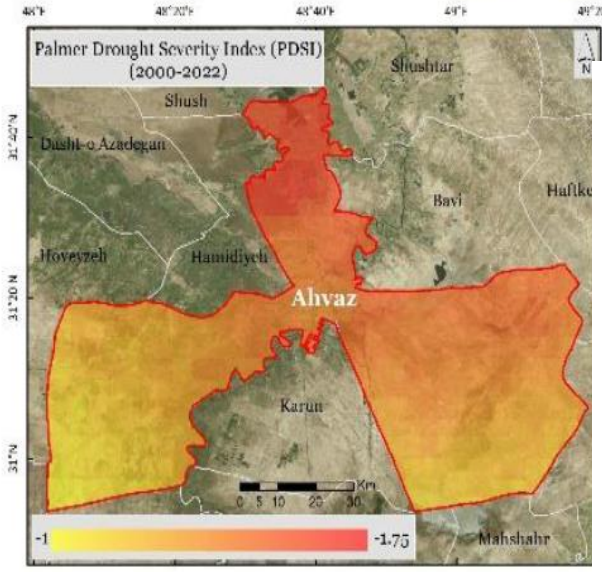

Wind Erosivity Severity Index (WESI)
(2000-2022)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0.17
0.33

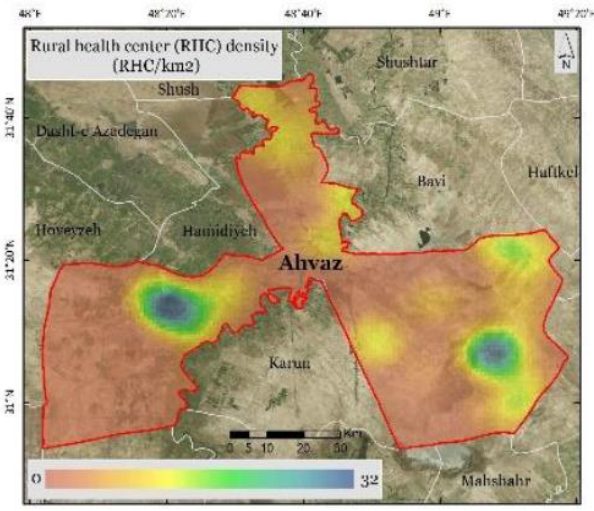

Visibility (m)
(2000-2022)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
2630
8602

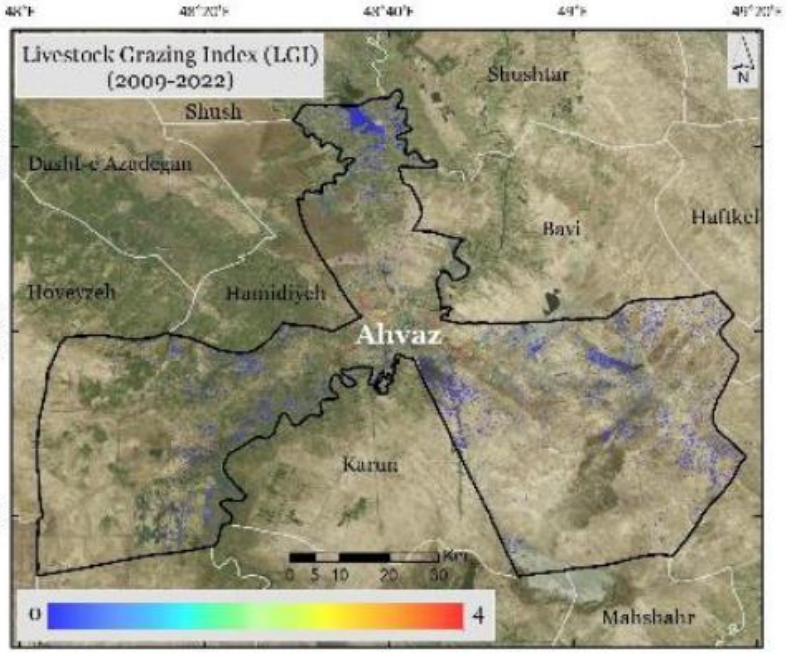

Literacy rate (LR) density
(LR/km2)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0
168

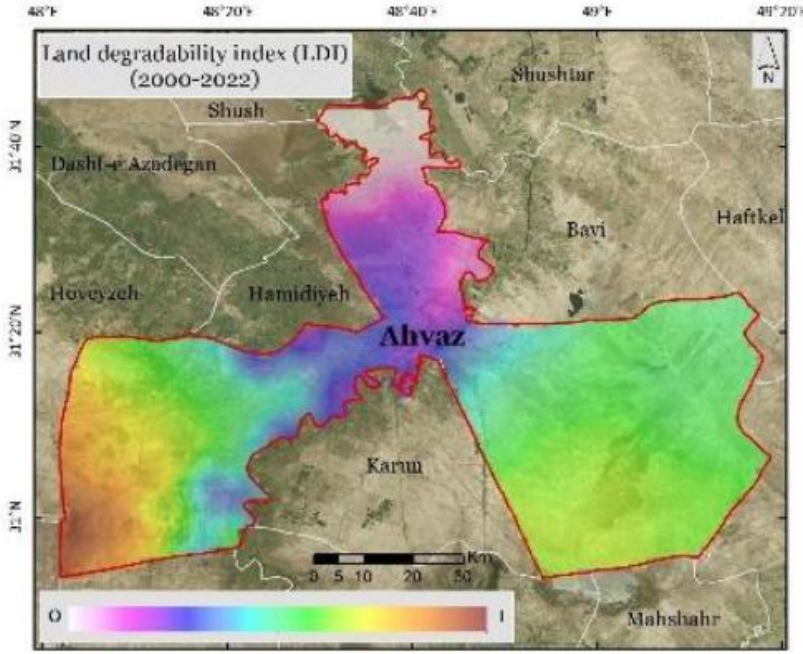

Net dust deposition (kg.m−2 y−1)
(1980-2021)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0.3
0.58

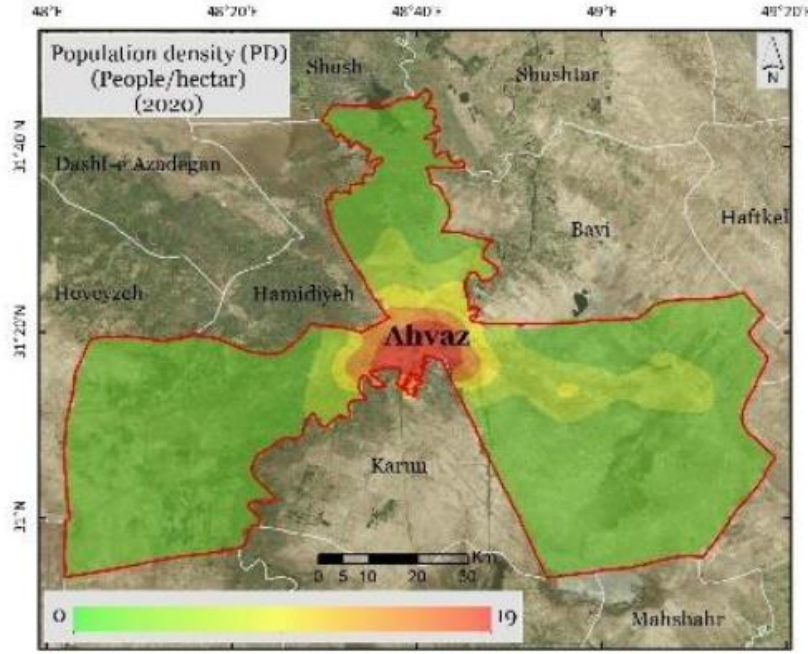

Dust emission rate (kg.m−2 y−1)
(1980-2021)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0.4
1.3

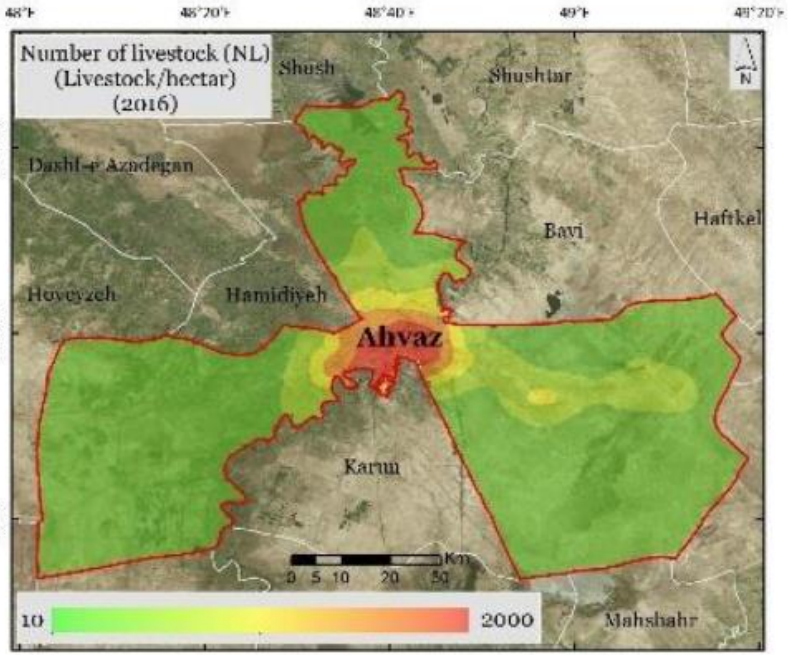

Palmer Drought Severity Index (PDSI)
(2000-2022)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
-1
-1.75

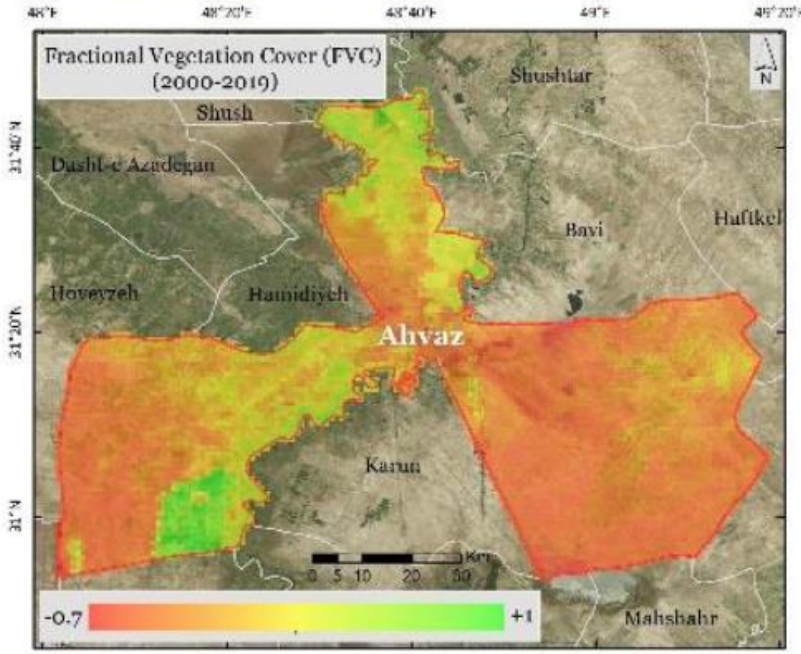

Rural health center (RHC) density
(RHC/km2)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0
32

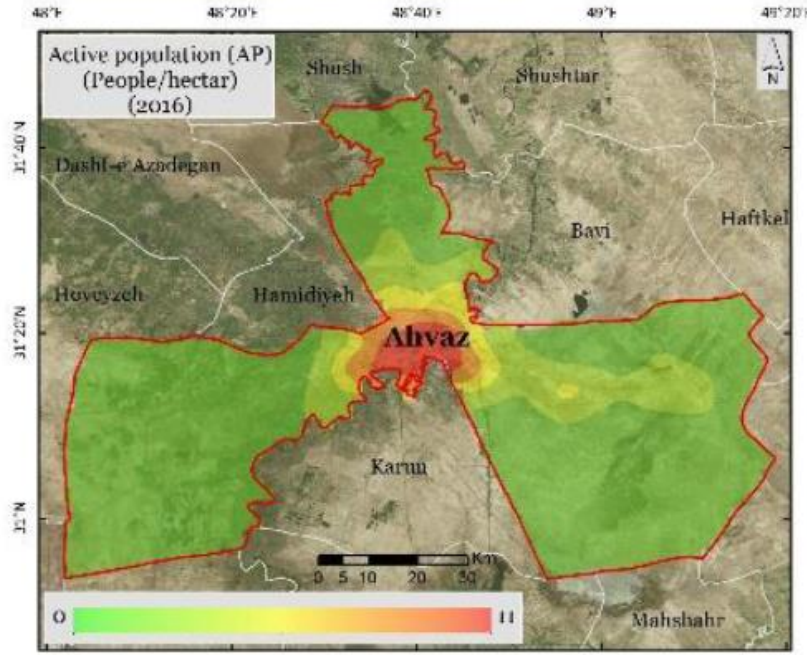

Livestock Grazing Index (LGI)
(2009-2022)
Shushtar
Shush
Dashl-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0
4

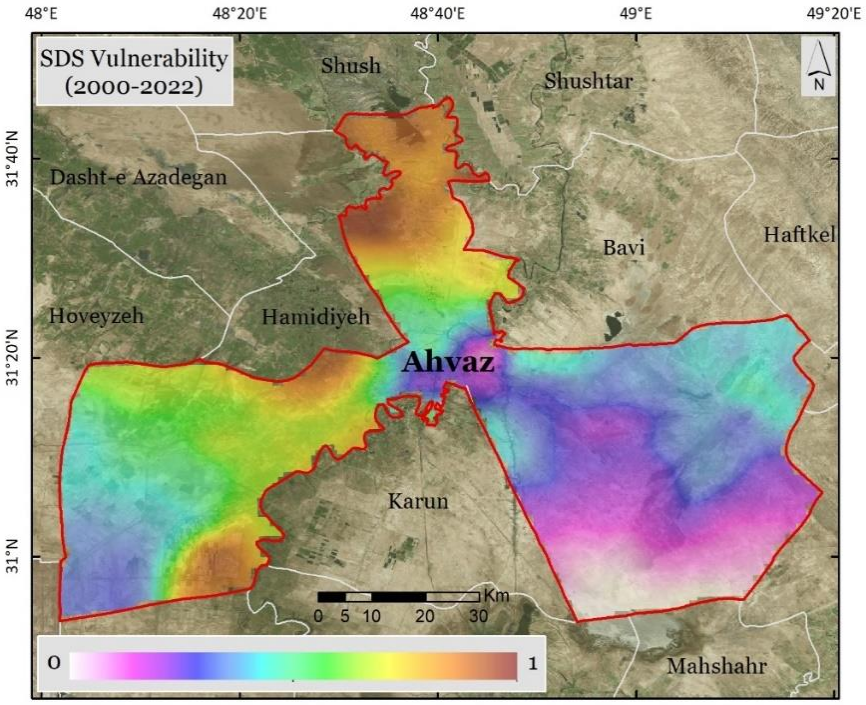

Land degradability index (LDI)
(2000-2022)
Shushtar
Shush
Dashl-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0
1

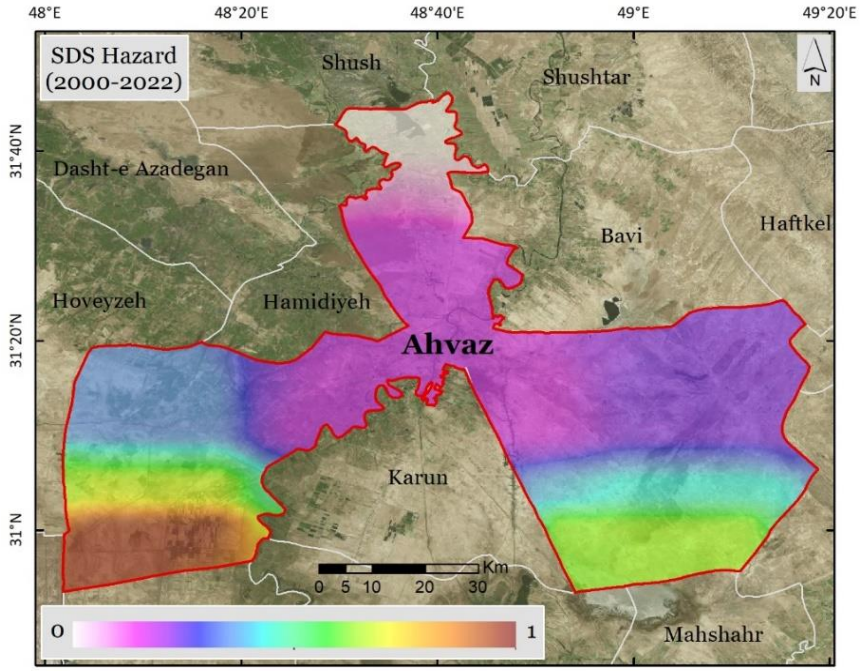

Population density (PD)
(People/hectar)
(2020)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0
19

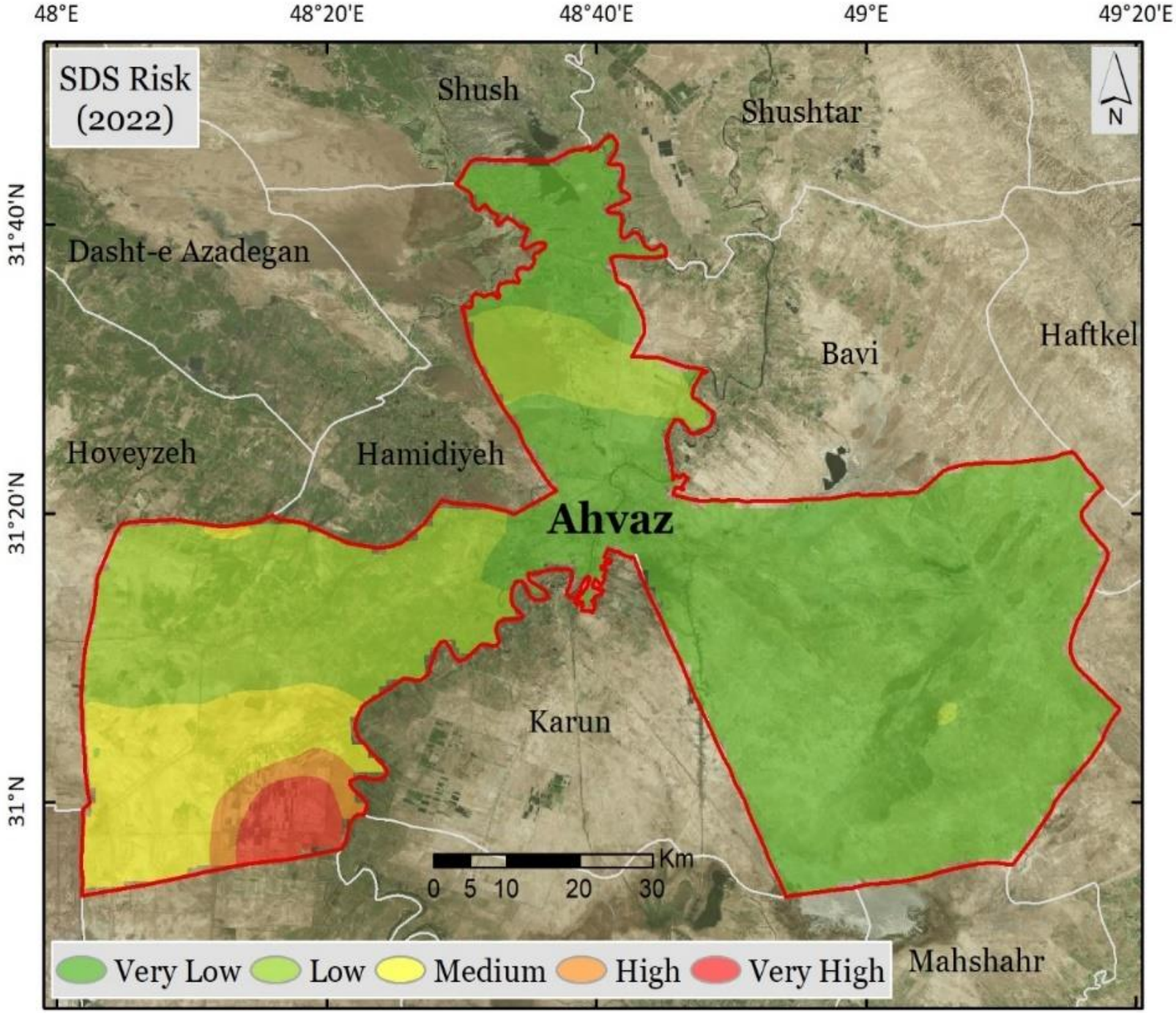

Number of livestock (NL)
(Livestock/hectar)
(2016)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
10
2000

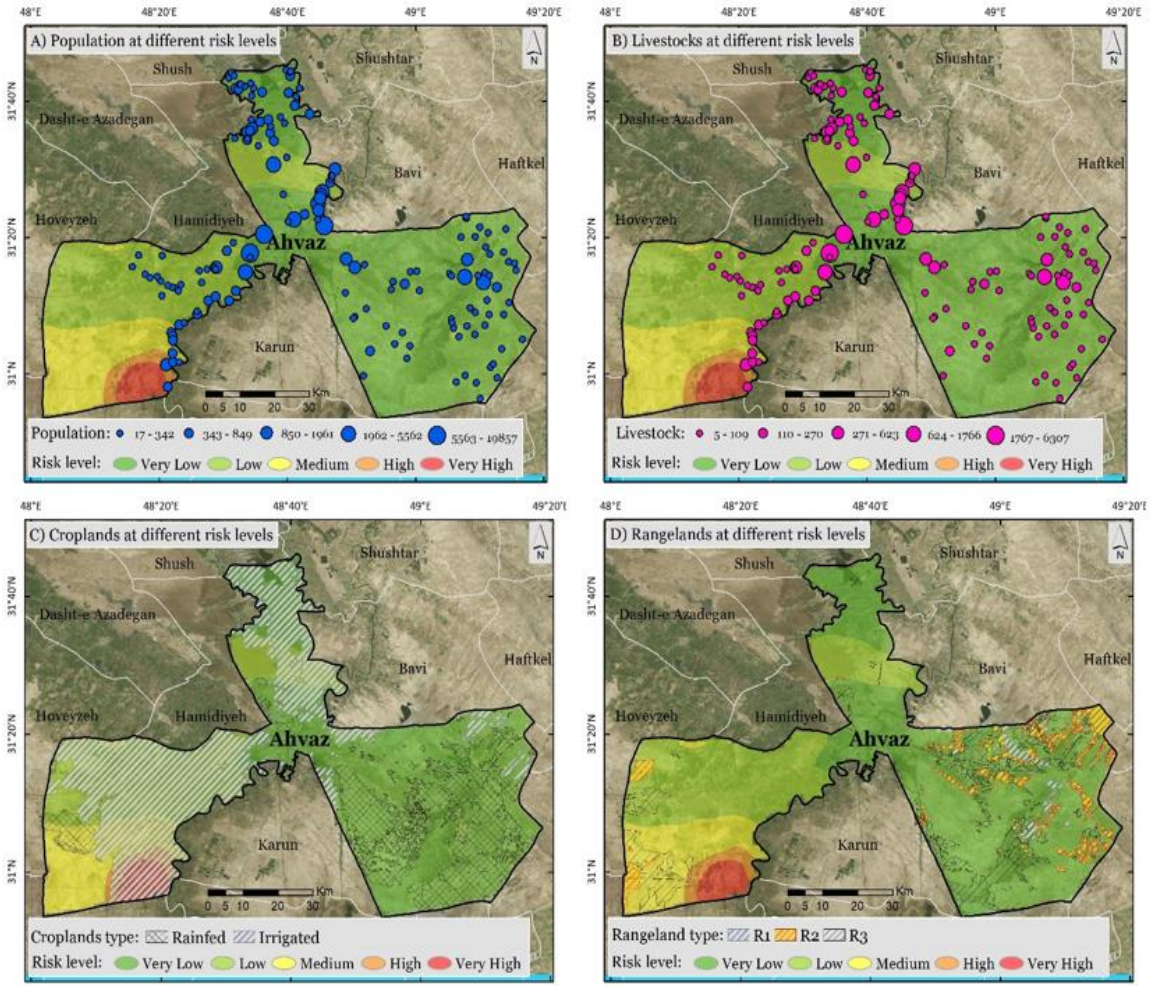

Fractional Vegetation Cover (FVC)
(2000-2019)
Shushtar
Shush
Dashl-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
-0.7
+1


Active population (AP)
(People/hectar)
(2016)
Shush
Shushtar
Dashl-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
0
11


SDS Vulnerability
(2000-2022)
48°E
48°20'E
48°40'E
49°E
49°20'E
31°40'N
31°20'N
31°N
Shush
Shushtar
Dasht-e Azadegan
Haftkel
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
N
Km
0 5 10 20 30
0
1

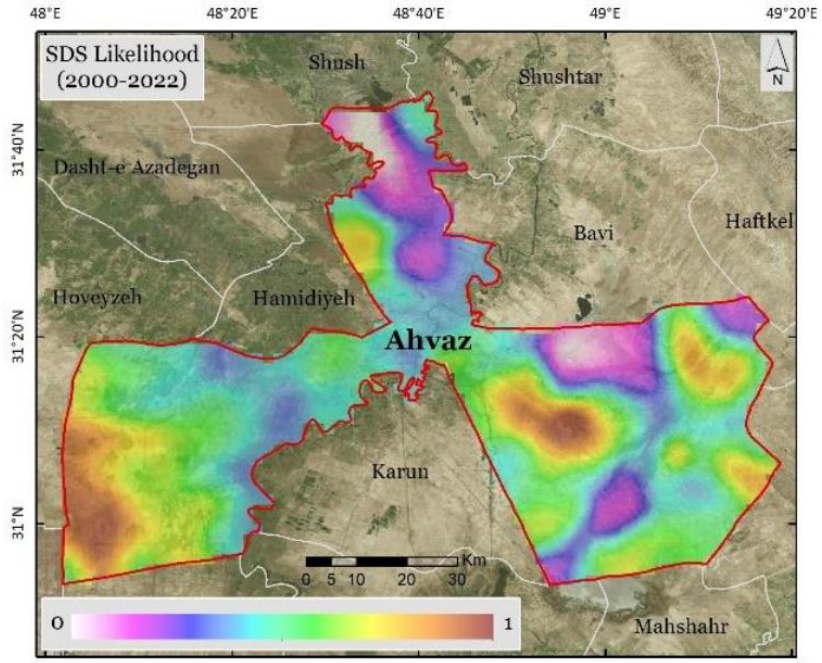

SDS Hazard
(2000-2022)
48°E
48°20'E
48°40'E
49°E
49°20'E
31°40'N
31°20'N
31°N
Shush
Shushtar
Dasht-e Azadegan
Haftkel
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
N
Km
0 5 10 20 30
0
1

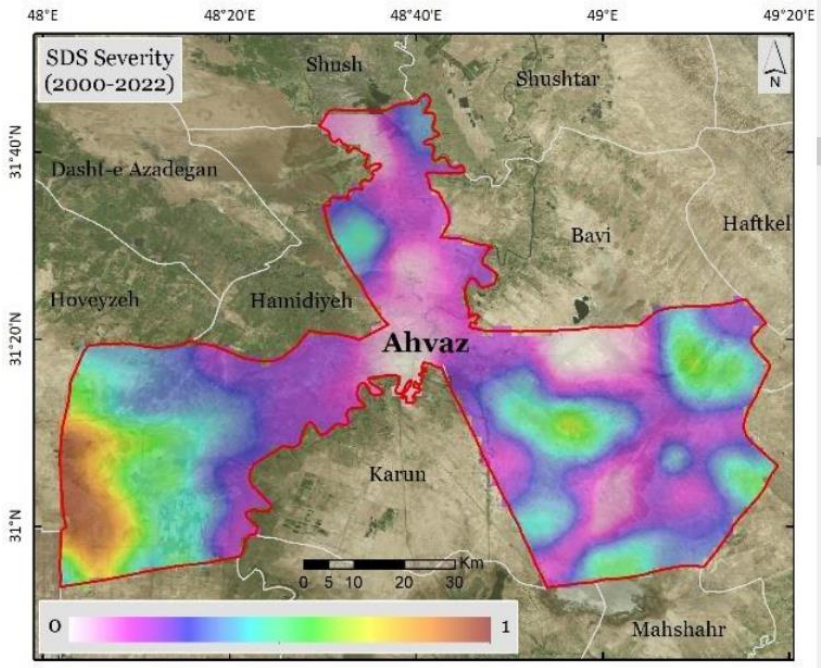

SDS Risk
(2022)
48°E
48°20'E
48°40'E
49°E
49°20'E
31°40'N
31°20'N
31°N
Shush
Shushtar
Dasht-e Azadegan
Haftkel
Bavi
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
N
Km
0 5 10 20 30
Very Low
Low
Medium
High
Very High

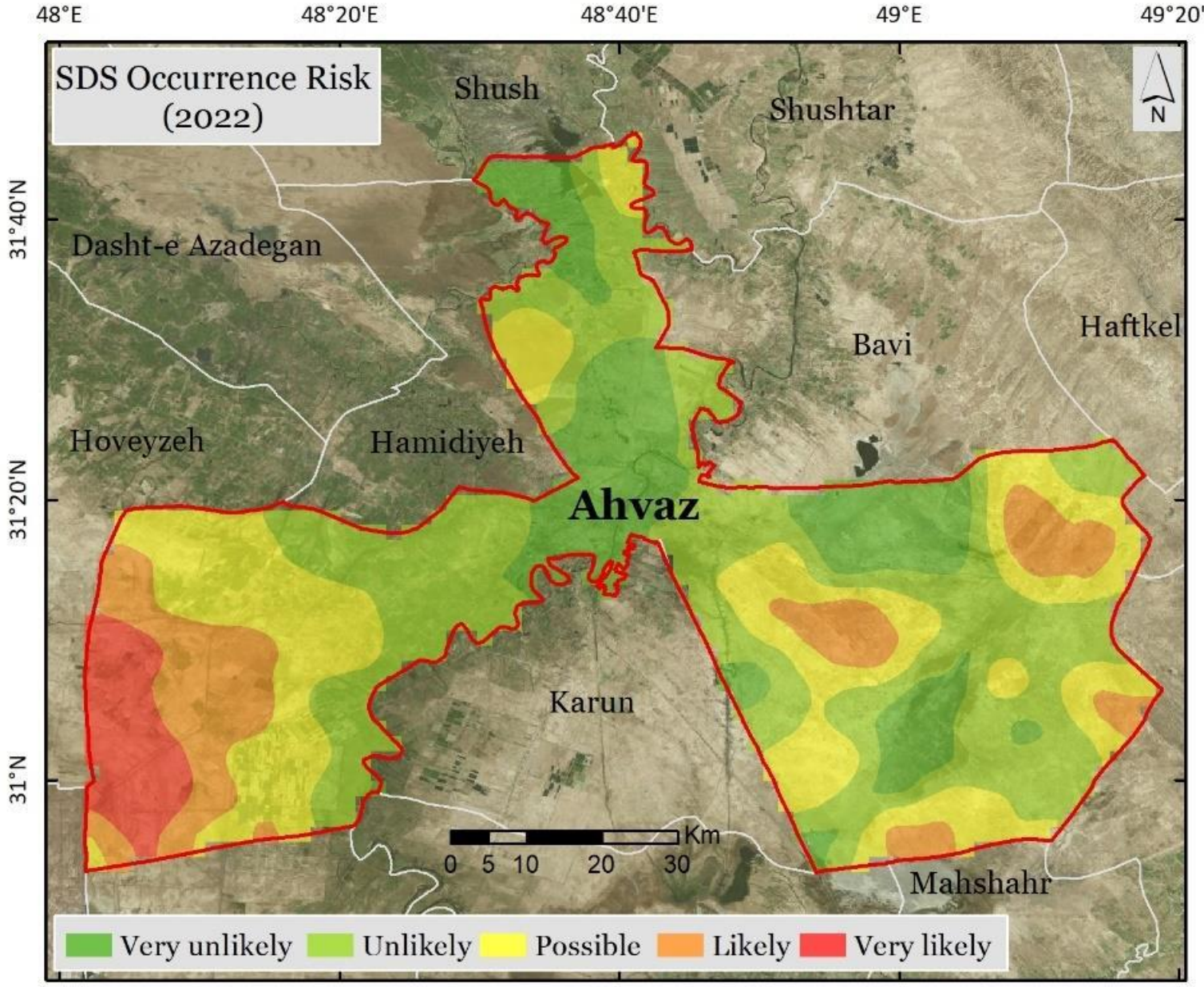


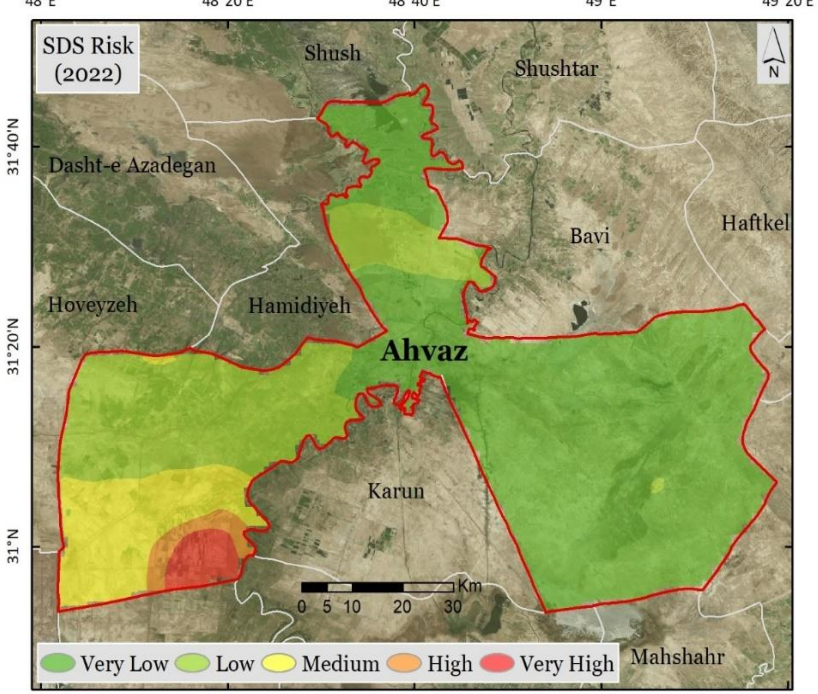
Risk level	Population	Livestock	Rainfed cropland	Irrigated cropland	R1	R2	R3
Unit	Number		km²				
Very high	3 603	1 141	111	26	2	39	73
High	53 326	16 941	194	187	35	84	190
Medium	37 219	11 822	348	411	25	59	154
Low	16 538	5 253	346	766	5	46	129
Very low	5 538	1 760	142	435	0	25	98

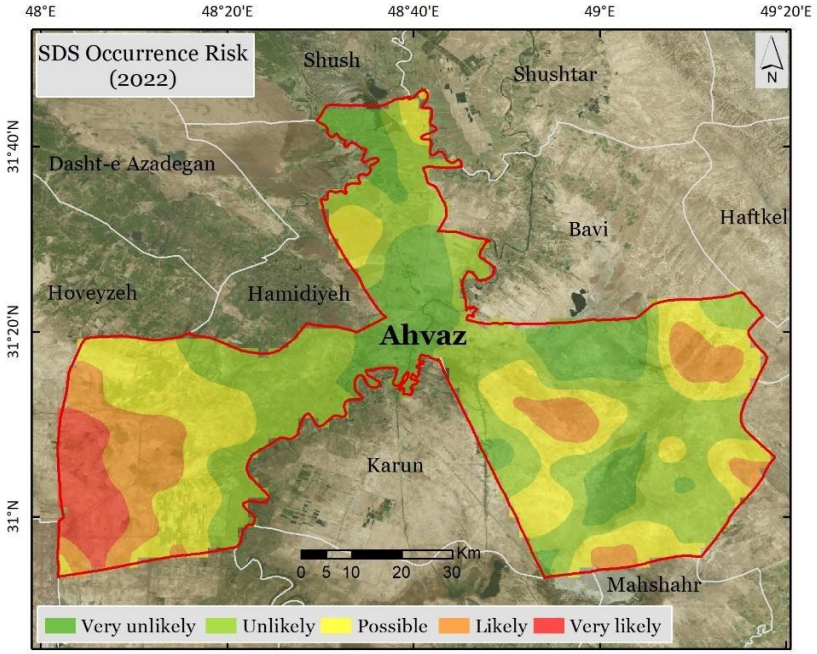
Note: R1 = rangeland with CC ≥ 50 percent; R2 = rangeland with 25 < CC < 50 percent; R3 = rangeland with 5 ≤ CC ≤ 25 percent, where CC = canopy coverage.

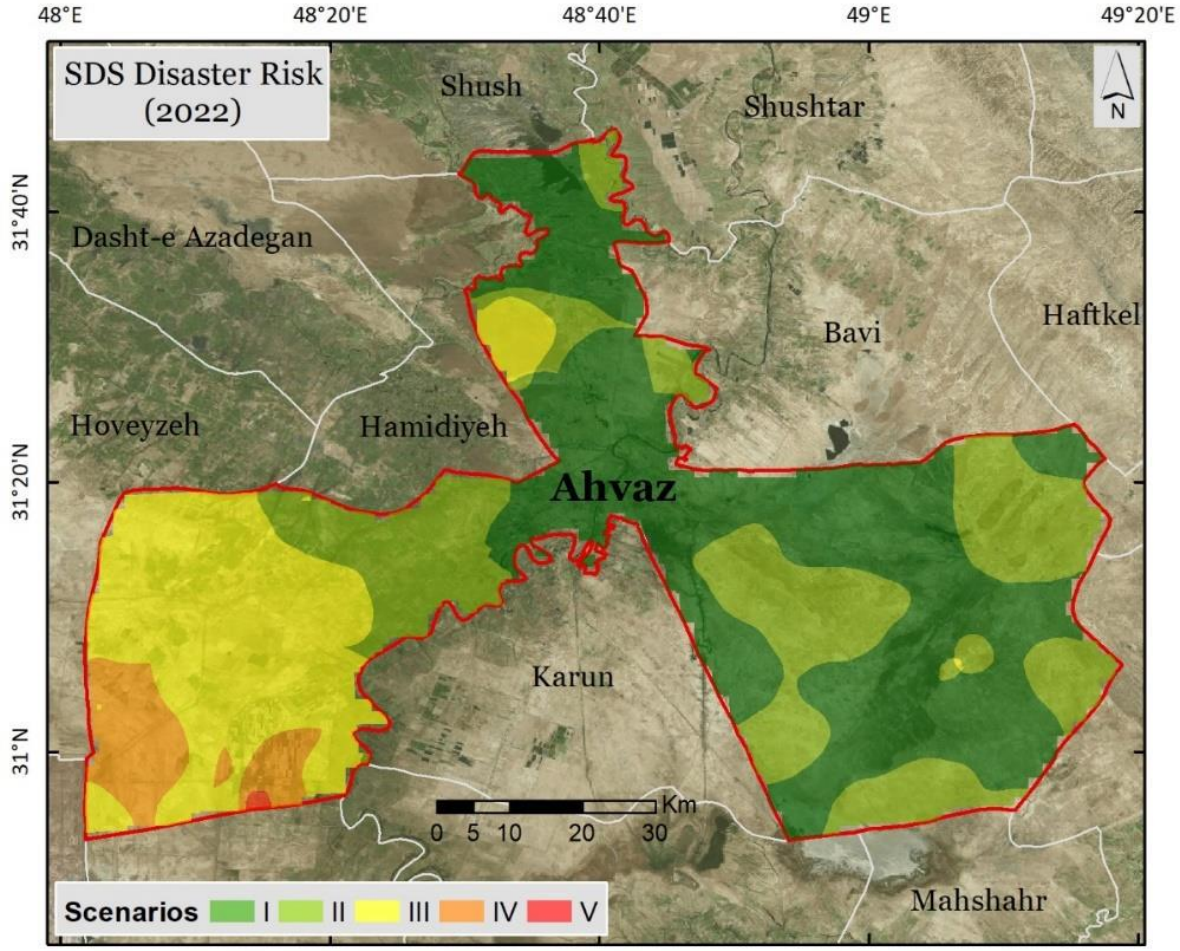

SDS Likelihood
(2000-2022)
48°E
48°20'E
48°40'E
49°E
49°20'E
31°40'N
31°20'N
31°N
Shush
Shushtar
Dasht-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
N
0 5 10 20 30
Km
0
1


SDS Severity
(2000-2022)
48°E
48°20'E
48°40'E
49°E
49°20'E
31°40'N
31°20'N
31°N
Shush
Shushtar
Dasht-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
N
0 5 10 20 30
Km
0
1


SDS Occurrence Risk
(2022)
48°E
48°20'E
48°40'E
49°E
49°20'E
31°40'N
31°20'N
31°N
Shush
Shushtar
Dasht-e Azadegan
Bavi
Haftkel
Hoveyzeh
Hamidiyeh
Ahvaz
Karun
Mahshahr
N
0 5 10 20 30
Km
Very unlikely
Unlikely
Possible
Likely
Very likely







SDS risk occurrence	SDS impact risk				
	Very low	Low	Medium	High	Very high
Very likely	III	III	IV	V	V
Likely	II	III	III	IV	V
Possible	II	III	III	III	IV
Unlikely	I	II	III	III	III
Very unlikely	I	I	II	II	III

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Proposed management structure/responsibilities, coordination, operational activities and communication mechanisms for implementing the CP according to different SDS risk scenarios

Risk scenario	Prepare	Response	Recovery	Fund	Responsible(s)
V	CSD, APA	FWS, FFP, DEG, CMT, TNCM	TNCM, WFPL, CAI	PBO, governorate, and agriculture development funds	NDMO (CMT, FWS and TNCM) IRIMO (EWS) NRWO (CSD and PGP) DoE (DEG and PGP) Stakeholders, ranchers, farmers, etc. (APA, FFP, WFPL, CAI and PGP) IRCS (CMT, FWS and TNCM) Insurance companies (AHPI and DEG) Rural development funds (AHPI and DEG) Water user associations (FWS and WFPL) Road maintenance directory (TNCM)
IV	CSD, APA	FWS, FFP, DEG, CMT, TNCM	TNCM, WFPL, CAI		
III	CSD		CAI		
II					
I					
Independent of risk scenarios	EWS, AHPI, PGP				

AHPI = agriculture, health and property insurance;
APA = animal protective actions (keep livestock in stables, keep bees in hives and cover fishponds with nylon or glass when SDS occurs);
CAI = cleaning agriculture infrastructures;
CMT = crisis management team (if an SDS is categorized as a crisis, this group will form, and by implementing the mitigation measures it will manage the SDS crisis);
CSD = cadastre system development to make a systematic and target-oriented resources allocation to combat SDS;
DEG = damage estimation group led by the Ministry of Jahad-Agriculture (if an SDS is associated with damage, this group will form, and by developing measurable indicators of Sendai Framework Monitor Indicator C-2, it will estimate the amount of damage);
EWS = early warning system;
FFP = fruit and food protection;
FWS = food and water supply;
PGP = promoting good practices related to agriculture (available local knowledge, implemented practices and technologies, and successful projects to mitigate SDS in agriculture);
TNCM = transport network crisis management;
WFPL = washing fruits and plant leaves. For responsible organizations:
DoE = Department of Environment;
IRCS = Iranian Red Crescent Society;
IRIMO = Iran Meteorological Organization;
NDMO = National Disaster Management Organization;
NRWO = Natural Resources and Watershed Management Organization;
PBO = Planning and Budgeting Organization.

Operational activities to reduce SDS disaster risk for agriculture in Ahvaz

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Operational activities	Time	Responsibility
Preparedness		
Collect and provide regular data about water, soil, agriculture, socioeconomic, meteorology and air quality of Ahvaz County to the geodatabase management system	As soon as possible	General governorate of Khuzestan, general meteorological organization of Khuzestan, General Jahad-Agriculture organization of Khuzestan, General NRWO of Khuzestan, General DoE of Khuzestan and research institutes
Soil conservation activities (soil enrichment, no tillage, low tillage and crop rotation)	Before the cultivation season	Land users, including herders and farmers
Water resources management (runoff collection and wetland management)	In wet seasons	Ministry of Energy, Ministry of Jahad-Agriculture and land users
Restoration (afforestation, reforestation, shrub planting and farming)	When needed	NRWO and land users
Land-use planning (rangeland management and livestock grazing management)	In 3–7 years	General governorates and PBO
Farm-side wind-breaks, roadside tree planting and non-living wind-breaks	When needed	NRWO and land users
Agricultural and livestock insurance	Annually	Agriculture Bank of Iran
Establish a financial mechanism to support anticipatory actions	When needed	Ministry of Jahad-Agriculture NRWO, international support funds and agricultural investment funds
Capacity-building and awareness-raising about SDS	When needed	Ministry of Jahad-Agriculture, universities, NDMO and United Nations agencies (FAO, UNCCD, World Health Organization and WMO)
Climate-smart agriculture practices including avoiding cultivating crops with high water consumption, developing an efficient water resource management framework to integrate the agricultural and industrial drainage water with the Karun River water for agricultural irrigation systems and wetting dust sources; development and expansion of the use of new irrigation approaches; use of new technologies, such as superabsorbent to preserve soil moisture; and reduction of rural migration to other areas	As soon as possible	Ministry of Jahad-Agriculture NRWO
Prevent SDS deposition on aquaculture systems	Closest time before SDS occurrence	Iranian/State Fishery Organization, universities, United Nations agencies (FAO, UNCCD, World Health Organization, WMO, etc.) and aquafarmers
Prevent bees from leaving hives	Closest time before SDS occurrence	NDMO, beekeepers and land users
SDS sources control and mitigation measures including stabilizing soil surface by mulching, planting climate-compatible shrubs and trees, and building wind-breaks and mechanical and biological barriers (see Appendix 4 for an overview of additional agricultural measures)	When needed	NRWO helps land users
Health services for people affected by dust	When needed	Ministry of Health, Treatment, and Medical Education (health house and centres and hospital emergency departments)

Operational activities to reduce SDS disaster risk for agriculture in Ahvaz

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Operational activities	Time	Responsibility
Response		
SDS early warning system (spatial spread, durability and intensity)	Real/near real time	WMO Sand and Dust Storm Warning Advisory and Assessment System and IRIMO
SDS agriculture-specific information (television, text messages and social media)	Real/near real time	NDMO, provincial NDMO and IRIMO
Emergency rescue teams for lost people and livestock	When needed	Provincial NDMO and Red Crescent
Health services for people affected by dust	When needed	Ministry of Health, Treatment, and Medical Education (health house and centres and hospital emergency departments)
Recovery		
Estimate the impact/costs of SDS for agriculture and livestock sectors	When needed	NDMO, provincial NDMO, universities and research institutions
Provide health services for people affected by dust	When needed	Ministry of Health, Treatment, and Medical Education (health house and centres and hospital emergency departments)
Use sprinkler irrigation system to wash plant leaves in irrigated agriculture lands	As soon as possible if applicable	Land users
Provide veterinary services to herders	As soon as possible	County veterinary network
Provide financial support to farmers and ranchers	When needed	Ministry of Jahad-Agriculture NRWO, international support funds, and agricultural investment funds

Proposed management structure/responsibilities, coordination, operational activities and communication mechanisms for implementing the CP for different domains of the system

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Domain	Methods and tools	Responsible
Cropland and rangeland	Weekly vegetation cover monitoring using remote-sensing indices, e.g. NDVI and FVC Monthly agricultural productivity monitoring using satellite-based NPP Yearly land degradation assessment by LDI	NRWO DoE General governorates Universities and research institutes
SDS sources	Monitoring changes in the extent of SDS emission sources by NDD Time series analysis of the intensity and frequency of SDS events by DSI, DER and Vis	
Socioeconomics	Human development: ➢ Income stability due to SDS mitigation in agriculture by periodic agriculture census ➢ Awareness about SDS evaluated using questionaries ➢ Migration status of SDS-affected rural areas by national population and housing census	

Frameworks and institutions responsible for SDSS preparedness, response and recovery

Action frameworks	Lead institutions	Support institutions
National master plan	DoE National Committee for Combating SDS	Ministry of Jahad-Agriculture NRWO, NDMO and universities
Action plan	MJA-NRWO	Research institutes
Contingency plan	Ministry of Jahad-Agriculture NRWO	NDMO, IRIMO and Ministry of Health and Medical Education
Control desertification and SDS sources	Ministry of Jahad-Agriculture NRWO	General governorates and PBO
Water, soil and agriculture resources management	Ministry of Jahad-Agriculture (deputy of water and soil)	NRWO and Ministry of Energy
Compensate and provide financial support to affected rural communities	Government and insurance companies	General governorates and PBO and state and private banks
Protection plan and protocols for livestock, bees and aquatics	MJA (Agricultural Research, Education and Extension Organization)	Research institutes and NRWO
Orchardists support and fruit preservation plan	Ministry of Jahad-Agriculture NRWO	Research institutes
Emergency food and water supplies plan	NDMO and Iranian Red Crescent Society (IRCS)	MJA-NRWO and provincial governorate
Biodiversity and medicinal plants	Research institutes	MJA (deputy of water and soil) and NRWO
SDS awareness-raising culture for preparedness, response and recovery	MJA(Agricultural Research, Education and Extension Organization)	Research institutes and universities

Follow-up recommendations and management actions

Within Ahvaz County

1) Hold capacity development workshops (meetings and administrative discussions) for SDS stakeholders in Ahvaz County
2) Establish a cross-sectoral SDS expert group in Ahvaz to guide enhanced SDS contingency planning implementation
3) Design and conduct a training workshop for the SDS expert group
4) Further raise awareness among local communities living in SDS high-risk areas of Ahvaz
5) Adopt a multi- and cross-sectoral lens in the development and implementation of SDS contingency planning
6) Government of the IR. Iran should conduct the feasibility assessments needed for implementing this CP.
7) Based on the feasibility study results and in line with its overall responsibilities, the Government of the IR. Iran should reconfirm its SDS priority interventions for the different agricultural subsectors

Beyond Ahvaz County

1) For further upscaling of SDS activities beyond Ahvaz, develop countrywide SDS risk and vulnerability maps. Based on those, develop related contingency plans at local scales for other areas affected by SDS, with a focus on agriculture.
2) The Government of the IR. Iran should integrate an SDS contingency plan into the national DRR programme following Table 8.
3) The Government of the IR. Iran should consider adapting, implementing and distributing this SDS contingency planning approach into other SDS-affected counties.

Proposed elements and tasks to develop an SDS-oriented contingency plan in agriculture

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Knowledge creation/sharing

- Conduct research to identify emission sources, transport pathways and deposition areas of SDS and the impacts on agriculture, and rural comunities to create baselines for each region
- Coordinate with regional countries/institutions and United Nations entities to share knowledge
- Raise awareness about SDS drivers and consequences

Forecast and early warning system

- Forcast the occurrence of SDS
- Provide agriculture rural specific early warning messages for SDS impact mitigation
- Develop an online interorganizational warning network for syncronized action planning

Enhanc cohesion between the national and local action plans for agriculture, DRM, SDS and with other sectors

- National DRR and DRM plans to combat SDS
- National master plan to combat SDS in agriculture
- Agriculture-specific local action plans at county/district levels

Capacity development in agriculture to enhance resilience and adaptability of agriculture towards SDS

- Multi-hazard risk reduction and role and responsibilities of agriculture
- Create protocols for prevention, mitigation and adaptation towards SDS impacts
- Create and implement operational response plans during SDS events
- Create recovery protocols and operational plans to mitigate SDS impacts

Agriculture damage and loss estimation

- Develop time series remote-sensing indicators to model vegetation cover and plant phonology behaviours to be combined with field data to estimate damage and loss caused by SDS in agricutural lands
- Utilize the FAO damage and loss methodology to generate precise and holistic data for the agricultural sector (https://elearning.fao.org/course/view.php?id=608)
- Apply the Sendai Framework Monitor Indicator C-2 measuring "Direct agricultural loss attributed to disasters" (https://www.preventionweb.net/sendai-framework/sendai-framework-indicators)

Multiscale SDS (geo)database development

- Create and develop an SDS (geo)database management system, which contains the maps of SDS sources, transport and deposition areas, vulnerability, hazard and risk assessment/mapping procedures, decision support system and protocols to regularly update

Determining the responsible organizations

- Further define the responsibilities of key stakeholders, institutions and government agencies; SDS includes several domains (croplands, rangelands and rural comunities) in a transparent way, and in accordance with existing laws, regulations and programmes
- Enhance the intra- and inter-agency interactions as the prerequisite to better SDS risk management
- The transnational nature of the phenomenon dictates the need for strengthening regional cooperation, international relations and use of the capacities of United Nations entities

I'm extremely grateful to

FAO

Significant technical guidance, inputs and advice were provided by the FAO experts

Mr. Stephan Baas,

Mrs. Wirya Khim,

Mrs. Tamara van ‘t Wout,

Mr. Nick Middleton,

Mrs. Caren Brown,

Mrs. Khazal Kamar,

Mr. Feras Ziadat

Mr. Gerold Boedeker,

Mrs. Marjan Ghanbari,

Mr. Hooman Moezzi,

Mr. Sina Saemian.

MJA-NRWO

Significant technical guidance, data and inputs and advice were provided by the SDS experts

Mr. Vahid Jafarian,

Mr. Mohsen Abdolhoseini,

Mr. Ali Amooyi,

Mr. Hossein Badripour,

Mr. Ali Hossein Dehghan,

Mr. Ali Hajibaglou,

Mrs. Soodabeh Namdari,

Mr. Mahmoud Rajabi,

Mr. Forood Sharifi,

Mr. Navid Ziaei,

Mr. Parviz Garshasbi

My Research Team

Scientific and technical inputs were provided by my SDS team of the Department of Remote Sensing and GIS, Faculty of Geography, University of Tehran

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Mr. Masoud Soleimani,

Mr. Mohsen Bakhtiari,

Mr. Ramin Papi,

Mr. Saham Mirzaei,

Mr. Sadri Seifi.

Tehran

Current Projects:

1. **SDS risk analysis and contingency planning for dryland forest and rangeland conservation and restoration in Kerman and Khorasan Jonoobi Provinces, by FAO**

2. **Dust disaster risk analysis and developing risk reduction procedure for Tehran metropolitan, by Natural Disasters Research Institute, NDRI (https://en.ndri.ac.ir/) , Iran**

Acknowledgments

University of Tehran

- I am extremely grateful to University of Tehran and specially My Research Team for being the major hand in these works.

- My deepest appreciation goes to FAO for their invaluable support, which played a vital role in enabling us to accomplish this endeavor successful.

- My sincerest thanks to CDRF for their instrumental contribution in organizing and hosting this specialized webinar.

- My sincerest thanks to all the Esteemed Attendees who dedicated their valuable time to listen to my speech during this webinar.

- I am incredibly grateful to my Amazing Wife and Daughters for their unwavering support and assistance throughout my journey in dust research.

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Thank you